NATIONAL GREENHOUSE GAS INVENTORY REPORT OF THE CZECH REPUBLIC

SUBMISSION UNDER UNFCCC AND UNDER THE KYOTO PROTOCOL

REPORTED INVENTORIES 1990-2016

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Executive Summary

ES 1 Vykazování bilancí emisí a propadů skleníkových plynů v České republice

Jakožto jedna ze stran Rámcové Úmluvy OSN o změně klimatu má Česká republika povinnost připravovat a pravidelně aktualizovat národní inventarizace vykazování emisí a propadů skleníkových plynů. Kromě toho, z členství v Evropské Unii plynou pro Českou republiku další požadavky jako plnění povinností specifikovaných v článku 7 Nařízení EU č. 525/2013. Tato verze národní inventarizační zprávy prezentuje úrovně emisí skleníkových plynů pro časovou řadu 1990 až 2016 s důrazem na poslední vykazovaný rok, tedy 2016. Všechny dříve provedené změny ve vykazování jsou i nadále součástí tohoto dokumentu.

Inventarizace emisí a propadů skleníkových plynů byla připrave v souladu s metodickými pokyne Mezivláního panelu pro změnu klimatu: IPCC 2006 Guidelines (IPCC 2006). Konkrétní využití této metodiky a využití územně specifických postupů je pospáno v jednotlivých kapitolách níže. V případě, že dojde ke zpřesnění metodických postupů vyvstává v řadě případů potřeba přepočítat vykázané emise v celé časové řadě. Tím se udržuje konzitentní přístup k vykazování emisí.

Národní inventarizační zpráva je připravena podle požadavků metodického pokynu Rámcové Úmluvy OSN o změně klimatu. NIcméně státy Dodatku I Úmluvy, které jsou současně smluvními stranami Kjótského protokolu, mají take povinnost vykazovat další informace specifikované článkem 7.1 Kjótského Protokolu. Pravidla o vykazování těchto informací jsou uvedena v Rozhodnutí 15/CMP.1. Informace vztažené k požadavků Kjóstkého Protokolu jsou uvedeny v části 2 tohoto reportu.

Obě části Národní inventarizační zprávy společně s oficiálními tabulkami pro reporting (CRF – Common Reporting Format) jsou každoročně odesílány k 15. březnu Evropské Komisi a k 15. dubnu sekrateriátu Rámcové Úmluvy OSN o změně klimatu.

ES 2 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 2016 with specific accent on the latest year 2016 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 2006), 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 15th March to European Commission and by 15th 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 3 Summary of national emission and removal related trends

ES 3.1 GHG inventory

In 2016, the most important GHG in the Czech Republic was CO_2 contributing 82.2% to total national GHG emissions and removals expressed in CO_2 eq., followed by CH_4 10.6% and N_2O 4.7%. PFCs, HFCs, SF_6 and NF_3 contributed for 2.6% to the overall GHG emissions in the country.

Tab. ES 1 provides data on GHG emissions in comparison of overall trend from 1990 to 2016. For overview of GHG emissions and removals by categories please see chapter ES 3.

Tab. ES 1 GHG emission/removal overall trends

	Base year	2016	Base year	2016	Trend
	[kt CO_2 eq.]		%		
CO_2 emissions without net CO_2 from LULUCF	164227.40	106543.30	83.16	82.22	-35.12
CO_2 emissions with net CO_2 from LULUCF	157580.43	101145.88	82.54	81.41	-35.81
CH_4 emissions without CH_4 from LULUCF	23613.43	13771.60	11.96	10.63	-41.68
CH_4 emissions with CH_4 from LULUCF	23657.59	13804.46	12.39	11.11	-41.65
N_2O emissions without N_2O from LULUCF	9550.55	6064.66	4.84	4.68	-36.50
N_2O emissions with N_2O from LULUCF	9590.58	6092.07	5.02	4.90	-36.48
F-gases	84.24	3203.72	0.04	2.58	
Total (without LULUCF)	**197475.63**	**129583.28**			**-34.38**
Total (with LULUCF)	**190912.83**	**124246.14**			**-34.92**
Total (without LULUCF, with indirect)	**199597.37**	**130348.69**			**-34.69**
Total (with LULUCF, with indirect)	**193034.57**	**125011.55**			**-35.24**

Over the period 1990 - 2016 CO_2 emissions and removals decreased by 35.81%, CH_4 emissions decreased by 41.65% during the same period mainly due to lower emissions from 1 Energy, 3 Agriculture and 5 Waste; N_2O emissions decreased by 36.48% over the same period due to emission reduction in 3 Agriculture and despite increase from the 1.A.3 Transport category. Emissions of HFCs and PFCs increased by orders of magnitude, whereas SF_6 emissions kept steady trend over the whole period.

ES 4 Overview of source and sink category emission estimates and trends, including KP-LULUCF activities

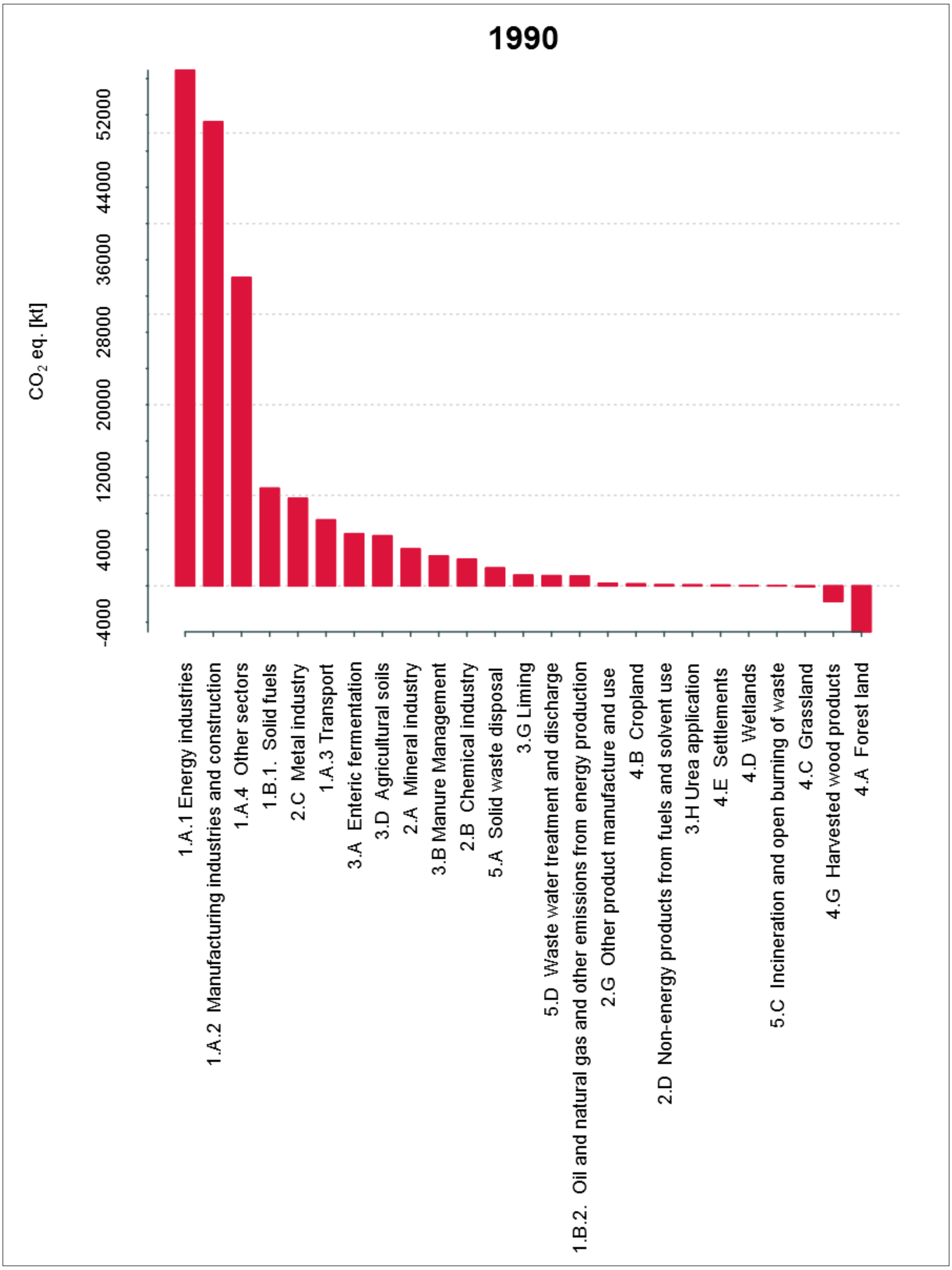

Fig. ES 1 Sources and sinks of greenhouse gases in 1990 (kt CO_2 eq.)

ES 4.1 GHG inventory

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

	Base year kt CO_2 eq.	2016 kt CO_2 eq.	2016 Total share [%]	2016 Sectoral share [%]	Trend %
1. Energy	**161339.98**	**100280.60**	**80.71**	**100.00**	**-37.85**
A. Fuel combustion (sectoral approach)	149478.48	96249.72	77.47	95.98	-35.61
1. Energy industries	56915.91	54449.09	43.82	54.30	-4.33
2. Manufacturing industries and construction	51234.04	9396.92	7.56	9.37	-81.66
3. Transport	7284.03	18449.82	14.85	18.40	153.29
4. Other sectors	34044.50	13546.23	10.90	13.51	-60.21
5. Other	NO	407.66	0.33	0.41	100.00
B. Fugitive emissions from fuels	11861.51	4030.88	3.24	4.02	-66.02
1. Solid fuels	10779.39	3420.64	2.75	3.41	-68.27
2. Oil and natural gas and other emissions from energy production	1082.12	610.25	0.49	0.61	-43.61
C. CO_2 transport and storage	NO	NO	NA	NA	0.00
2. Industrial Processes	**17113.01**	**15221.74**	**12.25**	**100.00**	**-11.05**
A. Mineral industry	4082.45	2816.07	2.27	16.44	-31.02
B. Chemical industry	2944.23	1527.23	1.23	13.44	-48.13
C. Metal industry	9670.32	7311.48	5.88	44.74	-24.39
D. Non-energy products from fuels and solvent use	125.56	139.73	0.11	0.91	11.28
E. Electronic industry	NO,NE	6.39	0.01	0.12	100.00
F. Product uses as ODS substitutes	NO	3122.53	2.51	22.43	100.00
G. Other product manufacture and use	290.46	298.31	0.24	1.93	2.70
H. Other	NO	NO	NA	NA	0.00
3. Agriculture	**15898.12**	**8519.68**	**6.86**	**100.00**	**-46.41**
A. Enteric fermentation	5754.89	2957.46	2.38	34.14	-48.61
B. Manure management	3315.36	1580.18	1.27	20.97	-52.34
C. Rice cultivation	NO	NO	NA	NO	0.00
D. Agricultural soils	5531.71	3603.26	2.90	40.76	-34.86
E. Prescribed burning of savannas	NO	NO	NA	NO	0.00
F. Field burning of agricultural residues	NO	NO	NA	NO	0.00
G. Liming	1187.63	168.01	0.14	1.92	-85.85
H. Urea application	108.53	210.76	0.17	2.21	94.19
I. Other carbon-containing fertilizers	NO	NO	NA	NA	0.00
J. Other	NO	NO	NA	NA	0.00
4. Land use, land-use change and forestry	**-6562.80**	**-5337.14**	**-4.30**	**100.00**	**-18.68**
A. Forest land	-5076.02	-4519.32	-3.64	91.15	-10.97
B. Cropland	213.22	124.36	0.10	-0.07	-41.67
C. Grassland	-96.83	-661.65	-0.53	8.29	583.32
D. Wetlands	21.48	25.03	0.02	-0.38	16.52
E. Settlements	86.31	124.06	0.10	-1.33	43.73
F. Other land	NO,NA	NO,NA	NA	NA	0.00
G. Harvested wood products	-1712.97	-430.67	-0.35	2.47	-74.86
H. Other	NO	NO	NA	NA	0.00
5. Waste	**3124.51**	**5561.26**	**4.48**	**100.00**	**77.99**
A. Solid waste disposal	1979.27	3671.11	2.95	64.40	85.48
B. Biological treatment of solid waste	NE,IE	711.36	0.57	12.91	100.00
C. Incineration and open burning of waste	21.25	115.99	0.09	2.57	445.73
D. Waste water treatment and discharge	1123.99	1062.80	0.86	20.12	-5.44
E. Other	NO	NO	NA	NA	0.00
Total CO_2 equivalent emissions without land use, land-use change and forestry	**197475.63**	**129583.28**	**-**	**-**	**-34.38**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**190912.83**	**124246.14**	**100.00**		**-34.92**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	**199597.37**	**130348.69**	**-**	**-**	**-34.69**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	**193034.57**	**125011.55**	**-**	**-**	**-35.24**

In 2016, 100 280.60 kt CO_2 eq., that are 80.71% of national total emissions (including 4 Land Use, Land-Use Change and Forestry) arose from 1 Energy; 95.98% of these emissions arise from fuel combustion activities. The most important sub-category of 1 Energy with 54.30% of total sectoral emissions in 2016 is 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction responses for 9.37% and 1.A.3 Transport for 18.40% of total sectoral emissions. From 1990 to 2016 emissions from 1 Energy decreased by 37.85%.

2 Industrial Processes is the second largest category with 12.25% of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2016 (15 221.74 kt CO_2 eq.); the largest sub-category is 2.C Metal Production with 44.74% of sectoral share. From 1990 to 2016 emissions from 2 Industrial Processes decreased by 11.05%.

3 Agriculture is the third largest category in the Czech Republic with 6.86% share of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2016 (8 519.68 kt CO_2 eq.); 40.76% of these emissions arose from 3.D Agricultural Soils. From 1990 to 2016 emissions from 3 Agriculture decreased by 46.41%.

4 Land Use, Land-Use Change and Forestry is the only category where removals exceed emissions. Net removals from this category decreased from 1990 to 2016 by 18.68% to –5 337.14 kt CO_2 eq.

4.48% of the national total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2016 arose from 5 Waste. 64.40% share of GHG emissions arose from 5.A Solid waste disposal. Emissions from 5 Waste increased from 1990 to 2016 by 77.99% to 5 561.26 kt CO_2 eq.

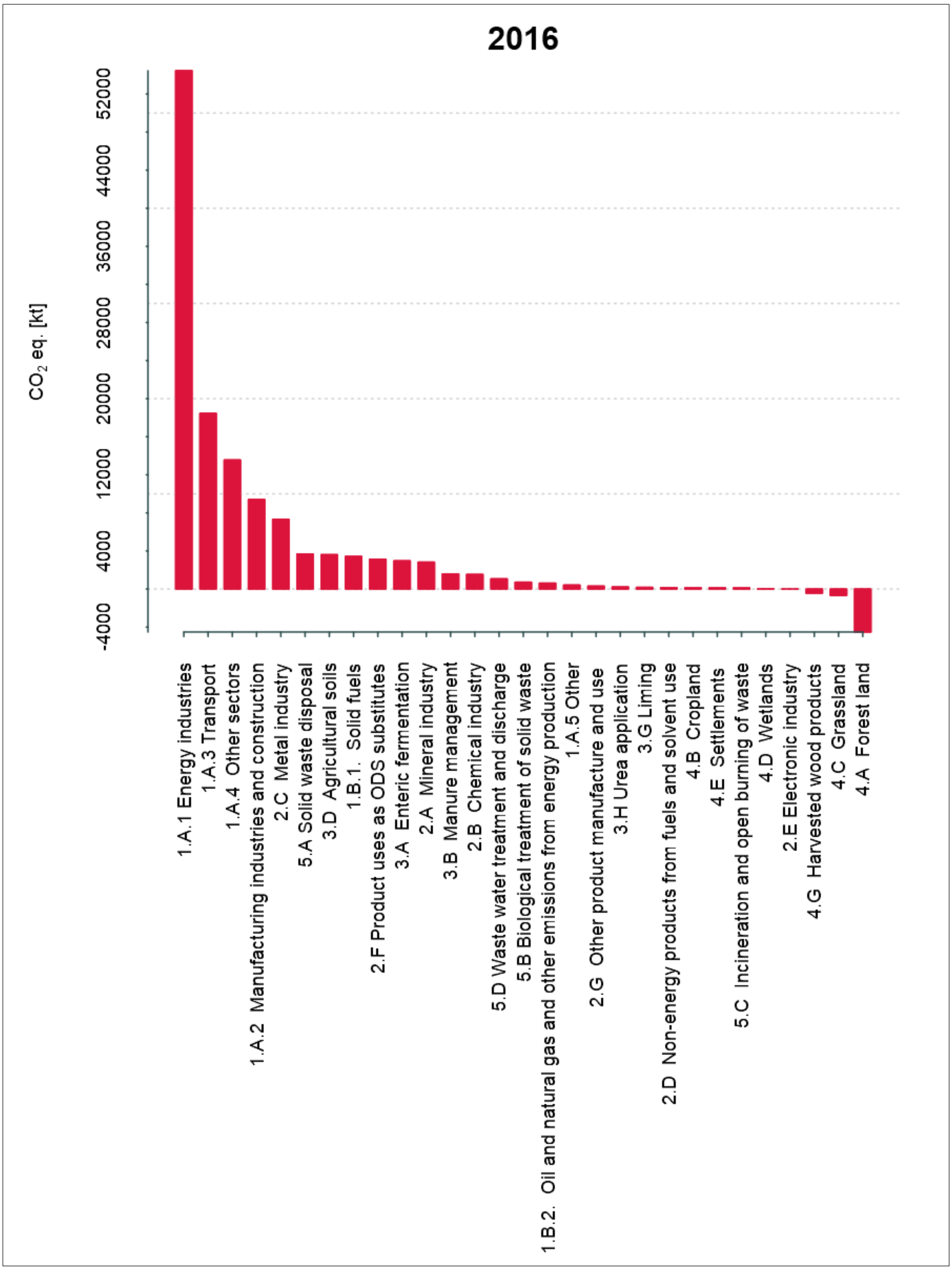

Fig. ES 2 Sources and sinks of greenhouse gases in 2016 (kt CO_2 eq.)

ES 4.2 KP-LULUCF activities

Emission and removals estimates of GHGs for the KP LULUCF activities and HWP contribution for the years 2013-2016 are presented in Tab. ES 3 to Tab. ES 5.

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

A. Article 3.3 activities	Unit	2013	2014	2015	2016
A.1. Afforestation and Reforestation					
CO_2 emissions/removals	Gg	-498.47	-553.76	-593.74	-635.53
CH_4	Gg	NO	NO	NO	NO
N_2O	Gg	NO	NO	NO	NO
Net CO_2 equivalent emissions/removals	Gg CO_2 eq.	-498.47	-553.76	-593.74	-635.53
A.2. Deforestation					
CO_2 emissions/removals	Gg	233.81	230.85	179.56	218.64
CH_4	Gg	NO	NO	NO	NO
N_2O	Gg	0.00	0.00	0.00	0.00
Net CO_2 equivalent emissions/removals	Gg CO_2 eq.	234.18	231.18	179.87	218.92

**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	2016
B.1. Forest Management					
CO_2 emissions/removals	Gg	-5 805.23	-5 740.07	-5 510.69	-4 059.54
CH_4	Gg	1.00	1.16	1.27	1.31
N_2O	Gg	0.06	0.06	0.07	0.07
Net CO_2 equivalent emissions/removals	Gg CO_2 eq.	-5 763.94	-5 691.74	-5 458.15	-4 005.01

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

Harvested Wood Products	Unit	2013	2014	2015	2016
HWP contribution					
CO_2 emissions/removals	Gg	-126.91	-96.16	-460.00	-430.67
CH_4	Gg	NO	NO	NO	NO
N_2O	Gg	NO	NO	NO	NO
Net CO_2 equivalent emissions/removals	Gg CO_2 eq.	-126.91	-96.16	-460.00	-430.67

ES 5 Other information

ES 5.1 Overview of emission estimates and trends of indirect GHGs and SO_2

Emission estimates of indirect GHGs and SO_2 for the period from 1990 to 2016 are presented in Tab. ES 6.

Tab. ES 6 Indirect GHGs and SO_2 for 1990 to 2016 [kt]

	NO_X	CO	NMVOC	SO_X (as SO_2)
1990	738.52	1068.64	300.70	1870.91
1991	723.47	1153.04	263.24	1767.49
1992	699.43	1158.25	248.04	1554.42
1993	684.06	1189.87	224.28	1466.04
1994	441.29	1070.90	247.01	1284.80
1995	418.85	927.52	207.24	1090.23
1996	437.65	960.26	257.10	931.11
1997	461.65	976.05	263.80	977.45
1998	408.21	802.10	258.61	438.27
1999	375.14	720.96	239.94	264.35
2000	291.70	947.76	257.88	232.61
2001	303.38	957.74	298.63	228.69
2002	287.47	923.11	295.20	222.61
2003	287.28	929.26	290.54	217.41
2004	290.04	917.37	278.99	215.10
2005	281.01	832.62	266.86	208.43
2006	275.64	857.44	266.51	206.72
2007	272.44	864.21	260.31	212.02
2008	253.71	804.78	251.85	170.01
2009	235.03	802.13	246.68	168.70
2010	225.31	823.42	241.85	163.83
2011	212.44	804.77	229.69	167.49
2012	198.79	803.48	224.46	160.11
2013	185.12	821.21	222.59	145.01
2014	176.89	798.26	216.40	132.49
2015	171.30	802.62	215.81	127.90
2016	164.23	805.39	212.58	115.92
Trend [%]	-77.76	-24.63	-29.31	-93.80
NEC	286	-	220	265

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

Emissions of indirect greenhouse gases decreased from the period from 1990 to 2016: for NO_X by 76.81%, for CO by 24.89%, for NMVOC by 28.23% and for SO_2 by 93.16%. The most important emission source for indirect greenhouse gases and SO_2 are fuel combustion activities, for details see chapter 9 in Part1: Annual inventory report.

Part 1: Annual inventory submission

1 Introduction

1.1 Background information on GHG inventories and climate change

1.1.1 Climate change

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

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

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

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

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

1.1.2 Greenhouse gas inventories

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

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

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

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

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

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

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

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

1.2 A description of the national inventory arrangements

1.2.1 Institutional, legal and procedural arrangements

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

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

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

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

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

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

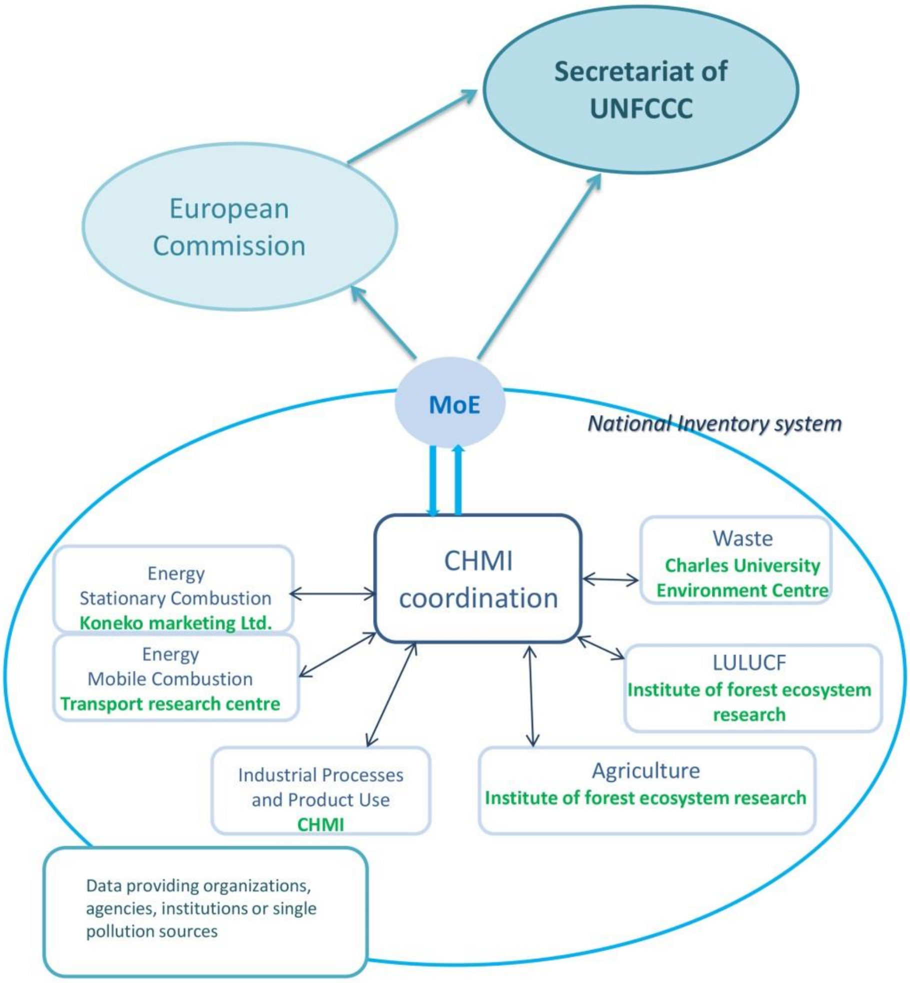

Fig. 1-1 Institutional arrangements of National Inventory System in the Czech Republic

1.2.2 Overview of inventory planning, preparation and management

UNFCCC, the *Kyoto Protocol* and the EU greenhouse gas monitoring mechanism require the Czech Republic to annually submit a *National Inventory Report* (NIR) and *Common Reporting Format* (CRF) tables. The annual submission contains emission estimates for the second but last year, so the 2018 submission contains estimates for the calendar year of 2016. The organisation of the preparation and reporting of the Czech greenhouse gas inventory and the duties of its institutions are detailed in the previous section (1.2.1).

The preparation of the inventory includes the following three stages:

- inventory planning
- inventory preparation
- inventory management.

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

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

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

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

1.2.3 Quality assurance, quality control and verification plan

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

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

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

1.2.3.1 CHMI as a coordinating institution of QA/QC activities

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

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

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

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

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

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

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

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

1.2.3.2 Inventory process

The annual inventory process describes at a general level how the inventory is produced by the national system. The quality of the output is ensured by the inventory experts in the course of compilation and reporting, which consist of four main stages: planning, preparation, evaluation and improvement (Fig. 1-2). 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.

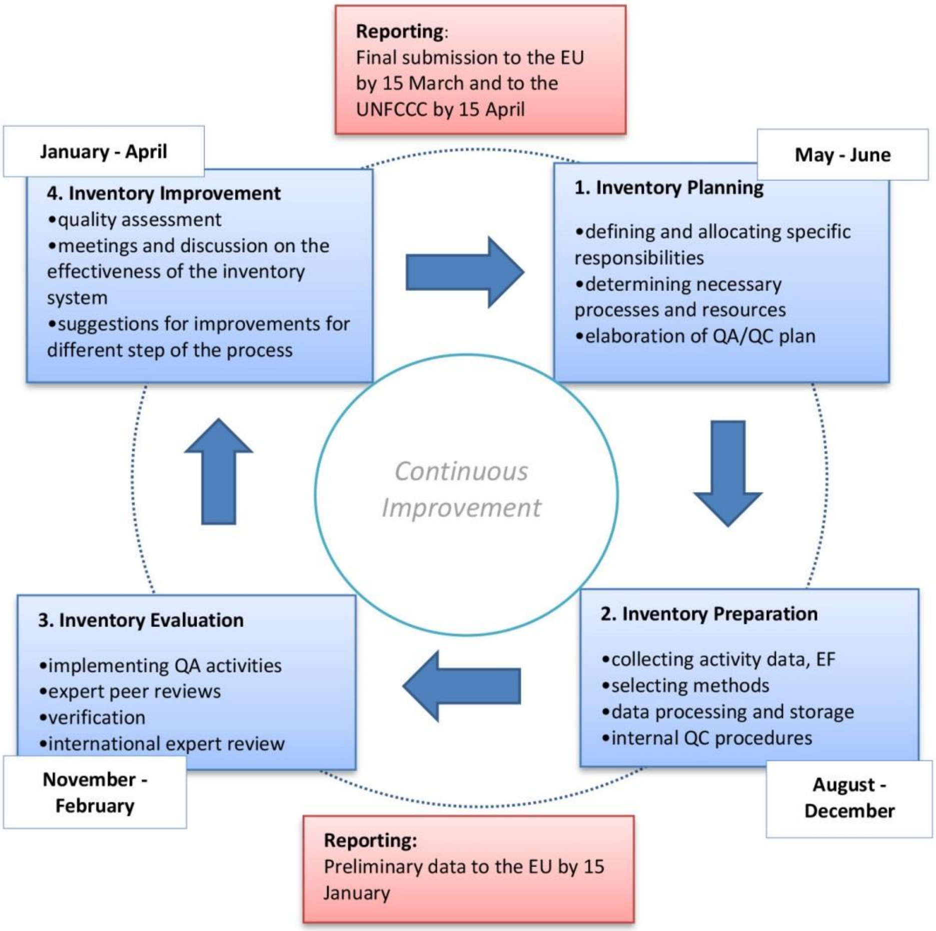

Fig. 1-2 Timeschedule of submissions and QA/QC prodedures

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 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.

1.2.3.5 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 2018 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.

1.2.3.6 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
15–20 November	Final update of all detailed calculation sheets for the given category using the new data. Auto-control (1st step of QC procedure) carried out by the expert responsible for the given category.	Compiler of the category from the sector-solving institution
21–25 November	2nd step of QC procedure carried out by the expert from the sector-solving institution familiar with the topic	Expert from the sector-solving institution familiar with the topic
26-30 November	Data from the calculation sheets are submitted to the sectoral module of the CRF Reporter and are controlled by the person responsible for the given category and by the expert from the sector-solving institution familiar with the topic.	Compiler of the category and the expert from the sector-solving institution familiar with the topic
1–5 December	Finalization of the QC control of the data output and completion of the control form for the given category	Sectoral QA/QC guarantor
6–10 December	Submission of all sectoral data outputs as well as records of the carried out QC procedures to CHMI	Main compiler of the sector-solving institution
10–15 December	Inventory compiler from CHMI (administrator of CRF Reporter) receives all data files and the records from the sector-solving institution for archiving, carries out the formal control of data in the CRF Reporter. If necessary, the sectoral QA/QC expert is contacted to remedy possible drawbacks.	Inventory compiler from CHMI (Eva Krtková)
16–20 December	Inventory compiler from CHMI (administrator of CRF Reporter) carries out the final control of data in the CRF Reporter and informs on the results the NIS coordinator who carries out independent control and informs MoE on the results.	NIS coordinator (manager) (Eva Krtková)
up to 31 December	CRF Tables submission to MoE for the approval	MoE and Sector coordinating group

Time period	Activity	Responsible person
Up to 15 January	CRF Tables submitted to the European Commission within the reporting procedure pursuant to Article 7of the Decision No. 525/2013/EC	MoE

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

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

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

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

1.2.3.2 Quality assurance procedures

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

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

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

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

1.2.3.3 Implementation of QA/QC procedures in cases of recalculations

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

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

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

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

1.2.3.4 Final approval of the inventory before submission

Regarding the national GHG inventory submission to the UNFCCC (15 April.) the same procedure will be applied as for the corresponding reporting to the EC. The following approval procedure is within the authorization of the Ministry of the Environment of the Czech Republic. The procedure involves that the report is sent by the Ministry of the Environment, well ahead via email, to the relevant ministries in the Czech Republic (e.g. Ministry of Finance, Ministry of Transport, Ministry of Foreign Affairs, Ministry of Education, Youth and Sports, etc.), organizations (e.g. Czech Environmental Inspectorate, Czech Environmental Information Agency, non-governmental organizations, etc.), as well as to the unions of different producers (e.g. Czech-Moravian Confederation of Trade Unions, Confederation of Industry of the Czech Republic, Association of Chemical Industry of the Czech Republic, Union of Czech and

Moravian Production Co-operatives, Czech Cement Association, etc.) before the official submission to the UNFCCC for their comments and observations. This is the so called proceeding of external comments. Thereafter, comments and observations must be resolved by the Climate Change Department of the Ministry of the Environment in consultation with CHMI. Such procedure is in accordance with the Provision no. 11/06 of the Ministry of the Environment, regarding the procedure for preparation and hand-over of reporting information

1.2.3.5 Sectoral specifications of QA/QC plan

1.2.3.5.1 Energy – stationary combustion

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

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

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

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

Sectoral administrator, Andrea Paulů:

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

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

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

<u>QC procedures at the Tier 2</u> are included upon the suggestion of the QA/QC sectoral guarantor after the consultation with the NIS coordinator. They are aimed mainly at the comparison with independent data

sources that are not based on data processing from the CzSO energy balance. The relevant independent sources in the Czech Republic are represented by data published and verified within the EU Emission Trading Scheme (ETS) from the national system REZZO, used for the registration of ambient air pollutants, and based mainly on data collection from individual plants. In addition to emission data the REZZO database includes also activity data, independent of CzSO data. The way how to optimally use the above data sources is determined on the basis of systematic research and is covered in the national inventory improvement plan.

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

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

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

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

Person	Activity
Mr. Vladimir Neužil	Sectoral QA/QC guarantor responsible for the compliance of all QA/QC procedures with the IPCC 2006 Guidelines and QA/QC plan
Ms. Andrea Paulů	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. Andrea Paulů, **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 export. The last step is documentation and archivation of data.

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

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

External expert (Ms. 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
Ms. 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, Andrea Paulů:

- 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 (Andrea Paulů) and is followed by the control of the QA/QC colleague familiar with the topic (Vladimír Neužil). At this control level (Tier 1), the individual steps are controlled according to the table 6.1 (IPCC 2006).

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

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

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

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

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

Person	Activities
Mr. Vladimir Neužil	Sectoral QA/QC guarantor responsible for the compliance of all QA/QC procedures with the IPCC 2006 Guidelines and the QA/QC plan.
Ms. Andrea Paulů	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. Andrea Paulů	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	Ms. Beáta Ondrušová	Ms. Eva Krtková	Mr. Bernauer
2.C	Ms.Eva Krtková	Ms. Beáta Ondrušová	Mr.Toman
2.D	Ms. Eva Krtková	Ms. Beáta Ondrušová	Mr. Vladimír Neužil
2.E, 2.F, 2.G	Ms. Beáta Ondrušová	Ms. Eva Krtková, Mr. Vlarimír Řeháček	Mr. Bernauer – 2.G Mr. Martin Beck

1.2.3.5.5 Agriculture

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

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

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

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

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

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

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

Person	Activity
Ms. Jana Beranová (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)
Ms. Janka Szemesova (SHMI)	Consultation of QA/QC procedures and GHG estimation

1.2.3.5.6 LULUCF, KP 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
Ms. 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 Mr. Risto Saarikivi, who is focusing on waste in more general terms. Mr. Havránek implements the IPCC methodology and Mr. Risto Saarikivi 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)
Mr. Risto Saarikivi	2nd step of QC procedure, Tier 1 and Tier 2

1.2.3.5.8 Template for documentations of performed QC procedures

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

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

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

1.3 Inventory preparation, and data collection, processing and storage

1.3.1 Activity data collection

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

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

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

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

1.3.2 Data processing and storage

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

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

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

Archiving process scheme

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

The archiving system was updated in 2017. Currently the archive is stored at secure ftp with access only for the inventory coordinator and IT responsible expert. The archiving servers are backed up 3 times on secure servers owned by CHMI.

Material archived by the sector-solving organizations

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

Material archived by the coordinator

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

Structural arrangements of the NIS Archive

The archiving system contains and connects 4 individual units.

1) The archive of the sector-solving organization
    - Functionality and administration are based on contracts with the sector-solving organizations
    - Administration is provided by the sectoral organizations
2) Central storage site for sharing material in the context of NIS
    - Storage site accessible at private ftp
    - Administered by the NIS coordinator
    - Contains working materials for current submissions intended for archiving
3) Central closed archive of the NIS Coordinator
    - Internal central archive, administered by the NIS coordinator
    - Contains all the officially archived materials
    - The content of the archive is stored in duplicate on special media designed for data archiving
    - The archive is located in the seat of the coordinator (CHMI – Prague Komořany)
    - Entries in the archive are always performed as of 30 June of the relevant year of submission and a detailed records of them is also archived.
    - Entries in the archive are also performed after the end of re-submissions or during any other unplanned intervention into the database or text part of already archived submissions.

- Prior to archiving, data for archiving must be checked and authorized by the QA/QC guarantor of the relevant sectoral organization.

4) Central accessible archive

- Mirror image of the central closed archive, available on the internet
- Does not contain sensitive documents, but does contain a complete list of archived files
- Available at http://portal.chmi.cz
- Administered by the NIS coordinator
- Updating corresponds to the entries in the Central closed archive, available a maximum of 3 working days after completion of archiving.

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

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

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

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

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

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

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

On the other hand, in preparing this inventory, somewhat less attention was paid to emissions of the precursors NO_X, CO, NMVOC and SO_2, which are covered primarily by the *Convention on Long-Range Transboundary Air Pollution* (CLRTAP) and are not directly related to the Kyoto Protocol. Their inventories are compiled for the purposes of CLRTAP by NFR (*New Format of Reporting*) by another team at CHMI. Thus emissions of precursors in the GHG inventory (CRF) have been fully taken over and transferred from NFR to CRF. A detailed description of the methodology used to estimate emissions of *precursors* is provided in the *Czech Informative Inventory Report (IIR), Submission under the UNECE/CLRTAP Convention* (submitted annually by 15th 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 95% 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 2016 evaluated with LULUCF (Approach 2)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.A.1 Energy industries - Solid Fuels	CO_2	34.62	32.60	LA, TA
1.A.3.b Transport - Road transportation	CO_2	46.72	45.13	LA,TA
2.C.1 Iron and Steel Production	CO_2	52.05	86.96	LA, TA
1.A.4 Other sectors - Gaseous Fuels	CO_2	57.11	66.42	LA, TA
5.A Solid Waste Disposal on Land	CH_4	61.03	80.32	LA, TA
4.A.1 Forest Land remaining Forest Land	CO_2	64.79	84.77	LA, TA
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	68.36	83.56	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	71.25	70.60	LA, TA
1.A.4 Other sectors - Solid Fuels	CO_2	73.87	56.43	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	76.28	74.24	LA, TA
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	78.52	19.01	LA, TA
3.A Enteric Fermentation	CH_4	80.76	90.80	LA, TA
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	82.93	92.08	LA
1.A.1 Energy industries - Gaseous Fuels	CO_2	84.93	82.21	LA, TA
2.A.1 Cement Production	CO_2	86.07	98.59	LA
5.D Wastewater treatment and discharge	CH_4	86.96	94.04	LA
1.A.4 Other sectors - Liquid Fuels	CO_2	87.81	86.12	LA, TA
5.B Biological treatment of solid waste	CH_4	88.62	88.09	LA, TA
3.B Manure Management	N_2O	89.39	96.96	LA
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	90.10	99.98	LA
1.B.2.b Natural Gas	CH_4	90.76	97.95	LA
5.B Biological treatment of solid waste	N_2O	99.44	77.38	TA
4.G Harvested wood products	CO_2	93.40	89.11	TA
1.A.4 Other sectors - Solid Fuels	CH_4	95.36	89.90	TA

Tab. 1-11 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2016 evaluated without LULUCF (Approach 2)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.A.1 Energy industries - Solid Fuels	CO_2	36.68	33.60	LA, TA
1.A.3.b Transport - Road transportation	CO_2	49.50	46.53	LA, TA
2.C.1 Iron and Steel Production	CO_2	55.15	91.57	LA
1.A.4 Other sectors - Gaseous Fuels	CO_2	60.51	68.66	LA, TA
5.A Solid Waste Disposal on Land	CH_4	64.67	83.06	LA, TA
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	68.45	87.79	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	71.51	72.98	LA, TA
1.A.4 Other sectors - Solid Fuels	CO_2	74.28	58.31	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	76.84	76.79	LA,TA
5.B Biological treatment of solid waste	N_2O	76.89	80.03	LA, TA
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	79.26	19.79	LA, TA
3.A Enteric Fermentation	CH_4	81.63	89.93	LA, TA
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	83.93	99.19	LA
1.A.1 Energy industries - Gaseous Fuels	CO_2	86.05	85.01	LA, TA
2.A.1 Cement Production	CO_2	87.25	84.57	LA
5.D Wastewater treatment and discharge	CH_4	88.20	86.85	LA
1.A.4 Other sectors - Liquid Fuels	CO_2	89.10	86.42	LA, TA
5.B Biological treatment of solid waste	CH_4	89.96	88.96	LA, TA
3.B Manure Management	N_2O	90.77	90.32	LA
1.A.4 Other sectors - Solid Fuels	CH_4	95.67	90.75	TA

Tab. 1-12 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2016 evaluated with LULUCF (Approach 1)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.A.1 Energy industries - Solid Fuels	CO_2	36.44	29.79	LA,TA
1.A.3.b Transport - Road transportation	CO_2	49.17	41.24	LA, TA
1.A.4 Other sectors - Gaseous Fuels	CO_2	54.56	68.07	LA, TA
2.C.1 Iron and Steel Production	CO_2	59.81	59.12	LA, TA
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	63.61	86.55	LA, TA
4.A.1 Forest Land remaining Forest Land	CO_2	66.62	82.05	LA, TA
1.A.4 Other sectors - Solid Fuels	CO_2	69.38	51.05	LA, TA
5.B Biological treatment of solid waste	N_2O	71.82	74.41	LA, TA
5.A Solid Waste Disposal on Land	CH_4	74.25	77.23	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	76.63	100.00	LA
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	78.98	16.58	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	81.33	80.10	LA, TA
3.A Enteric Fermentation	CH_4	83.46	92.54	LA, TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	85.59	83.80	LA, TA
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	87.58	71.58	LA
2.A.1 Cement Production	CO_2	88.80	85.22	LA, TA
1.A.4 Other sectors - Liquid Fuels	CO_2	89.69	89.05	LA
5.D Wastewater treatment and discharge	CH_4	90.32	89.92	LA
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	90.93	99.96	LA
3.B Manure Management	N_2O	91.53	87.90	LA, TA
3.B Manure Management	CH_4	92.07	96.84	LA
2.B.1 Ammonia Production	CO_2	92.56	91.90	LA, TA
5.B Biological treatment of solid waste	CH_4	93.05	93.11	LA, TA
2.A.2 Lime Production	CO_2	93.51	93.64	LA, TA
1.B.2.b Natural Gas	CH_4	93.92	89.92	LA, TA
1.A.4 Other sectors - Biomass	CH_4	94.33	96.23	LA
4.A.2 Land converted to Forest Land	CO_2	94.69	95.57	LA, TA
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	95.02	100.00	LA
4.G Harvested wood products	CO_2	95.33	95.93	LA, TA
1.A.1 Energy industries - Liquid Fuels	CO_2	95.61	94.17	LA, TA
1.A.3.b Transport - Road transportation	N_2O	95.87	96.53	LA
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	96.34	64.07	TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	96.56	91.32	TA
3.G Liming	CO_2	98.79	94.67	TA
1.A.4 Other sectors - Solid Fuels	CH_4	96.77	95.15	TA

Tab. 1-13 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2016 evaluated without LULUCF (Approach 1)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.A.1 Energy industries - Solid Fuels	CO_2	38.08	30.56	LA,TA
1.A.3.b Transport - Road transportation	CO_2	51.38	42.30	LA,TA
1.A.4 Other sectors - Gaseous Fuels	CO_2	57.01	69.94	LA,TA
2.C.1 Iron and Steel Production	CO_2	62.50	60.73	LA,TA
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	66.47	88.23	LA,TA
1.A.4 Other sectors - Solid Fuels	CO_2	69.35	52.44	LA,TA
5.B Biological treatment of solid waste	N_2O	71.90	75.82	LA,TA
5.A Solid Waste Disposal on Land	CH_4	74.43	78.72	LA,TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	76.92	100.00	LA
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	79.38	17.13	LA,TA
1.B.1.a Coal Mining and Handling	CH_4	81.83	72.91	LA,TA
3.A Enteric Fermentation	CH_4	84.06	81.26	LA,TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	86.29	85.42	LA,TA
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	88.36	83.63	LA,TA
2.A.1 Cement Production	CO_2	89.64	86.88	LA,TA
1.A.4 Other sectors - Liquid Fuels	CO_2	90.57	89.42	LA,TA
5.D Wastewater treatment and discharge	CH_4	91.23	91.08	LA,TA
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	91.86	91.80	LA,TA
3.B Manure Management	N_2O	92.49	92.52	LA,TA
3.B Manure Management	CH_4	93.05	93.84	LA,TA
2.B.1 Ammonia Production	CO_2	93.57	94.43	LA,TA

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
5.B Biological treatment of solid waste	CH_4	94.08	95.01	LA,TA
2.A.2 Lime Production	CO_2	94.56	95.56	LA,TA
1.B.2.b Natural Gas	CH_4	94.99	90.32	LA,TA
1.A.4 Other sectors - Biomass	CH_4	95.42	97.22	LA
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	95.76	100.00	LA
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	96.82	65.84	TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	97.04	93.20	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. 1-11 and Tab. 1-13 that no additional *key category* was identified when the LULUCF categories were not considered.

On the whole, 35 (Approach 1) and 24 (Approach 2) 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. 1-14. Complete tables for key category analysis are presented in Annex 1 of this report.

Tab. 1-14 Figures for key categories assessed

	Approach 1	Approach 2
Key categories (KC) with LULUCF	35	24
KC identified by LA	31	21
KC identified by TA	29	19
KC identified by LA + TA concurrently	22	15
KC identified by only LA	9	6
KC identified by only TA	4	3
Key Categories (KC) without LULUCF:	28	20
KC identified by LA	26	19
KC identified by TA	25	16
KC identified by LA + TA concurrently	23	14
KC identified by only LA	3	5
KC identified by only TA	2	1

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).

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. The procedure is planned in the internal improvement plan of the CHMI for the 2018 (preparation of 2019 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 3.79%. The corresponding uncertainty in trend is 2.30%. For the case without LULUCF the estimated overall uncertainty in level assessment is 3.65% and 2.33% 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 2016. For CO_2, CH_4 and N_2O the base year is 1990; for F-gases the base year is 1995.

Tab. 2-1 GHG emissions from 1990-2016 excl. bunkers [kt CO_2 eq.]

	CO_2[1]	CH_4[3]	N_2O[3]	HFCs	PFCs	NF_3	SF_6	Total emissions[4] excl. LULUCF	Total emissions[4] incl. LULUCF
1990	164227.40	23657.59	9590.58				84.24	199597.37	193034.57
1991	148512.48	22073.04	8170.22				84.08	180785.92	171226.71
1992	144074.22	20711.08	7385.39		NO		85.41	174157.46	163780.20
1993	137962.67	19791.45	6561.71				86.56	166245.21	156228.97
1994	131532.51	18658.51	6509.15				87.66	158452.93	150676.84
1995	131972.06	18234.11	6864.66	36.00	0.01	NO	88.68	158867.50	150666.46
1996	134648.71	18095.43	6684.49	84.20	0.68	NO	98.31	161229.60	152905.84
1997	130849.71	17693.76	6641.18	168.67	1.73	NO	96.10	157040.36	149393.44
1998	125125.66	16987.94	6527.85	214.74	1.66	NO	94.98	150411.78	142779.92
1999	116441.58	16253.40	6392.91	246.48	1.10	NO	95.94	140750.99	132754.69
2000	126896.91	15424.80	6312.25	330.65	4.69	NO	108.40	150160.25	141411.56
2001	126666.37	15184.14	6414.66	423.60	9.75	NO	98.82	149837.35	140769.80
2002	123598.03	14762.71	6161.33	523.03	16.39	NO	121.28	146163.49	137469.17
2003	127048.37	14786.56	5822.50	630.49	8.55	NO	144.69	149381.45	142156.45
2004	127759.33	14359.25	6312.60	707.04	12.81	NO	120.61	150184.08	142553.80
2005	125294.53	14731.87	6135.33	793.11	14.89	NO	111.84	148044.88	140506.82
2006	126380.29	14980.43	5949.39	1053.00	31.09	NO	105.12	149486.88	144052.97
2007	128180.73	14565.38	5965.84	1429.78	29.00	NO	93.79	151173.61	147907.74
2008	122933.87	14672.60	6107.07	1678.77	39.76	NO	88.67	146435.34	140064.37
2009	115255.28	14317.54	5713.19	1753.01	45.44	NO	89.05	138034.77	130249.41
2010	117495.55	14535.65	5500.82	2008.84	48.01	0.15	82.76	140535.27	134533.25
2011	115023.30	14538.52	5686.72	2241.77	8.24	0.59	88.64	138480.32	131242.07
2012	110914.08	14528.99	5603.45	2380.17	6.19	0.89	92.44	134371.95	127306.27
2013	106401.19	13948.17	5587.53	2505.38	4.08	1.41	83.04	129285.77	122926.96
2014	104060.31	13954.58	5825.53	2695.69	3.02	2.37	79.90	127367.58	121060.88
2015	104784.56	14024.75	5861.81	2925.69	1.96	2.15	78.27	128419.12	121887.10
2016	106543.30	13804.46	6092.07	3121.50	1.44	2.15	78.63	130348.69	125011.55
%[2)]	-35.12	-41.65	-36.48	8569.74	16214.85	NA	-6.66	-34.69	-35.24

Note: Global warming potentials (GWPs) used (100 years time horizon): CH_4 = 25; N_2O = 298; SF_6 = 22 800; NF_3 = 17 200; HFCs and PFCs consist of different substances,

	CO_2 [1]	CH_4 [3]	N_2O [3]	HFCs	PFCs	NF_3	SF_6	Total emissions[4] excl. LULUCF	incl. LULUCF
therefore GWPs have to be calculated individually depending on substances									
[1]GHG emissions excluding emissions/removals from LULUCF									
[2] relative to base year									
[3]incl. LULUCF									
[4] incl.indirect emissions									

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 148 000 kt CO_2 eq. and continues fluctuating ever since (see Fig. 2-1). From 2010 to 2016 the total GHG emissions (incl. indirect emissions and incl. LULUCF) decreased by 7.20% or – 9 682.36 kt CO_2 eq. resulting in total emissions of 125 011.55 kt CO_2 eq. The decrease was caused by CO_2, CH_4, PFCs emissions and SF_6 emissions (decreased by 9.32%; 5.03%; 97.00%; 4.99%) despite increase in HFC emissions and N_2O emissions (raised by 55.39%; 10.75%) compared to previous year. The total GHG emissions and removals in 2016 were -35.24% below the base year level including LULUCF and indirect emissions and -34.69%, when excluding LULUCF.

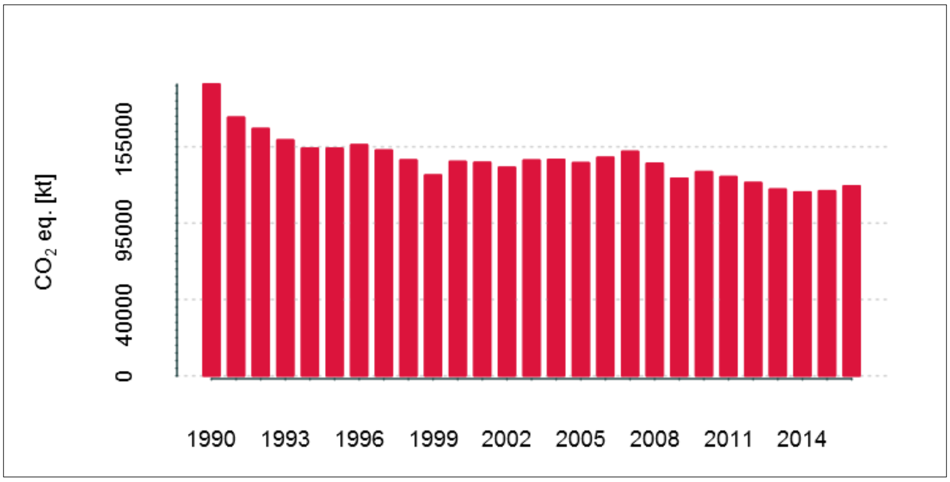

Fig. 2-1 Total trend of GHG emissions, [kt CO_2 eq.]

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

Greenhouse gases emission trend between 2007 and 2009 and supposedly up to present days passed through significant change driven mainly by economic recession. It is noteworthy that in 2016 some of the industrial and energy subsectors reached its lowest amounts of emitted GHGs according to the whole reported time-series.

2.2 Description and interpretation of emission trends by sector

2.2.1 Description and interpretation of emission trends by gas

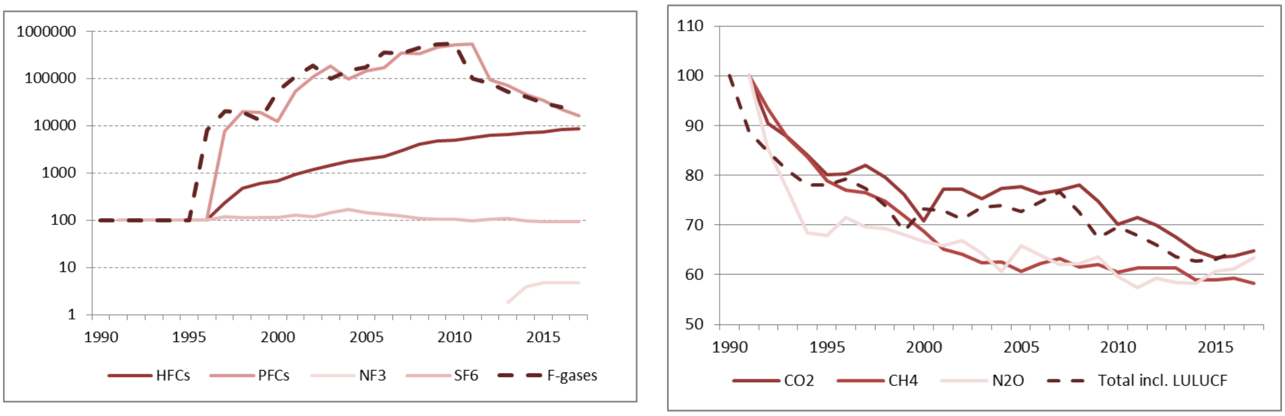

Fig. 2-2 Trend in CO_2, CH_4 and N_2O emissions 1990 - 2016 in index form (base year = 100%) and Trend in HFCs, PFCs (1995 – 2016) and SF_6 (1990 – 2016) actual emissions in index form (base year = 100%)

The major greenhouse gas in the Czech Republic is CO_2, which represents 85.34% of total GHG emissions and removals in 2016, compared to 85.08% in the base year. It is followed by CH_4 (11.06% in 2016, 12.26% in the base year), N_2O (4.88% in 2016, 4.97% in the base year) and F-gases (2.56% in 2016, 0.08% in the base year). The trend of individual GHG emissions relative to emissions in the respective base years is presented in Fig. 2-2.

CO_2

CO_2 emissions have been rapidly decreasing in early 90's, after 1994 the emissions have kept at average of 68% of the amount produced in 1990. Inter-annual decrease in CO_2 emissions (excl. LULUCF, exl. indirect emissions) from 2010 to 2016 by 9.32% results the total decrease of 35.12% from 1990 to 2016. Quoting in absolute figures, CO_2 emissions and removals decreased from 157 580.43 to 101 145.88 kt CO_2 in the period from 1990 to 2016, mainly due to lower emissions from the 1 Energy category (mainly 1.A.2 Manufacturing Industries & Construction, 1.A.4.a Commercial/Institutional and 1.A.4.b Residential).

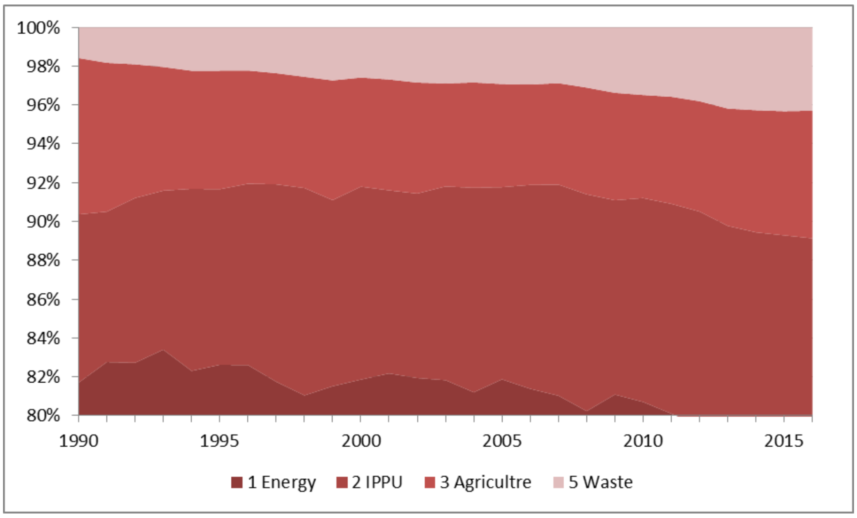

Fig. 2-3 Percentual share of GHGs (Y-axis begins at 80% - part of CO_2 share is hidden)

The main source of CO_2 emissions is fossil fuel combustion; within the 1.A Fuel Combustion category, 1.A.1 Energy Industry and 1.A.4 Other sectors are the most important. CO_2 emissions increased remarkably between 1990 and 2016 from the 1.A.3 Transport category from 7 031.87 to 18 027.59 kt CO_2 eq.

CH_4

CH_4 emissions share decreased almost steadily during the period from 1990 to 2004, from 2004 methane fluctuated around 60% of its base year emissions. In 2016 CH_4 emissions were 41.65% below the base year level (incl. LULUCF), mainly due to lower contribution of 1.B Fugitive Emissions from Fuels and emissions from 3 Agriculture and despite increase from the 5 Waste category. The main sources of CH_4 emissions are 1.B Fugitive Emissions from Fuels (solid fuel), 3 Agriculture (3.A Enteric Fermentation and 3.B Manure Management) and 5 Waste (5.A Solid Waste Disposal on Land and 5.D Wastewater Treatment and Discharge).

N_2O

N_2O emissions strongly decreased from 1990 to 1994 by 32.13% over this period and then shows slow decreasing trend with inter-annual fluctuation. N_2O emissions decreased between 1990 and 2016 from 9 590.58 to 6092.07 kt CO_2 eq (incl.LULUCF). In 2016 N_2O emissions were 36.48% below the base year level, mainly due to lower emissions from 3 Agriculture and 2.B Chemical Industry and despite increase from the 1.A.3 Transport category.

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

HFCs

HFCs actual emissions increased remarkably between 1995 and 2016 from 36.00 to 3 121.50 kt CO_2 eq. Emissions of HFCs have been rapidly increasing since the base year 1995. In 2016, HFCs emissions were more than 87-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 2016 from 0.01 to 1.44 kt CO_2 eq. In 2016, PFCs emissions are over 163 times higher than in the base year 1995. HFCs and PFCs have not been imported and used before 1995.

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

SF_6

SF_6 actual emissions in 1995 accounted for 88.68 kt CO_2 eq. Between 1995 and 2016 they inter-annually fluctuated with maximum of 144.69 kt CO_2 eq. In 2016 SF_6 reached amount of 78.63 kt, the level was 11.33% lower than the base year (1995).

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

NF_3

With the technological progress a new gas is used since 2010 in semiconductor manufacturing. NF_3 is a gas, used mainly for manufacturing of LCD displays, solar panels and etching semiconductors. Base year for this gas is 1995. In 2016 the emissions of NF_3 equalled to 2.15 kt CO_2 eq.

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 2016:

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

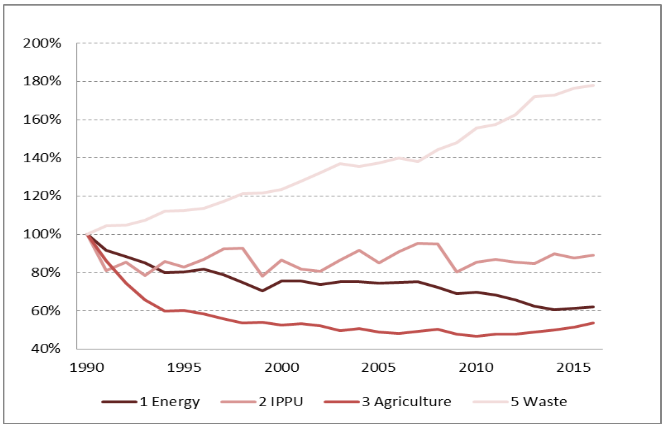

Fig. 2-4 Emission trends in 1990-2016 by categories in index form (base year = 100)

The dominant category is the 1 Energy sector, which caused for 76.93% of total GHG emissions in 2016 (80.83% in 1990) excluding LULUCF and indirect emissions, followed by the categories 2 Industrial Processes and Product Use and 3 Agriculture, which caused for 11.68% and 6.54% of total GHG emissions in 2016 (8.57% and 7.97% in 1990, resp.), 5 Waste category covered 4.27% and 4 LULUCF category removed 5 337.14 kt CO_2 eq. which represents share of 4.09% of all GHG emissions.

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

Tab. 2-2 Summary of GHG emissions by category 1990-2016 [kt CO_2 eq.]

	1 Energy	2 IPPU	3 Agriculture	4 LULUCF	5 Waste
1990	161339.98	17113.01	15898.12	-6562.80	3124.51
1991	147957.10	13847.99	13702.88	-9559.21	3266.79
1992	142438.58	14609.67	11859.32	-10377.26	3275.76
1993	137047.96	13451.41	10465.88	-10016.24	3356.73
1994	128983.49	14690.24	9530.55	-7776.09	3503.45
1995	129812.10	14211.15	9588.19	-8201.04	3510.88
1996	131766.17	14899.73	9296.98	-8323.76	3549.21
1997	126985.97	15797.67	8889.20	-7646.93	3665.98
1998	120645.43	15899.75	8524.23	-7631.86	3792.03
1999	113594.51	13354.90	8595.05	-7996.29	3806.09
2000	121973.32	14804.42	8371.40	-8748.69	3853.46
2001	122217.03	14017.60	8493.33	-9067.55	3993.32
2002	118898.93	13782.21	8293.06	-8694.32	4126.98
2003	121382.55	14801.58	7866.08	-7225.01	4285.11
2004	121141.48	15712.44	8089.63	-7630.27	4234.83
2005	120346.04	14549.02	7803.15	-7538.05	4294.58
2006	120773.00	15575.84	7670.18	-5433.92	4371.05
2007	121647.69	16320.09	7843.31	-3265.87	4314.32
2008	116670.55	16236.68	7991.66	-6370.97	4511.55
2009	111154.39	13719.72	7583.63	-7785.37	4621.05
2010	112645.46	14653.08	7411.91	-6002.02	4861.48
2011	110177.11	14858.85	7585.63	-7238.25	4917.13
2012	106159.49	14654.13	7581.34	-7065.68	5077.39
2013	100847.75	14497.67	7764.78	-6358.82	5373.05
2014	97861.37	15345.08	7958.76	-6306.71	5401.69
2015	98957.27	14993.33	8158.20	-6532.02	5511.73
2016	100280.60	15221.74	8519.68	-5337.14	5561.26
[1]%	1.35%	1.49%	4.54%	-18.95%	0.92%
[2]%	-37.85%	-11.05%	-46.41%	-18.68%	77.99%

[1] Difference relative to previous year

[2] Difference relative to base year

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

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2005	2010	2015	2016
Total (net emissions)	190912.83	148921.27	140253.91	139454.73	133569.91	121088.50	124246.14
1. Energy	**161339.98**	**129812.10**	**121973.32**	**120346.04**	**112645.46**	**98957.27**	**100280.60**
A. Fuel combustion (sectoral approach)	149478.48	120507.09	114847.26	113936.92	106853.95	94569.51	96249.72
1. Energy industries	56915.91	61850.19	62061.93	63165.64	62123.38	53678.15	54449.09
2. Manufacturing industries and construction	51234.04	26192.98	23425.60	18844.61	12089.43	9700.31	9396.92
3. Transport	7284.03	9354.55	11932.42	17106.65	17007.86	17744.33	18449.82
4. Other sectors	34044.50	23109.37	17247.37	14546.55	15304.13	13065.91	13546.23
5. Other	NO	NO	179.95	273.47	329.14	380.81	407.66
B. Fugitive emissions from fuels	11861.51	9305.01	7126.06	6409.12	5791.51	4387.76	4030.88
1. Solid fuels	10779.39	8468.06	6249.66	5513.41	4894.36	3774.33	3420.64
2. Oil and natural gas and other emissions from energy production	1082.12	836.95	876.40	895.71	897.15	613.43	610.25
2. Industrial Processes	**17113.01**	**14211.15**	**14804.42**	**14549.02**	**14653.08**	**14993.33**	**15221.74**
A. Mineral industry	4082.45	3019.09	3633.37	3345.75	3048.42	2575.79	2816.07
B. Chemical industry	2944.23	2808.20	2937.08	2837.88	2371.07	2070.59	1527.23
C. Metal industry	9670.32	7949.20	7435.43	7103.10	6752.62	6975.84	7311.48
D. Non-energy products from fuels and solvent use	125.56	103.75	148.60	136.23	117.72	139.55	139.73
E. Electronic industry	NO,NE	NO,NE	11.17	6.64	41.93	5.32	6.39
F. Product uses as ODS substitutes	NO	36.01	332.75	802.49	2016.65	2927.20	3122.53
G. Other product manufacture and use	290.46	294.90	306.04	316.93	304.69	299.04	298.31
3. Agriculture	**15898.12**	**9588.19**	**8371.40**	**7803.15**	**7411.91**	**8158.20**	**8519.68**
A. Enteric fermentation	5754.89	3588.22	3048.32	2848.43	2720.02	2895.96	2957.46
B. Manure management	3315.36	2304.97	2041.56	1836.06	1581.17	1554.11	1580.18
D. Agricultural soils	5531.71	3474.46	3120.69	2979.97	2937.48	3356.62	3603.26
G. Liming	1187.63	111.26	113.21	64.51	61.97	164.41	168.01
H. Urea application	108.53	109.27	47.61	74.17	111.27	187.10	210.76
4. Land use, land-use change and forestry	**-6562.80**	**-8201.04**	**-8748.69**	**-7538.05**	**-6002.02**	**-6532.02**	**-5337.14**
A. Forest land	-5076.02	-7359.82	-7451.99	-6130.21	-4237.45	-5967.69	-4519.32
B. Cropland	213.22	234.25	224.98	244.82	172.20	131.92	124.36
C. Grassland	-96.83	-344.25	-404.90	-404.50	-460.66	-358.28	-661.65
D. Wetlands	21.48	9.08	26.34	21.17	34.11	25.09	25.03
E. Settlements	86.31	91.80	133.42	175.75	136.24	95.81	124.06
F. Other land	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
G. Harvested wood products	-1712.97	-833.55	-1277.74	-1446.16	-1647.58	-460.00	-430.67
5. Waste	**3124.51**	**3510.88**	**3853.46**	**4294.58**	**4861.48**	**5511.73**	**5561.26**
A. Solid waste disposal	1979.27	2404.98	2798.38	3058.11	3462.42	3653.77	3671.11
B. Biological treatment of solid waste	NE,IE	NE,IE	NE,IE	60.90	202.65	678.57	711.36
C. Incineration and open burning of waste	21.25	64.92	57.88	124.12	127.29	121.59	115.99
D. Waste water treatment and discharge	1123.99	1040.98	997.20	1051.44	1069.12	1057.79	1062.80
Memo items:							
International bunkers	528.22	562.83	593.83	978.94	965.41	895.14	964.06
Aviation	528.22	562.83	593.83	978.94	965.41	895.14	964.06
CO_2 emissions from biomass	6445.39	5787.22	6652.88	8667.39	12342.53	16193.69	16461.81
Long-term storage of C in waste disposal sites	15558.30	19691.70	24677.97	30258.81	36422.71	41586.48	42554.38
Indirect N_2O	2111.77	728.70	554.23	526.19	427.33	344.49	366.48
Indirect CO_2	2121.74	1745.19	1157.65	1052.09	963.33	798.60	765.41
Total CO_2 equivalent emissions without LULUCF	**197475.63**	**157122.31**	**149002.60**	**146992.78**	**139571.94**	**127620.52**	**129583.28**
Total CO_2 equivalent emissions with LULUCF	**190912.83**	**148921.27**	**140253.91**	**139454.73**	**133569.91**	**121088.50**	**124246.14**
Total CO_2 equivalent emissions, including indirect CO_2, without LULUCF	**199597.37**	**158867.50**	**150160.25**	**148044.88**	**140535.27**	**128419.12**	**130348.69**
Total CO_2 equivalent emissions, including indirect CO_2, with LULUCF	**193034.57**	**150666.46**	**141411.56**	**140506.82**	**134533.25**	**121887.10**	**125011.55**

Energy (IPCC Category 1)

The trend for GHG emissions from 1 Energy category shows decreasing trend of emissions. They strongly decreased from 1990 to 1994 and then fluctuated by 2002. After 2002 they stayed relatively stable by 2007. In the period 2002 – 2007 emissions kept around 120 000 kt CO_2 eq. Total decrease between 1990 and 2016 is 37.85%. Between 2015 to 2016 emissions from category 1 Energy slightly increased by 1.34%.

From the total 100 280.60 kt CO_2 eq. in 2016 95.98% comes from 1.A Fuel Combustion, the rest are 1.B Fugitive Emissions from Fuels (mainly Solid Fuels). 1.B Fugitive Emissions from Fuels is the largest source for CH_4, which represented 28.03% of all CH_4 emissions in 2016. 35.15% of all CH_4 emissions in 2016 originated from Energy category.

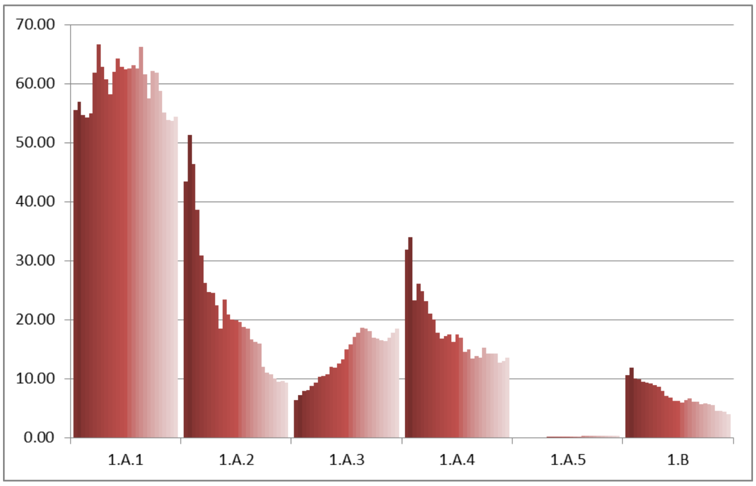

Fig. 2-5 Trends in Energy by categories 1990-2016 (Tg CO_2 eq.)

CO_2 emissions from fossil fuels combustion (category 1.A Energy) are the main source in Czech Republic's inventory with a share of 89.83% in national CO_2 emissions (excl. LULUCF). CO_2 from category 1 Energy contributes for 72.65% to total GHG emissions, CH_4 for 0.04% and N_2O for 0.007% in 2016.

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 2016. 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 2016 emissions from this category decreased by 11.05%. In 2016 emissions amounted for 15 221.74 kt CO_2 eq.

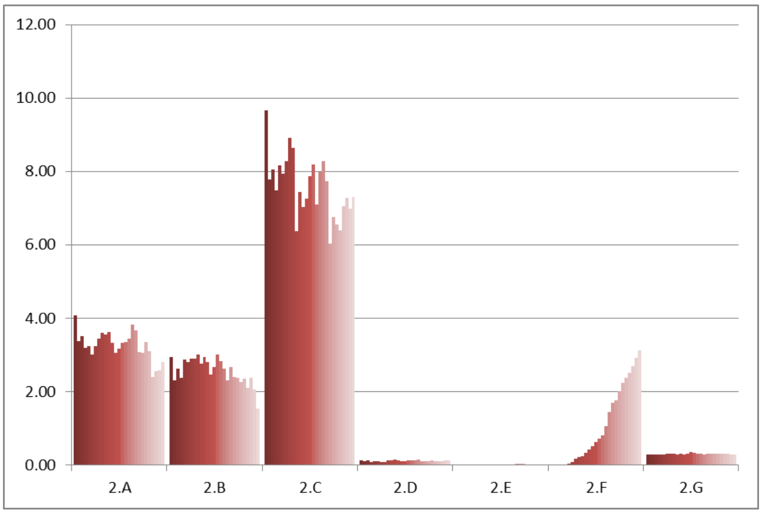

Fig. 2-6 Trends in IPPU by categories 1990-2016 (Tg CO_2 eq.)

The main categories in the 2 Industrial Processes and Product Use category are 2.C Metal Industry (48.03%), 2.F Product Uses as ODS substitutes (20.51%), 2.A Mineral Industry (18.50%) and 2.B Chemical Industry (10.03%) of the sectoral emissions in 2016 (Fig. 2-6).

The most important GHG of the 2 Industrial Processes and Product Use category was CO_2 with 75.39% of sectoral emissions, followed by F-gases (21.05%).

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 53.38% below the base year level.

Agriculture amounted 8 519.68kt CO_2 eq. in 2016 which corresponds to 6.54% of national total emissions (excluding LULUCF). The most important sub-category 3.D Agricultural Soils (N_2O emissions) contributed by 42.29% to sectoral total in 2016, followed by the 3.A Enteric Fermentation (CH_4 emissions, 34.71%).

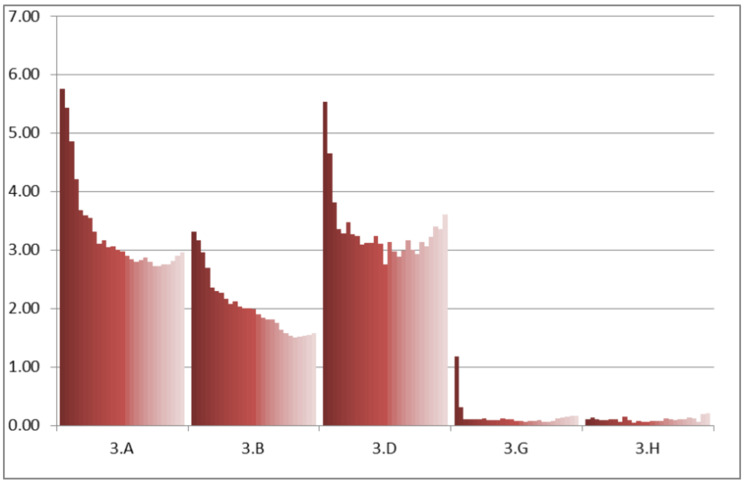

Fig. 2-7 Trends in Agriculture by categories 1990-2016 (Tg CO_2 eq.)

3 Agriculture is the largest source for N_2O and second largest source for CH_4 emissions (73.25% of total emissions of N_2O and 26.86% of total emissions of CH_4, excluding LULUCF). However it's emission trend steadily decreases over the whole observed period.

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

GHG removals from the 4 Land Use, Land-Use Change and Forestry category vary through the whole time series with minimum of -10 377.26 kt CO_2 eq. in 1992 and maximum -3 265.87 kt CO_2 eq. in 2007. In 2016 removals were by 18.68% lower than the base year level.

Emissions and removals amounted to -5 337.14 kt CO_2 eq. in 2016, which corresponds to 4.27% of total national emissions. Emissions and removals are calculated from all categories and in line with IPCC 2006 Gl. (IPCC 2006).

LULUCF category is the largest sink for CO_2. Net CO_2 removals from this category amounted to -5 337.14 kt CO_2 eq. in 2016. CH_4 emissions amounted to 32.75 kt CO_2 eq., N_2O to 27.4 kt CO_2 eq. Trends of the sub-categories in LULUCF sector are presented in Fig. 2-8.

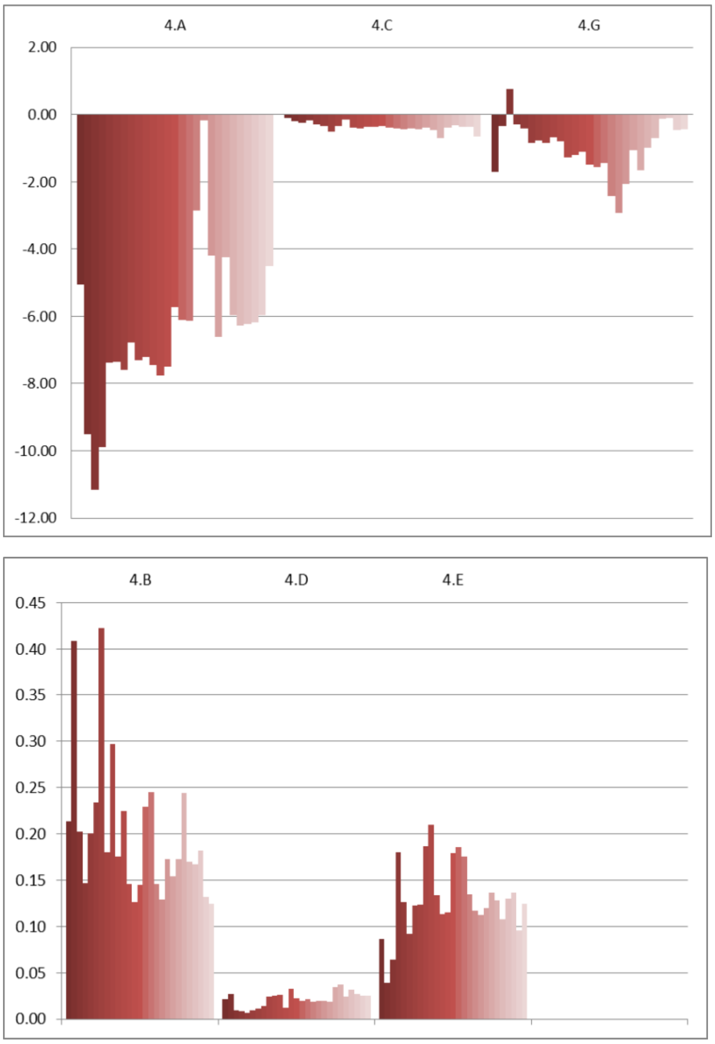

Fig. 2-8 Trends in LULUCF by separate source and sink categories 1990 – 2016 (Tg CO_2 eq.)

Waste (IPCC Category 5)

GHG emissions from category 5 Waste substantially increased during the whole period. In 2016 emissions amounted for 5 561.26 kt CO_2 eq., which is 77.99% above the base year level. The increase of emissions is mainly due to higher emissions of CH_4 from 5.A Solid Waste Disposal and due higher emissions in 5.C Incineration and open burning of waste. The share of category 5 Waste in total emissions was 4.27% in 2016.

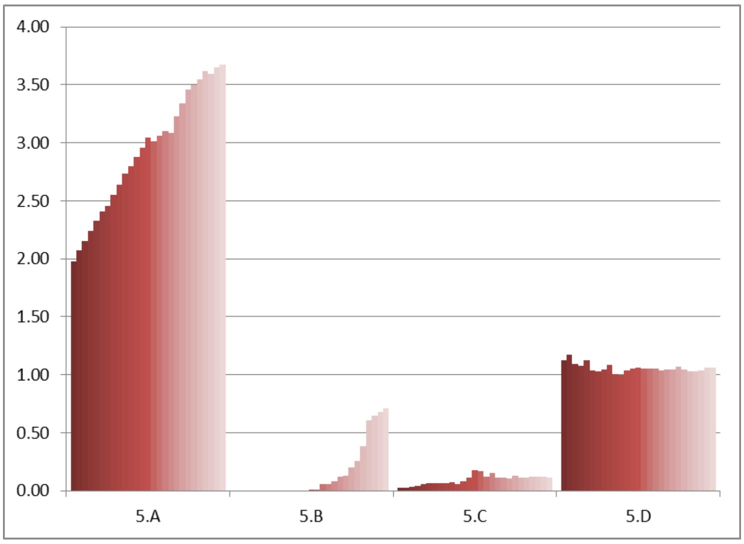

Fig. 2-9 Trends in Waste by categories 1990-2016 (Tg CO_2 eq.)

The main source is solid 5.A Solid Waste Disposal, which accounted for 66.01% of sectoral emissions in 2016, followed by 5.D Wastewater Treatment and Discharge (19.11%) and 5.B Biological treatment of solid waste (12.79%). Trends of the separate sub-categories in Waste sector can be observed on Fig. 2-9.

93.22% of all emissions from Waste category are CH_4 emissions; CO_2 contributes by 2.04% and N_2O by 4.74%.

2.2.2 Description and interpretation of emission trends of indirect greenhouse gases and SO_2

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

2.2.3 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 2016. There removals are enhanced by estimates for Afforestation/Reforestation activities and by the contribution from changes in carbon pools associated with Harvested Wood Products (HWP). On the contrary, Deforestation represents emissions for all years (Tab. 2-4).

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

Year	Article 3.3 activities		Article 3.4 activities		HWP
	Afforestration and Reforestration	Deforestation	Forest Management	Other Art. 3.4 activities	HWP contribution
2013	-498.47	234.1843	-5890.85	NA	-126.91
2014	-553.76	231.1817	-5787.90	NA	-96.16
2015	-593.74	179.8656	-5918.15	NA	-460.00
2016	-635.53	218.9199	-4435.69		-430.67
Total*	-2281.50	864.15	-22032.58	NA	-1113.75

**) 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 2017 CzSO carried on extensive updates of activity data which are resulting in increased amount of recalculations appeared in this submission. Especially in April 2017, CzSO continued to perform extensive updates of the net caloric values of some Solid Fuels, resulting in recalculations in most categories. This submission is the first one to include these updates.

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

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

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

3.1.1 Key categories in sector 1 Energy

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

On the whole, 16 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 2016.

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.b also was identified as a key category by the latest assessment. 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 (2016)

Category	Gas	KC A1	KC A2	KC A1[1]	KC A1[2]	KC A2[1]	KC A2[2]	% of total GHG[1]	% of total GHG [2]
1.A.1 Energy industries - Solid Fuels	CO_2	LA,TA	LA, TA	yes	yes	yes	yes	40.50	38.84
1.A.3.b Transport - Road transportation	CO_2	LA,TA	LA,TA	yes	yes	yes	yes	14.15	13.57
1.A.4 Other sectors - Gaseous Fuels	CO_2	LA,TA	LA, TA	yes	yes	yes	yes	5.99	5.74
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	LA,TA	LA, TA	yes	yes	yes	yes	4.22	4.05
1.A.4 Other sectors - Solid Fuels	CO_2	LA,TA	LA, TA	yes	yes	yes	yes	3.06	2.94
1.B.1.a Coal Mining and Handling	CH_4	LA,TA	LA, TA	yes	yes	yes	yes	2.61	2.50
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	LA,TA	LA, TA	yes	yes	yes	yes	2.62	2.51
1.A.1 Energy industries - Gaseous Fuels	CO_2	LA,TA	LA, TA	yes	yes	yes	yes	2.37	2.27
1.A.4 Other sectors - Liquid Fuels	CO_2	LA	LA, TA	yes	yes	yes	yes	0.98	0.94
1.B.2.b Natural Gas	CH_4	LA, TA	LA	yes	yes	yes		0.46	0.44
1.A.4 Other sectors - Solid Fuels	CH_4	TA	TA	yes	yes	yes	yes	0.24	0.23
1.A.4 Other sectors - Biomass	CH_4	LA		yes	yes			0.46	0.44
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	LA		yes	yes			0.36	0.35
1.A.1 Energy industries - Liquid Fuels	CO_2	LA, TA		yes	yes			0.31	0.30
1.A.3.b Transport - Road transportation	N_2O	LA		yes	yes			0.29	0.28
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	TA		yes	yes			0.25	0.24

KC: key category
[1] *including LULUCF*
[2] *excluding LULUCF*

3.1.2 Emissions Trends

CO_2 emissions from the 1.A sector decreased by 35.7% from 147 Mt CO_2 in 1990 to 94 Mt CO_2 in 2016. Furthermore CO_2 emissions from the 1.B sector decreased by 64.8% from 458 kt in 1990 to 161 kt in

2016, as well as CH_4 emissions from 1.B sectors decreased by 66.1% from 456 kt in 1990 to 155 kt in 2016. Fig. 3-1 indicates overall trend in CO_2 and CH_4 emissions in the whole time series for both sectors. Furthermore Tab. 3-2 provides data for trends in 1 Energy for each gas reported in sector.

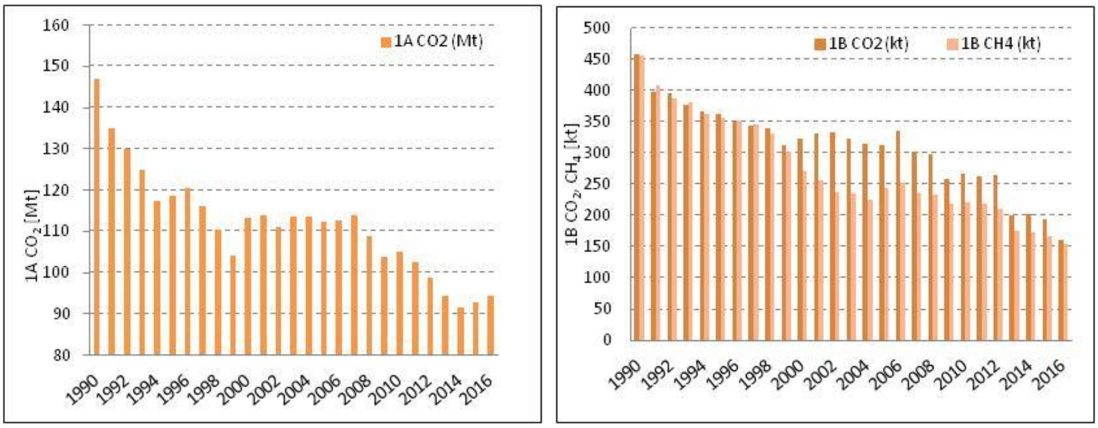

Fig. 3-1 Trend total CO_2 (Sectoral Approach) in 1.A and trend of CO_2 and CH_4 from 1.B sector in period 1990 – 2016

Tab. 3-2 Emissions of greenhouse gases and their trend from 1990 – 2016 from IPCC Category 1 Energy

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]
1990	147 264	529.71	2.80
1991	135 272	476.66	2.58
1992	130 476	447.69	2.59
1993	125 325	438.76	2.53
1994	117 845	415.45	2.53
1995	118 903	405.53	2.59
1996	120 916	401.19	2.75
1997	116 550	391.30	2.75
1998	110 606	368.62	2.76
1999	104 367	335.21	2.84
2000	113 621	306.14	2.35
2001	114 213	291.66	2.39
2002	111 359	272.66	2.43
2003	113 871	269.96	2.56
2004	113 866	259.53	2.64
2005	112 649	275.88	2.72
2006	112 858	285.28	2.78
2007	114 116	267.92	2.89
2008	109 200	266.44	2.86
2009	104 021	253.65	2.80
2010	105 389	258.15	2.77
2011	102 929	257.17	2.77
2012	99 113	249.48	2.72
2013	94 688	214.55	2.67
2014	91 784	210.88	2.70
2015	92 957	206.85	2.79
2016	94 576	194.09	2.86
Trend 1990/2016	-36%	-63%	2%

3.1.2.1 Emission trends by subcategories

The individual subsectors have different contributions to trends in emissions. Fig. 3-2 illustrates the trends in emissions on the example of CO_2 emissions and the share of CO_2 emissions in different subsectors in 2016.

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

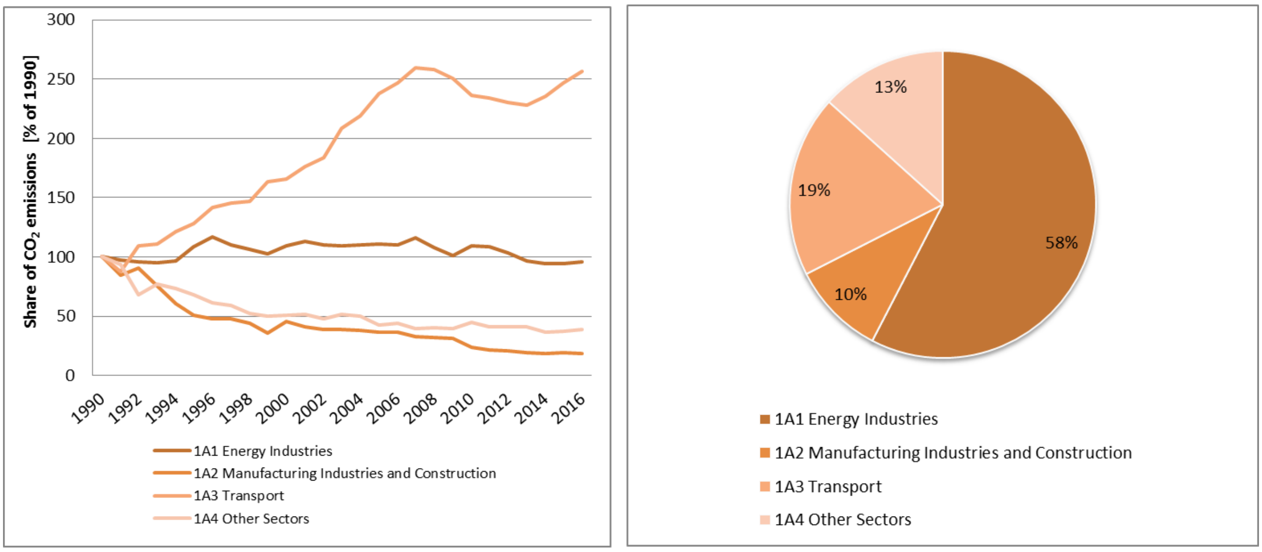

Fig. 3-2 Share and development of CO_2 emissions from 1990 - 2016 in individual sub-sectors; share of CO_2 emissions in individual subsectors in 2016 [kt]

2014 and 2016 is apparent slight increase by 1.9 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 32.2 Tg CO_2 in 1990 to 9.3 and 12.5 Tg CO_2 in 2016, respectively.

The fugitive emissions from Solid fuels also indicate substantial decrease in the whole time-series, i.e. 65.7% for CO_2 emission and 68.4% for CH_4 emissions. Fugitive CH_4 emissions from Oil and Natural Gas also indicate decrease for 43.9% in the time series. Fugitive CO_2 emissions from Oil and Natural Gas indicates increase, however these emissions are of minor importance in the whole submission.

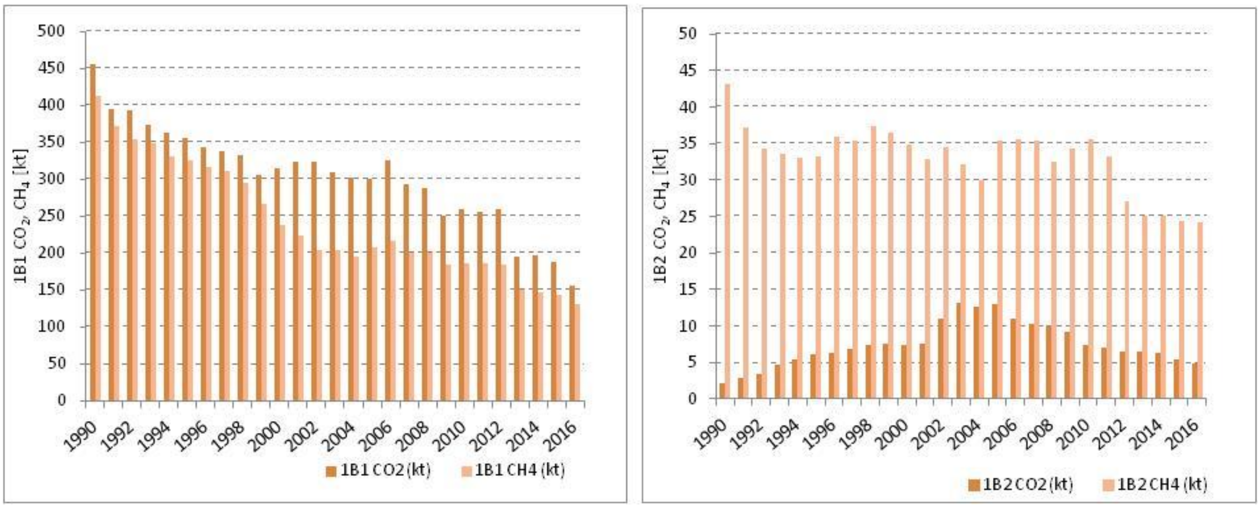

Fig. 3-3 CO_2 and CH_4 trend from the sector Fugitive Emissions from Solid Fuels and from from the sector Fugitive Emissions from Oil and Natural Gas

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

Tab. 3-3 Total GHG emissions in [kt CO_2 eq.] from 1990 – 2016 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	161 340	149 478	56 916	51 234	7 284	34 044	NO	11 862	10 779	1 082
1991	147 957	137 329	55 540	43 482	6 390	31 916	NO	10 628	9 698	931
1992	142 439	132 349	54 705	46 354	7 973	23 317	NO	10 090	9 227	863
1993	137 048	127 115	54 321	38 583	8 076	26 134	NO	9 933	9 088	845
1994	128 983	119 540	54 969	30 860	8 812	24 899	NO	9 444	8 612	832
1995	129 812	120 507	61 850	26 193	9 355	23 109	NO	9 305	8 468	837
1996	131 766	122 612	66 578	24 657	10 366	21 011	NO	9 155	8 250	905
1997	127 153	118 161	62 867	24 608	10 602	20 085	NO	8 991	8 099	892
1998	120 645	112 009	60 726	22 509	10 747	17 854	173	8 636	7 696	940
1999	113 595	105 714	58 225	18 507	11 986	16 829	167	7 881	6 959	922
2000	121 973	114 847	62 062	23 426	11 932	17 247	180	7 126	6 250	876
2001	122 217	115 465	64 245	20 879	12 662	17 517	161	6 752	5 925	828
2002	118 899	112 594	62 800	19 999	13 244	16 311	242	6 305	5 431	873
2003	121 383	115 168	62 449	19 937	15 018	17 519	245	6 215	5 399	816
2004	121 141	115 194	62 568	19 569	15 773	17 010	273	5 947	5 186	762
2005	120 358	113 949	63 166	18 856	17 107	14 547	273	6 409	5 513	896
2006	120 817	114 182	62 615	18 588	17 765	14 956	259	6 635	5 735	900
2007	121 677	115 493	66 264	16 688	18 691	13 503	347	6 183	5 287	897
2008	116 714	110 577	61 533	16 240	18 564	13 863	377	6 136	5 312	825
2009	111 198	105 469	57 462	15 988	18 019	13 636	364	5 729	4 861	868
2010	112 667	106 876	62 123	12 111	17 008	15 304	329	5 792	4 894	897
2011	110 183	104 426	61 882	11 105	16 823	14 229	387	5 756	4 917	839
2012	106 160	100 620	58 748	10 768	16 552	14 236	316	5 540	4 856	684
2013	100 848	96 277	55 162	10 050	16 430	14 326	309	4 571	3 937	634
2014	97 862	93 348	53 780	9 525	16 967	12 757	319	4 514	3 882	632
2015	98 958	94 571	53 678	9 701	17 744	13 066	381	4 388	3 774	613
2016	100 281	96 250	54 449	9 397	18 450	13 546	408	4 031	3 421	610
Total Trend 1990-2016	**-38%**	**-36%**	**-4.0%**	**-82%**	**153%**	**-60%**	**136%[1)]**	**-66%**	**-68%**	**-44%**

[1)] *Trend 1998-2016*

3.2 Fuel combustion activities (CRF 1.A)

3.2.1 Comparison of the sectoral approach with the reference approach

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

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

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

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

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

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

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

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

Tab. 3-6 and

Year	Type of fossil fuels	Apparent Consumption [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]
1990	Liquid Fuels	358.6	71.8	300.0	286.8	4.6
	Solid Fuels	1 315.1	86.7	1 179.2	1 228.4	-4.0
	Gaseous Fuels	219.9		205.4	219.9	-6.6
	Other Fuels				0.3	
	Total	**1 893.5**	**158.5**	**1 684.6**	**1 735.1**	**-2.9**
2000	Liquid Fuels	311.4	87.6	238.6	223.8	6.6
	Solid Fuels	901.8	66.3	822.7	835.5	-1.5
	Gaseous Fuels	314.5		305.1	314.5	-3.0
	Other Fuels				1.3	
	Total	**1 527.7**	**153.9**	**1 366.3**	**1 375.1**	**-0.6**
2005	Liquid Fuels	387.5	111.4	292.2	276.2	5.8
	Solid Fuels	847.1	75.5	762.9	771.6	-1.1
	Gaseous Fuels	323.0		318.9	323.0	-1.3
	Other Fuels				5.69	
	Total	**1 557.6**	**186.8**	**1 374.0**	**1 376.5**	**-0.2**
2010	Liquid Fuels	369.9	99.6	277.6	270.3	2.7
	Solid Fuels	781.1	71.5	702.0	709.6	-1.1
	Gaseous Fuels	338.5	3.8	309.8	334.7	-7.5
	Other Fuels				5.9	

Year	Type of fossil fuels	Apparent Consumption [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]
	Total	**1 489.5**	**174.9**	**1 289.4**	**1 320.5**	**-2.4**
2011	Liquid Fuels	358.0	92.6	273.4	265.4	3.0
	Solid Fuels	766.4	70.8	690.7	695.6	-0.7
	Gaseous Fuels	285.7	4.0	282.5	281.7	0.3
	Other Fuels				6.8	
	Total	**1 410.0**	**167.4**	**1 246.6**	**1 249.4**	**-0.2**
2012	Liquid Fuels	353.2	95.2	267.9	258.0	3.8
	Solid Fuels	719.7	71.0	658.6	648.8	1.5
	Gaseous Fuels	287.6	4.1	278.3	283.5	-1.8
	Other Fuels				5.8	
	Total	**1 360.5**	**170.2**	**1 204.8**	**1 196.1**	**0.7**
2013	Liquid Fuels	340.9	90.1	258.2	250.8	3.0
	Solid Fuels	719.2	73.7	619.9	645.5	-4.0
	Gaseous Fuels	291.4	3.9	282.8	287.6	-1.6
	Other Fuels				4.7	
	Total	**1 351.5**	**167.7**	**1 161.0**	**1 188.5**	**-2.3**
2014	Liquid Fuels	362.3	100.6	271.2	261.7	3.6
	Solid Fuels	664.6	76.6	597.6	588.0	1.6
	Gaseous Fuels	259.4	4.0	250.4	255.4	-2.0
	Other Fuels				5.8	
	Total	**1 286.3**	**181.1**	**1 119.1**	**1 110.9**	**0.7**
2015	Liquid Fuels	354.6	81.9	278.8	272.7	2.2
	Solid Fuels	684.5	75.4	594.9	609.2	-2.3
	Gaseous Fuels	272.0	4.0	263.2	268.0	-1.8
	Other Fuels				7.1	
	Total	**1 311.1**	**161.3**	**1 136.9**	**1 157.0**	**-1.7**
2016	Liquid Fuels	330.9	52.8	278.8	278.1	0.3
	Solid Fuels	683.6	78.3	596.6	605.3	-1.4
	Gaseous Fuels	294.5	4.2	286.5	290.2	-1.3
	Other Fuels				7.8	
	Total	**1309**	**135.3**	**1161.9**	**1181.4**	**-1.7**

Tab. 3-7 are reported values, set by the reference approach for the years 1990, 2000, 2005, 2010, 2011, 2012, 2013, 2014, 2015 and 2016 and a comparison between the reference and sectoral approach for the same years. In Tab. 3-8 is summarized comparison for all time period. In majority of cases relative differences are less than 2%. Differences greater than 2% are mainly caused by statistical differences and distribution losses.

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

Year	Type of fossil fuels	Apparent Consumption [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]
1990	Liquid Fuels	358.6	71.8	300.0	286.8	4.6
	Solid Fuels	1 315.1	86.7	1 179.2	1 228.4	-4.0
	Gaseous Fuels	219.9		205.4	219.9	-6.6
	Other Fuels				0.3	
	Total	**1 893.5**	**158.5**	**1 684.6**	**1 735.1**	**-2.9**
2000	Liquid Fuels	311.4	87.6	238.6	223.8	6.6
	Solid Fuels	901.8	66.3	822.7	835.5	-1.5
	Gaseous Fuels	314.5		305.1	314.5	-3.0
	Other Fuels				1.3	
	Total	**1 527.7**	**153.9**	**1 366.3**	**1 375.1**	**-0.6**
2005	Liquid Fuels	387.5	111.4	292.2	276.2	5.8
	Solid Fuels	847.1	75.5	762.9	771.6	-1.1
	Gaseous Fuels	323.0		318.9	323.0	-1.3
	Other Fuels				5.69	

Year	Type of fossil fuels	Apparent Consumption [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]
	Total	**1 557.6**	**186.8**	**1 374.0**	**1 376.5**	**-0.2**
2010	Liquid Fuels	369.9	99.6	277.6	270.3	2.7
	Solid Fuels	781.1	71.5	702.0	709.6	-1.1
	Gaseous Fuels	338.5	3.8	309.8	334.7	-7.5
	Other Fuels				5.9	
	Total	**1 489.5**	**174.9**	**1 289.4**	**1 320.5**	**-2.4**
2011	Liquid Fuels	358.0	92.6	273.4	265.4	3.0
	Solid Fuels	766.4	70.8	690.7	695.6	-0.7
	Gaseous Fuels	285.7	4.0	282.5	281.7	0.3
	Other Fuels				6.8	
	Total	**1 410.0**	**167.4**	**1 246.6**	**1 249.4**	**-0.2**
2012	Liquid Fuels	353.2	95.2	267.9	258.0	3.8
	Solid Fuels	719.7	71.0	658.6	648.8	1.5
	Gaseous Fuels	287.6	4.1	278.3	283.5	-1.8
	Other Fuels				5.8	
	Total	**1 360.5**	**170.2**	**1 204.8**	**1 196.1**	**0.7**
2013	Liquid Fuels	340.9	90.1	258.2	250.8	3.0
	Solid Fuels	719.2	73.7	619.9	645.5	-4.0
	Gaseous Fuels	291.4	3.9	282.8	287.6	-1.6
	Other Fuels				4.7	
	Total	**1 351.5**	**167.7**	**1 161.0**	**1 188.5**	**-2.3**
2014	Liquid Fuels	362.3	100.6	271.2	261.7	3.6
	Solid Fuels	664.6	76.6	597.6	588.0	1.6
	Gaseous Fuels	259.4	4.0	250.4	255.4	-2.0
	Other Fuels				5.8	
	Total	**1 286.3**	**181.1**	**1 119.1**	**1 110.9**	**0.7**
2015	Liquid Fuels	354.6	81.9	278.8	272.7	2.2
	Solid Fuels	684.5	75.4	594.9	609.2	-2.3
	Gaseous Fuels	272.0	4.0	263.2	268.0	-1.8
	Other Fuels				7.1	
	Total	**1 311.1**	**161.3**	**1 136.9**	**1 157.0**	**-1.7**
2016	Liquid Fuels	330.9	52.8	278.8	278.1	0.3
	Solid Fuels	683.6	78.3	596.6	605.3	-1.4
	Gaseous Fuels	294.5	4.2	286.5	290.2	-1.3
	Other Fuels				7.8	
	Total	**1309**	**135.3**	**1161.9**	**1181.4**	**-1.7**

Tab. 3-6 Activity data in energy units (TJ), used in reference and sectoral approach for basic groups of fossil fuels

Year	Type of fossil fuels	Apparent Consumption [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]
1990	Liquid Fuels	358.6	71.8	300.0	286.8	4.6
	Solid Fuels	1 315.1	86.7	1 179.2	1 228.4	-4.0
	Gaseous Fuels	219.9		205.4	219.9	-6.6
	Other Fuels				0.3	
	Total	**1 893.5**	**158.5**	**1 684.6**	**1 735.1**	**-2.9**
2000	Liquid Fuels	311.4	87.6	238.6	223.8	6.6
	Solid Fuels	901.8	66.3	822.7	835.5	-1.5
	Gaseous Fuels	314.5		305.1	314.5	-3.0
	Other Fuels				1.3	
	Total	**1 527.7**	**153.9**	**1 366.3**	**1 375.1**	**-0.6**
2005	Liquid Fuels	387.5	111.4	292.2	276.2	5.8
	Solid Fuels	847.1	75.5	762.9	771.6	-1.1
	Gaseous Fuels	323.0		318.9	323.0	-1.3
	Other Fuels				5.69	
	Total	**1 557.6**	**186.8**	**1 374.0**	**1 376.5**	**-0.2**
2010	Liquid Fuels	369.9	99.6	277.6	270.3	2.7

Year	Type of fossil fuels	Apparent Consumption [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]
	Solid Fuels	781.1	71.5	702.0	709.6	-1.1
	Gaseous Fuels	338.5	3.8	309.8	334.7	-7.5
	Other Fuels				5.9	
	Total	**1 489.5**	**174.9**	**1 289.4**	**1 320.5**	**-2.4**
2011	Liquid Fuels	358.0	92.6	273.4	265.4	3.0
	Solid Fuels	766.4	70.8	690.7	695.6	-0.7
	Gaseous Fuels	285.7	4.0	282.5	281.7	0.3
	Other Fuels				6.8	
	Total	**1 410.0**	**167.4**	**1 246.6**	**1 249.4**	**-0.2**
2012	Liquid Fuels	353.2	95.2	267.9	258.0	3.8
	Solid Fuels	719.7	71.0	658.6	648.8	1.5
	Gaseous Fuels	287.6	4.1	278.3	283.5	-1.8
	Other Fuels				5.8	
	Total	**1 360.5**	**170.2**	**1 204.8**	**1 196.1**	**0.7**
2013	Liquid Fuels	340.9	90.1	258.2	250.8	3.0
	Solid Fuels	719.2	73.7	619.9	645.5	-4.0
	Gaseous Fuels	291.4	3.9	282.8	287.6	-1.6
	Other Fuels				4.7	
	Total	**1 351.5**	**167.7**	**1 161.0**	**1 188.5**	**-2.3**
2014	Liquid Fuels	362.3	100.6	271.2	261.7	3.6
	Solid Fuels	664.6	76.6	597.6	588.0	1.6
	Gaseous Fuels	259.4	4.0	250.4	255.4	-2.0
	Other Fuels				5.8	
	Total	**1 286.3**	**181.1**	**1 119.1**	**1 110.9**	**0.7**
2015	Liquid Fuels	354.6	81.9	278.8	272.7	2.2
	Solid Fuels	684.5	75.4	594.9	609.2	-2.3
	Gaseous Fuels	272.0	4.0	263.2	268.0	-1.8
	Other Fuels				7.1	
	Total	**1 311.1**	**161.3**	**1 136.9**	**1 157.0**	**-1.7**
2016	Liquid Fuels	330.9	52.8	278.8	278.1	0.3
	Solid Fuels	683.6	78.3	596.6	605.3	-1.4
	Gaseous Fuels	294.5	4.2	286.5	290.2	-1.3
	Other Fuels				7.8	
	Total	**1309**	**135.3**	**1161.9**	**1181.4**	**-1.7**

Tab. 3-7 Results for CO_2 emissions (kt) according to reference approach and comparison with sectoral approach

Year	Type of fossil fuels	Apparent Consumption [kt CO_2]	Carbon excluded [kt CO_2]	RA [kt CO_2]	SA [kt CO_2]	(RA-SA)/SA [%]
1990	Liquid Fuels	26 351	5 392	20 959	22 220	-5.7
	Solid Fuels	127 096	9 280	117 816	113 360	3.9
	Gaseous Fuels	11 990	0	11 990	11 201	7.0
	Other Fuels				24	
	Total	**165 437**	**14 672**	**150 765**	**146 805**	**2.7**
2000	Liquid Fuels	22 667	6 481	16 186	17 296	-6.4
	Solid Fuels	87 187	7 093	80 094	79 108	1.2
	Gaseous Fuels	17 297	0	17 297	16 777	3.1
	Other Fuels				117	
	Total	**127 151**	**13 574**	**113 577**	**113 298**	**0.2**
2005	Liquid Fuels	28 326	8 282	20 044	21 120	-5.1
	Solid Fuels	81 664	7 750	73 914	73 179	1.0
	Gaseous Fuels	17 765	0	17 765	17 535	1.3
	Other Fuels				501	
	Total	**127 755**	**16 032**	**111 723**	**112 335**	**-0.5**
2010	Liquid Fuels	27 082	7 394	19 688	20 039	-1.8
	Solid Fuels	74 951	7 296	67 655	67 445	0.3

Year	Type of fossil fuels	Apparent Consumption [kt CO_2]	Carbon excluded [kt CO_2]	RA [kt CO_2]	SA [kt CO_2]	(RA-SA)/SA [%]
	Gaseous Fuels	18 717	210	18 507	17 126	8.1
	Other Fuels				512	
	Total	**127 755**	**16 032**	**111 723**	**112 335**	**-0.5**
2011	Liquid Fuels	26 200	6 883	19 317	19 738	-2.1
	Solid Fuels	73 875	7 238	66 637	66 729	-0.1
	Gaseous Fuels	15 785	220	15 565	15 610	-0.3
	Other Fuels				589	
	Total	**115 860**	**14 341**	**101 519**	**102 666**	**-1.1**
2012	Liquid Fuels	25 876	7 072	18 804	19 328	-2.7
	Solid Fuels	69 355	7 215	62 140	63 617	-2.3
	Gaseous Fuels	15 876	225	15 651	15 363	1.9
	Other Fuels				539	
	Total	**111 107**	**14 512**	**96 595**	**98 847**	**-2.3**
2013	Liquid Fuels	24 949	6 691	18 258	18 646	-2.1
	Solid Fuels	69 101	7 487	61 614	59 788	3.1
	Gaseous Fuels	16 117	215	15 902	15 640	1.7
	Other Fuels				413	
	Total	**110 167**	**14 393**	**95 774**	**94 486**	**1.4**
2014	Liquid Fuels	26 531	7 460	19 071	19 571	-2.6
	Solid Fuels	63 861	7 632	56 229	57 640	-2.4
	Gaseous Fuels	14 358	220	14 138	13 860	2.0
	Other Fuels				510	
	Total	**104 751**	**15 312**	**89 439**	**91 581**	**-2.3**
2015	Liquid Fuels	26 053	6 134	19 919	20 135	-1.1
	Solid Fuels	65 707	7 471	58 236	57 442	1.4
	Gaseous Fuels	15 060	223	14 837	14 572	1.8
	Other Fuels				615	
	Total	**106 820**	**13 828**	**92 992**	**92 763**	**0.2**
2016	Liquid Fuels	24 265	3 980	20 285	20 177	0.5
	Solid Fuels	65 685	7 826	57 859	57 664	0.3
	Gaseous Fuels	16 313	233	16 080	15 871	1.3
	Other Fuels				703	
	Total	**106 263**	**12 039**	**94 223**	**94 414**	**-0.2**

Tab. 3-8 Apparent consumption in energy units (PJ) used in reference and sectoral approach for all fossil fuels and corresponding results for CO_2 emissions (kt)

Year	Appar. cons. [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]	Activity data [kt CO_2]	Carbon excluded [kt CO_2]	Reference approach [kt CO_2]	Sectoral approach [kt CO_2]	(RA-SA)/SA [%]
1990	1 843.4	158.5	1 735.3	1 684.9	3.0	161 556	10 766	150 790	146 805	2.7
1991	1 664.2	114.0	1 588.6	1 550.2	2.5	148 743	10 766	137 978	134 873	2.3
1992	1 635.4	120.2	1 519.9	1 515.2	0.3	140 875	11 327	129 548	130 079	-0.4
1993	1 566.8	108.3	1 470.9	1 458.5	0.9	135 237	10 250	124 986	124 946	0.0
1994	1 511.6	130.6	1 380.5	1 381.0	0.0	128 479	12 125	116 354	117 477	-1.0
1995	1 573.8	168.0	1 366.3	1 405.8	-2.8	129 072	14 797	114 275	118 541	-3.6
1996	1 620.8	174.0	1 402.5	1 446.8	-3.1	131 038	15 311	115 727	120 566	-4.0
1997	1 570.7	171.2	1 419.2	1 399.5	1.4	132 874	15 251	117 623	116 206	1.2
1998	1 510.7	167.2	1 372.2	1 343.5	2.1	127 423	14 935	112 488	110 266	2.0
1999	1 428.4	149.1	1 273.5	1 279.3	-0.5	115 772	12 876	102 896	104 053	-1.1
2000	1 521.4	153.9	1 375.1	1 367.6	0.6	127 268	13 574	113 694	113 298	0.3
2001	1 538.4	151.2	1 402.5	1 387.2	1.1	128 336	13 262	115 074	113 882	1.0
2002	1 514.7	158.9	1 377.9	1 355.8	1.6	126 769	14 023	112 746	111 025	1.5
2003	1 555.4	167.5	1 389.3	1 387.9	0.1	128 578	14 871	113 707	113 549	0.1
2004	1 588.8	195.7	1 330.4	1 393.2	-4.5	125 000	17 064	107 936	113 551	-4.9
2005	1 566.5	186.8	1 376.5	1 379.7	-0.2	128 256	16 032	112 224	112 335	-0.1

Year	Appar. cons. [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]	Activity data [kt CO_2]	Carbon excluded [kt CO_2]	Reference approach [kt CO_2]	Sectoral approach [kt CO_2]	(RA-SA)/SA [%]
2006	1 576.4	196.8	1 394.4	1 379.5	1.1	130 843	17 090	113 754	112 522	1.1
2007	1 575.1	187.4	1 403.9	1 387.7	1.2	131 913	16 424	115 489	113 813	1.5
2008	1 528.5	192.4	1 339.9	1 336.2	0.3	125 702	16 524	109 178	108 902	0.3
2009	1 428.0	158.9	1 250.3	1 269.1	-1.5	115 276	13 513	101 762	103 762	-1.9
2010	1 470.2	174.9	1 320.5	1 295.3	1.9	121 262	14 899	106 362	105 123	1.2
2011	1 420.7	167.4	1 249.4	1 253.4	-0.3	116 450	14 342	102 108	102 666	-0.5
2012	1 380.8	170.2	1 196.1	1 210.6	-1.2	111 646	14 512	97 134	98 847	-1.7
2013	1 333.3	167.7	1 188.5	1 165.7	2.0	110 581	14 393	96 188	94 486	1.8
2014	1 306.0	181.1	1 110.9	1 124.9	-1.2	105 326	15 378	89 949	91 581	-1.8
2015	1 305.2	161.3	1 157.0	1 144.0	1.1	107 501	13 894	93 607	92 763	0.9
2016	1 305.0	135.3	1 181.4	1 169.7	1.0	106 965	12 039	94 926	94 414	0.5

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, 2017). Tab. 3-9 gives the amount of stored Kerosene Jet Fuel.

Tab. 3-9 Kerosene Jet Fuel in international bunkers

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
[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	10 163
Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
[TJ/year]	13 062	13 573	14 070	14763	15644	14287	13387	13272	12367	11929	12328	1241š	13368	

3.2.3 Feedstocks and non-energy use of fuels

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

Non-energy fuels are divided into three categories:

1) **Raw materials for the chemical industry (Feedstocks)**. These fossil fuels are used in particular in the production of organic compounds and to a lesser extent in the production of inorganic chemicals (e.g. ammonia) and their derivatives. For organic substances normally part of the carbon contained in the feedstock remains largely stored in these products. Typical examples of raw materials are the feedstocks for petrochemical industry (naphtha), natural gas, or different types of oils (e.g. the production of hydrogen for the subsequent production of ammonia by partial oxidation).
2) **Reductants**. Carbon is used as a reductant in metallurgy and inorganic technologies. Unlike the previous case, here when using fossil fuel as reductant only a very small amount of carbon remains long fixed in the products and the larger part of the carbon is being oxidized during the reduction process. Typical example of reductant is metallurgical coke.

3) **Non-energy products**. Non-energy products are materials, derived from fuels in refineries or coke plants, which unlike the previous two cases, are used directly for its conventional physical properties, specifically it is about lubricants (lubricating oils and petrolatum), diluents and solvents, bitumen (for covering roads and roofs) and paraffin. In category IPPU emissions of CO_2 and other GHG occur only to a limited extent (e.g. during the oxidation of lubricants and paraffin). Substantial emissions occur during their recovery and during disposal by incineration (in the sector and in Waste).

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

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

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

Another important type of liquid fuels consumed for non-energy purposes of fuels is a group marked as Other Oils. Their most significant share is Other Petroleum Products, which finds application in the production of hydrogen by partial oxidation with steam for subsequent production of ammonia and further part of it is also used as a Solvent Use. In 2016, the consumption of Other Petroleum Products for non-energy purposes (particularly in sub-sectors 2.B, 2.D) was 18.4 PJ. CO_2 produced during ammonia production (2.B.1) is reported in Table 1.A(d) under Other Oil. The rest of the Other Oil used in non-energy use is processed for the Solvents. Following the IPCC 2006 Gls., from Solvent Use (2.D.3) there is no CO_2 produced.

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

The liquid fuels, used specially for non-energy purposes, include also bitumen, whose consumption in 2016 was 18.7 TJ and lubricants with consumption in 2016 of 7.8 PJ. While in the case of using bitumen there are no emissions of CO_2 (Stored carbon), in the case of lubricants use, annually a part is oxidized to CO_2 (Reported in 2.D.1) Consequently, CO_2 reported in Table1.A(d) under Lubricants is the CO_2 which is arising in 2.D.1.

Solid fuels for non-energy purposes are mainly used as reductants. These include coke (Coke Oven Coke), from which in 2016 were used 53.0 PJ in the production of iron and steel (2.C.1). Consequently, CO_2 reported in Table1.A(d) under Coke Oven Coke is the CO_2 which is arising in 2.C.1 from Metallurgical coke use. In the Other bituminous coal in 2016 were used 9.0 PJ as non-energy use. Other bituminous coal was used as reductant in 2.C.1 as well.

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

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

In Tab. 3-10 are listed calorific values of the energy balance calculation of CzSO and default emission factors, which were used in the reference approach.

Tab. 3-10 Net calorific values and emission factors of feedstocks

Non-energy Fuels	NCV [GJ/kt]	EF [t CO_2/TJ]
LPG	45 945	65.86[1)]
Naphtha	43 600	73.30
White Spirit	40 193	73.30
Lubricants	40 193	73.30
Bitumen	40 193	80.70
Paraffin Wax	40 193	73.30
Petroleum Coke	39 400	97.50
Other Petroleum Products	39 220	73.30
Refinery Gas	46 023	55.08[1)]
Coke Oven Coke	28 776[2)]	107.00

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

3.2.4 Methodological issues

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

The data for the whole time series was constructed on the basis of data from the CzSO Questionnaire (CzSO, 2017), where the data on fuel consumption are provided in various ways. Data are available for Solid and Liquid Fuels in mass units (kt p.a.), where the net caloric values of these fuels are also tabulated. The consumption of gaseous fuels derived from fossil fuels is given in TJ p.a. Natural Gas is given in thousand m^3 and the consumption in TJ is also tabulated; however, in this case it is calculated using the gross caloric value. The Energy balance in mass units (kt p.a.) for last reported year (2016) is given in Annex 4, Tables A4-1 – A4-7.

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

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

3.2.4.1 Collection of activity data

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

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

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

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

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

3.2.4.2 Conversion of activity data to the CRF format

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

The Title page shall contain particularly the following information:

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

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

- complete division of data about consumption of each kind of fuels from Energy balance provided by CzSO into the structure compatible with CRF Reporter (for purposes of Sectoral and Reference Approaches)
- complete set of NCV for specific kinds of fuels and emission and oxidation factors (if applicable)
- computation of emission estimates
- summation of activity data and emissions for each group of fuels (solid, liquid, gaseous etc.) into specific subcategories

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

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, 2017), 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, 2017) in thousand m^3 and in TJ; however, the data in TJ is determined using the gross caloric value. Volume reported by CzSO in thousand m^3 is related to the „trade conditions“, i.e. temperature 15°C and pressure 101.3 kPa.

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

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

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

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

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

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

General CO_2 emission factors and NCV are provided in Tab. 3-11.

Tab. 3-11 Net calorific values (NCV), CO_2 emission factors and oxidation factors used in the Czech GHG inventory – 2016

Fuel (IPCC 2006 Guidelines definitions)	NCV [TJ/kt]	CO_2 EF [a] [t CO_2/TJ]	Oxidation factor	CO_2 EF [b] [t CO_2/TJ]
Crude Oil	42.400	73.30	1	73.30
Gas/Diesel Oil	42.600	74.10	1	74.10
Residual Fuel Oil	39.500	77.40	1	77.40
LPG [d]	45.945	65.86	1	65.86
Naphtha	43.600	73.30	1	73.30

Fuel (IPCC 2006 Guidelines definitions)	NCV [TJ/kt]	CO_2 EF [a] [t CO_2/TJ]	Oxidation factor	CO_2 EF [b] [t CO_2/TJ]
Bitumen	40.193	80.70	1	80.70
Lubricants	40.193	73.30	1	73.30
Petroleum Coke	39.400	97.50	1	97.50
Other Oil	39.220	73.30	1	73.30
Coking Coal [d]	29.452	93.55	1	93.55
Other Bituminous Coal [d]	23.530	94.80	0.9707	92.03
Lignite (Brown Coal) [d]	13.366	99.53	0.9846	98.00
Brown Coal Briquettes	20.005	97.50	0.9846[d]	96.00
Coke Oven Coke	28.116	107.00	1	107.00
Coke Oven Gas (TJ/mill. m^3)	16.064 [c]	44.40	1	44.40
Natural Gas (TJ/Gg) [d]	48.657	55.40	1	55.40
Natural Gas (TJ/mill. m^3) [d]	34.679	55.40	1	55.40

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

3.2.5 Uncertainties and time-series consistency

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

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

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

Activity data

Information on fuel consumption is taken from CzSO (CzSO, 2017).

Uncertainties:

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

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

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

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

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

Emission factors

For calcualtions were applied

1) Default emission factors

The research carried out in 2012 focused also on the determining of uncertainties of emission factors (CHMI, 2012b). Results are provided in the Tab. 3-12. 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. 3-12 Uncertainty data from Energy sector (stationary combustion) for uncertainty analysis

Gas	Source category	AD uncertainty [%]	EF uncertainty [%]	Origin of actual level of uncertainty
CO_2	1.A Stationary combustion – Solid Fuels	4	3	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO_2	1.A Stationary combustion – Gaseous Fuels	3	2.5	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO_2	1.A Stationary combustion– Liquid Fuels	5	3	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO_2	1.A Stationary combustion – Other Fuels – 1.A.2	10	15	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO_2	1.A.3.e Other Transportation	4	3	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CO_2	1.A.5.b Mobile sources in agriculture and forestry	7	3	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH_4	1.A Stationary combustion – Solid Fuels	5	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH_4	1.A Stationary combustion – Gaseous Fuels	4	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH_4	1.A Stationary combustion – Liquid Fuels	5	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH_4	1.A Stationary combustion – Biomass	8	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH_4	1.A.5.b Mobile sources in agriculture and forestry	7	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
CH_4	1.A.3.e Other Transportation	4	50	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N_2O	1.A Stationary combustion – Solid Fuels	5	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N_2O	1.A Stationary combustion – Gaseous Fuels	4	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N_2O	1.A Stationary combustion – Liquid Fuels	5	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N_2O	1.A Stationary combustion – Biomass	8	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N_2O	1.A Stationary combustion –	10	60	E. Krtkova, V. Neuzil, AD and EF unc. in line

Gas	Source category	AD uncertainty [%]	EF uncertainty [%]	Origin of actual level of uncertainty
	Other Fuels – 1.A.2			with 2006 Guidelines
N_2O	1.A.3.e Other Transportation	4	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines
N_2O	1.A.5.b Mobile sources in agriculture and forestry	7	60	E. Krtkova, V. Neuzil, AD and EF unc. in line with 2006 Guidelines

Time - series consistency

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

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

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

Example:

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

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

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

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

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

3.2.6 QA/QC and verification

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

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

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

The QC procedures are related to the processing, manipulation, documentation, storing and transmission of information. The first step of the control is carried out by the expert responsible for the Sectoral Approach (Vladimir Neuzil), followed up by the control carried out by the QA/QC experts familiar with the topic (Pavel Fott, former NIS coordinator, Andrea Paulů, new external employees of KONEKO). 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, Andrea Paulů) 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 The previous submission was controlled in detail by an in-country review..

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, 2016								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emissions**	**EF**	**Emissions**	**EF**	**Emissions**
	[TJ]	**[t CO_2/TJ]**	**[-]**	**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
Rafinery Gas	552.28	55.08	1	30.42	1	0.00000	0.1	0.00000
LPG	321.62	65.86	1	21.18	1	0.00000	0.1	0.00000
Heating and Other Gasoil	85.2	74.1	1	6.30	3	0.00026	0.6	0.00005
Fuel Oil - Low Sulphur	711	77.4	1	55	3	0.00213	0.6	0.00043
Other Bituminous Coal	77 469.50	95.3*)	0,9707*)	7 163.20	1	0.07747	1.5	0.11620
Brown Coal + Lignite	371 836.40	100.8*)	0,9846*)	36 909.70	1	0.37184	1.5	0.55775
Coal Tars	35.1	80.7	1	2.8	1	0.00004	1.5	0.00005
Coke Oven Gas	3 813.10	44.4	1	169.3	1	0.00381	0.1	0.00038
Natural Gas	49 989.30	55.40*)	1	2 769.40	1	0.04999	0.1	0.00500
Waste - fossil fraction	2 722.00	91.7	1	249.6	30	0.08166	4	0.01089
Waste - biomass fraction	4 083.00	100	1	408.3	30	0.12249	4	0.01633
Wood/Wood Waste	18 718.00	112	1	2 096.40	30	0.56154	4	0.07487
Gaseous Biomass	1 092.00	54.6	1	59.6	1	0.00109	0.1	0.00011
Total year 2016	531 428.49			47393.47		1.27		0.78
Total year 2015	519109.06			46669.59		1.22		0.77
Index 2016/2015	1.02			1.02		1.03		1.01
Total year 1990	569994.51			54645.46		0.62		0.81
Index 2016/1990	0.93			0.87		2.02		0.96

*) *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.

2016							
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Rafinery Gas	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
LPG	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
Other Bituminous Coal	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Coal Tars	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Coke Oven Gas	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Waste - fossil fraction	ISOH, MTI	D	D	D	Tier 1	Tier 1	Tier 1
Waste - biomass fraction	ISOH, MTI	D	D	D	Tier 1	Tier 1	Tier 1
Wood/Wood Waste	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Gaseous Biomass	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

The fraction of CO_2 emissions from sector 1.A.1 equalled 57.4% in 2016 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 2016, the fraction of CO_2 emissions in subsector 1.A.1.a equalled 87.5% of total CO_2 emissions in sector 1.A.1 .

From the total installed capacity of electricity generation 20.10 GWe in 2016, 11.38 GWe are accounted for thermal power plants:

Nuclear	4 290	MWe
Hydro	2 071	MWe
Solar photovoltaic	2 068	MWe
Wind	282	MWe
Combustible fuels	11 382	MWe
Total capacity	**20 096**	**MWe**

In the final energy balance of CzSO (CzSO, 2017), the consumption of the individual kinds of fuels in this sector is reported in section Transformation Sector under the items:

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

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

35.11 Production of electricity

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

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

Electricity production (GWh)	**83 309**
Main activity producer electricity plants	39 769
Main activity producer CHP plants	34 095
Autoproducer electricity plants	636
Autoproducer CHP plants	8 809
Heat production (TJ)	**128 439**
Main activity producer CHP plants	89 316
Main activity producer heat plants	18 276
Autoproducer CHP plants	11 443
Autoproducer heat plants	9 404

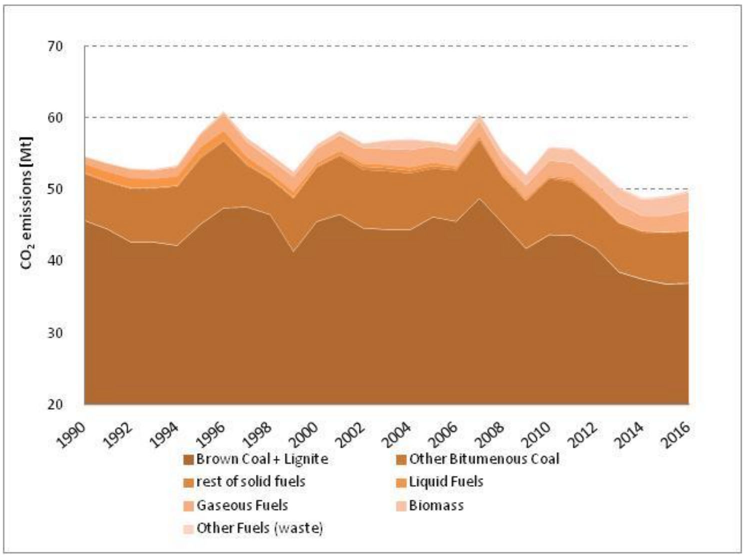

Fig. 3-4 Development of CO_2 emissions in 1.A.1.a category

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

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

The trend in emissions is mainly shaped by the development and structures of the electricity generation installations involved, since these installations account for the majority of the pertinent emissions. As is clear from the figure, Solid Fuels are the main driving force for emissions in this source category. Brown Coal and Lignite are the most important, with average consumption of 443 PJ, corresponding to 43 626 kt CO_2/year on an average for the whole 1990 – 2016 period. The second largest consumption corresponds to Other Bituminous Coal, with an average consumption of 78 PJ, corresponding to 7 292 kt CO_2/year on an average for the whole 1990 – 2016 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 26.94 t C/TJ; a country-specific emission factor equal to 25.78 t C/TJ for Other Bituminous Coal and Coking Coal has been used to calculate CO_2 emissions. In 2015 was conducted research in order to update these emission factors. The detailed description of the research is provided in Annex 3. As mentioned above, this means that approximately 95% of the emissions from fuels in this category were determined using country-specific emission factors, i.e. at the level of Tier 2.

Since submission in 2014 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

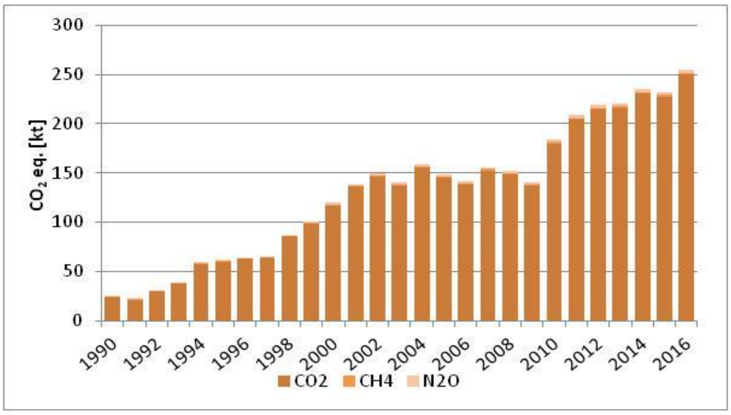

Fig. 3-5 Trend of GHG emissions from waste incineration for energy

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

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

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

Tab. 3-13 Capacity of municipal waste incineration plants in the Czech Republic, 2016

Incinerator (city)	Capacity [kt]
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.

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

See chapter 3.2.5.

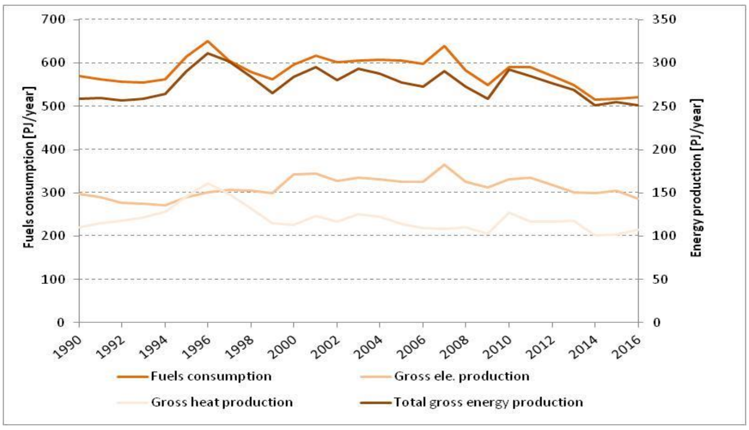

Fig. 3-6 The ratio between the total consumption of fuels from the heat sources in the category 1.A1.a and overall energy production

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 extensive uploads of activity data by CzSO. Following tables are describing the change caused by these recalculations.

Liquid fuels

Tab. 3-14 Recalculations caused by change in activity data for Liquid fuels in submission 2018

Fuel consumption		2011	2012	2013	2014	2015
Submission 2017	TJ	3 003.6	1 738.5	995.5	753.6	914.7
Submission 2018	TJ	4 284.7	3 249.7	2 056.9	2 084.2	1 926.7
Difference	TJ	1 281.1	1 511.2	1 061.3	1 330.6	1 012.0
	%	42.65	86.93	106.61	176.57	110.63
CO_2 emissions		2011	2012	2013	2014	2015
Submission 2017	kt	232.5	134.4	76.6	58.2	70.5
Submission 2018	kt	309.7	224.9	138.2	136.2	129.7
Difference	kt	77.2	90.5	61.6	78.1	59.2
	%	33.22	67.31	80.39	134.15	83.95
CH_4 emissions		2011	2012	2013	2014	2015
Submission 2017	kt	0.00901	0.00522	0.00299	0.00226	0.00274
Submission 2018	kt	0.01046	0.00690	0.00396	0.00368	0.00376
Difference	kt	0.00145	0.00168	0.00098	0.00142	0.00101
	%	16.11	32.24	32.68	62.62	36.88
N_2O emissions		2011	2012	2013	2014	2015
Submission 2017	kt	0.00180	0.00104	0.00060	0.00045	0.00055
Submission 2018	kt	0.00197	0.00124	0.00068	0.00061	0.00065
Difference	kt	0.00017	0.00019	0.00008	0.00015	0.00010
	%	9.47	18.57	14.20	34.14	18.44

Solid fuels

Tab. 3-15 Recalculations caused by change in activity data for Solid fuels in submission 2018

Fuel consumption		2009	2010	2011	2012	2013	2014	2015
Submission 2017	TJ	499 703.6	530 591.3	529 901.7	506 884.2	482 059.1	455 033.8	4521 83.4
Submission 2018	TJ	499 517.8	533 611.6	526 255.2	498 432.9	466 486.5	453 664.1	451 958.7
Difference	TJ	-185.8	3020.3	-3646.5	-8451.3	-15572.6	-1369.7	-224.8
	%	-0.04	0.57	-0.69	-1.67	-3.23	-0.30	-0.05
CO_2 emissions		2009	2010	2011	2012	2013	2014	2015
Submission 2017	kt	48 586.0	51 487.9	51 593.8	49 339.6	4 6810.4	4 4335.1	4 4111.5
Submission 2018	kt	48 571.0	51 750.1	51 285.5	48 613.8	4 5462.1	4 4230.2	4 4102.2
Difference	kt	-15.0	262.2	-308.3	-725.8	-1348.4	-104.9	-9.3
	%	-0.03	0.51	-0.60	-1.47	-2.88	-0.24	-0.02
CH_4 emissions		2009	2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.49970	0.53059	0.52990	0.50688	0.48206	0.45503	0.45218
Submission 2018	kt	0.49952	0.53361	0.52626	0.49843	0.46649	0.45366	0.45196
Difference	kt	-0.00019	0.00302	-0.00365	-0.00845	-0.01557	-0.00137	-0.00022

	%	-0.04	0.57	-0.69	-1.67	-3.23	-0.30	-0.05
N_2O emissions		**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.74464	0.78951	0.78613	0.75222	0.71484	0.67438	0.67136
Submission 2018	kt	0.74437	0.79404	0.78102	0.73990	0.69180	0.67262	0.67137
Difference	kt	-0.00028	0.00453	-0.00511	-0.01232	-0.02304	-0.00176	0.00000
	%	-0.04	0.57	-0.65	-1.64	-3.22	-0.26	0.00

Recalculations based on QA/QC procedures – Biomass

The recalculation of Biomass in 1.A.1.a.i was caused by change in activity data by CUEC. Table 3-15 shows the comparison of original and updated values.

Tab. 3-16 Recalculations caused by change in activity data for Biomass in submission 2018

Fuel consumption		**2014**	**2015**
Submission 2017	TJ	20 424.9	22 863.0
Submission 2018	TJ	20 577.8	23 011.9
Difference	TJ	152.9	148.9
	%	0.75	0.65
CO_2 emissions		**2014**	**2015**
Submission 2017	kt	2 191.7	2 454.2
Submission 2018	kt	2 206.9	2 469.1
Difference	kt	15.3	14.9
	%	0.70	0.61
CH_4 emissions		**2014**	**2015**
Submission 2017	kt	0.58618	0.65379
Submission 2018	kt	0.59077	0.65825
Difference	kt	0.00459	0.00447
	%	0.78	0.68
N_2O emissions		**2014**	**2015**
Submission 2017	kt	0.07813	0.08713
Submission 2018	kt	0.07874	0.08773
Difference	kt	0.00061	0.00060
	%	0.78	0.68

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

The recalculation of Other Fuels in 1.A.1.a.i was caused by change in activity data by CUEC. Tab. 3-17 shows the comparison of original and updated values.

Tab. 3-17 Recalculations caused by change in activity data for Other Fuels in submission 2018

Fuel consumption		**2014**	**2015**
Submission 2017	TJ	2 408.6	2 382.0
Submission 2018	TJ	2 510.5	2 481.2
Difference	TJ	101.9	99.2
	%	4.23	4.17
CO_2 emissions		**2014**	**2015**
Submission 2017	kt	220.9	218.4
Submission 2018	kt	230.2	227.5
Difference	kt	9.3	9.1
	%	4.23	4.17
CH_4 emissions		**2014**	**2015**
Submission 2017	kt	0.07226	0.07146
Submission 2018	kt	0.07532	0.07444
Difference	kt	0.00306	0.00298
	%	4.23	4.17
N_2O emissions		**2014**	**2015**

Submission 2017	kt	0.00963	0.00953
Submission 2018	kt	0.01004	0.00992
Difference	kt	0.00041	0.00040
	%	4.23	4.17

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, 2016								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emissions**	**EF**	**Emissions**	**EF**	**Emissions**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O /TJ]**	**[kt]**
Refinery Gas	4 096.0	55.1*)	1	225.6	1	0.00410	0.1	0.00041
Natural Gas	3 243.2	55.4*)	1	179.7	1	0.00324	0.1	0.00032
Total year 2016	**7 339.2**			**405.3**		**0.00734**		**0.00073**
Total year 2015	10 332.8			570.2		0.01033		0.00103
Index 2016/2015	0.71			0.71		0.71		0.71
Total year 1990	8 705.4			492.6		0.01017		0.00124
Index 2016/1990	0.84			0.82		0.72		0.59

*) *Country specific data*

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.

2016							
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Refinery Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Other Oil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1

This category includes all facilities that process raw petroleum imported into this country as their primary raw material. Domestic petroleum constitutes approximately 1.7% of the total amount in 2016. All fuels used in the internal refinery processes, internal consumption (reported by companies as “own use") for production of electricity and heat and heat supplied to the public mains are included in emission calculations in this subcategory. This corresponds primarily to the Česká rafinérská Inc. company in the Czech Republic. Fugitive CH_4 emissions are included in category 1.B.2.a Fugitive Emissions from Fuels - Oil.

The fraction of CO_2 emissions in subsector 1.A.1.b in CO_2 emissions in sector 1.A.1 equalled 0.75% in 2016. It contributed 0.43% to CO_2 emissions in the whole Energy sector.

In the CzSO Questionnaire (CzSO, 2017), 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 last 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:

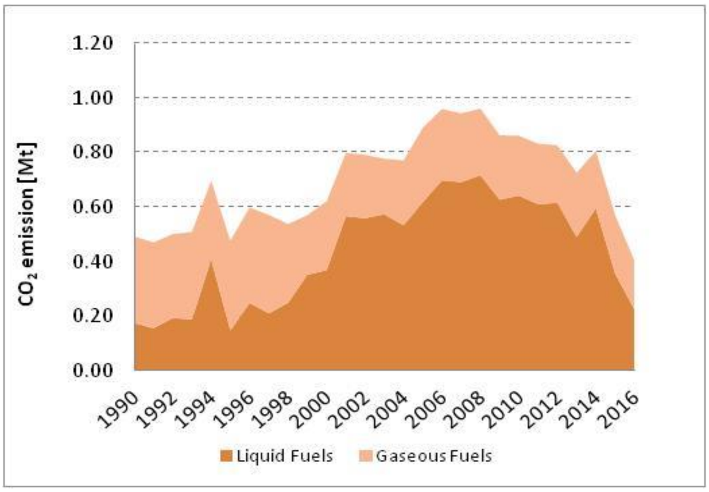

Fig. 3-7 Development of CO_2 emissions in 1.A.1.b category

No consumption of Solid Fuels occurred in this category.

Liquid Fuels are of the greatest importance and exhibit an increasing trend in the whole period. The fluctuations that have occurred over the years can be explained as resulting from differences in production quantities (see also Fig. 3-7). The maximum production equal to 716 kt CO_2 occurred in 2008, followed by a value of 697 kt CO_2 in 2006. Thereafter, production decreased to the resulting level of 357 kt CO_2 in 2015, resp. 226 kt CO_2 in 2016.

The second greatest role is played by Natural Gas, with emissions in the range between 205 kt CO_2 in 2003 and 360 kt CO_2 in 1997 and resulting with 179 kt CO_2 in 2016.

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)

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.

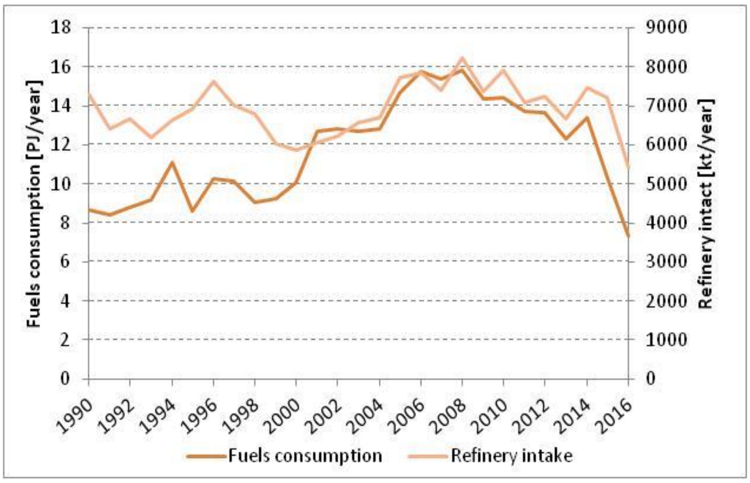

Fig. 3-8 Comparison of fuel consumption in the sector 1.A.1.b and amount of crude oil processed

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 QA/QC activity data for Liquid Fuels in 2018 were updated.

Tab. 3-18 Impact on emission estimates in 2015 after QA/QC for Liquid Fuels, 1.A.1.b

Fuel consumption		2015	CO_2 emissions		2015
Submission 2017	TJ	10038.66	**Submission 2017**	kt	617.57
Submission 2018	TJ	6489.24	**Submission 2018**	kt	357.40
Difference	TJ	-3549.42	**Difference**	kt	-260.17
	%	-35.36		%	-42.13
CH_4 emissions		**2015**	**N_2O emissions**		**2015**
Submission 2017	kt	0.01714	**Submission 2017**	kt	0.00278
Submission 2018	kt	0.00649	**Submission 2018**	kt	0.00065
Difference	kt	-0.01065	**Difference**	kt	-0.00213
	%	-62.13		%	-76.65

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

No further improvements 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, 2016								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emissions	EF	Emissions	EF	Emissions
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
Heating and Other Gasoil	681.6	74.1	1	50.5	3	0.00204	0.6	0.00041
Brown Coal + Lignite	43 867.5	100.8*)	0.985*)	4 354.4	1	0.04387	1.5	0.06580
Gas Works Gas	16 760.9	99.2*)	1	1 659.7	1	0.01676	0.1	0.00168
Coke Oven Gas	6 612.5	44.4	1	293.6	1	0.00661	0.1	0.00066
Natural Gas	102.5	55.4*)	1	5.7	1	0.00010	0.1	0.00001
Total year 2016	**68 025.0**			**6 363.9**		**0.06939**		**0.06856**
Total year 2015	65 747.3			6 155.5		0.06711		0.06520
Index 2016/2015	1.03			1.03		1.03		1.05
Total year 1990	28 984.6			1 516.4		0.03348		0.00824
Index 2016/1990	2.35			4.20		2.07		8.32

*) *Country specific data*

The table shows that while the index for 2016/1990 of fuel consumption is 2.35, the same index for CO_2 emissions is significantly higher. It is caused by the high proportion of coke oven gas in the fuel structure in 1990, which has a relatively low emission factor. Later, part of coke oven gas was reallocated to other subsectors (1.A.1.a and 1.A.2.a). Even more markedly the high proportion of coke oven gas, combined with relatively low emission factor, compared to other fuels, occurred in N_2O emissions.
The origin of the data, the emission factors used and the method of calculating the level of emissions for each gas is presented in details in the following outline.

2016							
Structure of Fuels	Source of Activity data	Emission factors			Method used		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Heating and Other Gasoil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Gas Works Gas	CzSO, CHMI	CS	D	D	Tier 2	Tier 1	Tier 1
Coke Oven Gas	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1

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

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

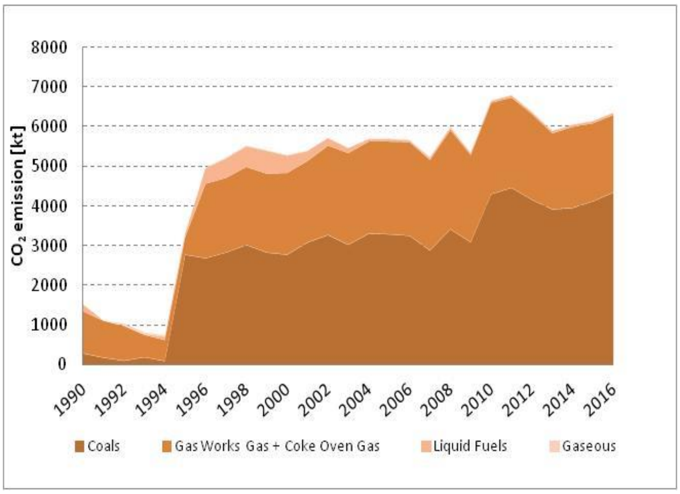

Fig. 3-9 Development of CO_2 emissions in 1.A.1.c category

deposits. The category also includes Coke plants and the production of Generator Gas. Other energy industries, such as facilities for extraction of Natural Gas and Petroleum are of minor importance in the Czech Republic.

The fraction of CO_2 emissions in subsector 1.A.1.c in CO_2 emissions in sector 1.A.1 equalled 12% in 2016. It contributed only 7% to CO_2 emissions in the whole Energy sector 1.A.

In the CzSO Questionnaire (CzSO, 2017), the consumption of the individual kinds of fuels in this sector is reported in capture Energy Sector under the items:

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

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

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

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

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

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

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

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

The amount of coal that was used for the production of technological steam is not directly accessible from the CzSO energy balance. Data from CHMI REZZO national emission database was used to determine the amount of coal. The quantity of coal for production of technological steam is given in Tab. 3-19.

Tab. 3-19 Consumption of Lignite for production of technological steam in Fuel combine Vřesová 1995 – 2016

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**	**2016**
Lignite [kt/year]	2 003	2 088	2 107	1 938	2 044	2 094	2 117	1 994	1 951	2 013	2 005

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.

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 1995-2016.

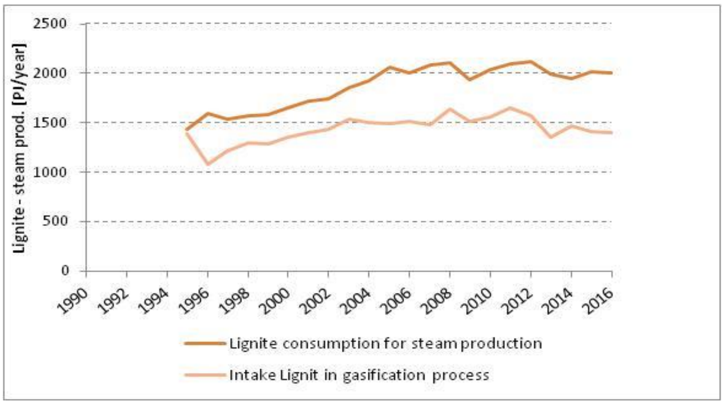

Fig. 3-10 Comparison of lignite consumption for steam production and gasification

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 net caloric value of Solid Fuels by CzSO, which resulted in recalculation of this category.

Tab. 3-20 Changes after recalculation in 1.A.1.c.ii for Solid Fuels

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	68852.8	68964.0	66173.4	60926.6	61275.1	62286.4
Submission 2018	TJ	71358.3	71399.8	66985.3	62362.2	64051.9	64927.6
Difference	TJ	2505.6	2435.9	811.9	1435.5	2776.8	2641.2
	%	3.64	3.53	1.23	2.36	4.53	4.24
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	6372.9	6513.8	6246.2	5693.2	5741.7	5847.5
Submission 2018	kt	6610.3	6746.3	6329.3	5841.8	6004.8	6097.3
Difference	kt	237.4	232.4	83.1	148.7	263.0	249.8
	%	3.73	3.57	1.33	2.61	4.58	4.27
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.06885	0.06896	0.06617	0.06093	0.06128	0.06229
Submission 2018	kt	0.07136	0.07140	0.06699	0.06236	0.06405	0.06493
Difference	kt	-0.00927	0.00239	0.00523	0.00606	0.00109	0.00177
	%	-13.46	3.47	7.90	9.94	1.77	2.83
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.06475	0.06639	0.06386	0.05861	0.05806	0.06082
Submission 2018	kt	0.06857	0.07032	0.06558	0.06166	0.06238	0.06478
Difference	kt	0.00383	0.00393	0.00172	0.00305	0.00431	0.00396
	%	5.91	5.93	2.70	5.21	7.42	6.51

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, 2016								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emissions**	**EF**	**Emissions**	**EF**	**Emissions**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O /TJ]**	**[kt]**
Anthracite	1594.6	98.3	1	156.8	10	0.01595	1.50000	0.00239
Other Bituminous Coal	746.1	94.5*)	0.9707*)	68.4	10	0.00746	1.50000	0.00112
Brown Coal + Lignite	276.9	99.2*)	0.9846*)	27.0	10	0.00277	1.50000	0.00042
Coke	7282.0	107	1	779.2	10	0.07282	1.50000	0.01092
Coke Oven Gas	4553.9	44.4	1	202.2	1	0.00455	0.10000	0.00046
Natural Gas	9257.2	55.4*)	1	512.8	1	0.00926	0.10000	0.00093
Wood/Wood Waste	1.4	112	1	0.2	30	0.00004	4.00000	0.00001
Total year 2016	**23 712.1**			**1746.89**		**0.11285**		**0.01624**
Total year 2015	25 682.5			1 923.1		0.12712		0.01893
Index 2016/2015	0.92			0.91		0.89		0.86
Total year 1990	155 319.2			14 860.7		1.39500		0.20941
Index 2016/1990	0.15			0.12		0.08		0.08

*) *Country specific data*

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

2016							
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Anthracite	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other Bituminous Coal	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Coke	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Coal Tars	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Coke Oven Gas	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Wood/Wood Waste	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

This category includes manufacturing in the area of pig iron (blast furnaces), rolling steel, casting iron, steel and alloys and is related only to ferrous metals. In the CzSO Questionnaire (CzSO, 2017), 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_2 emissions in subsector 1.A.2.a in CO_2 emissions in sector 1.A.2 equalled 18.8% in 2016. It contributed only 2% to CO_2 emissions in the whole Energy sector.

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

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

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

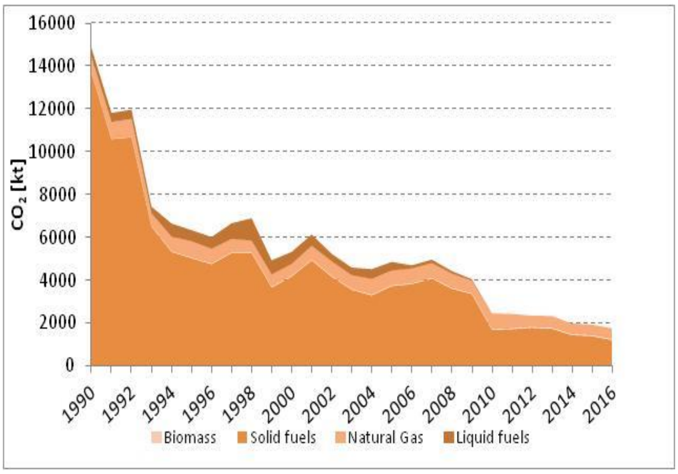

Fig. 3-11 Development of CO_2 emissions in source category 1.A.2.a

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

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

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

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

See chapter 3.2.5.

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

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

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.

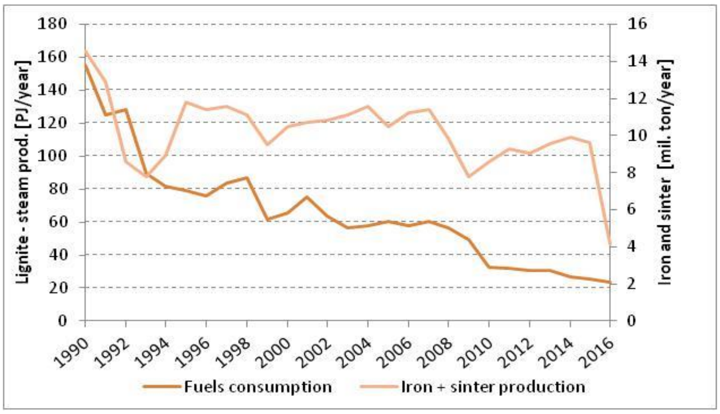

Fig. 3-12 The trend in the manufacture of agglomerates of iron ore and iron, in comparison with the development of fuel consumption in the sector 1.A.2.a

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. 3-21 Changes after recalculation in 1.A.2.a for Solid Fuels

Fuel consumption		2009	2010	2011	2012	2013	2014	2015
Submission 2017	TJ	37 659.7	19 231.8	19 921.5	20 757.5	20 817.8	17 234.8	16 730.4
Submission 2018	TJ	37 635.0	19 453.1	19 916.7	20 796.6	20 330.4	17 215.5	16 655.7
Difference	TJ	-24.8	221.3	-4.8	39.1	-487.4	-19.4	-74.7
	%	-0.07	1.15	-0.02	0.19	-2.34	-0.11	-0.45
CO_2 emissions		2009	2010	2011	2012	2013	2014	2015
Submission 2017	kt	3391.3	1692.2	1740.8	1800.4	1801.6	1462.5	1429.7
Submission 2018	kt	3388.7	1714.2	1739.9	1803.2	1759.2	1460.9	1423.3
Difference	kt	-2.7	21.9	-0.9	2.8	-42.4	-1.6	-6.4
	%	-0.08	1.30	-0.05	0.16	-2.35	-0.11	-0.45
CH_4 emissions		2009	2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.32947	0.14742	0.14943	0.15555	0.15885	0.12129	0.11884
Submission 2018	kt	0.32922	0.15021	0.14938	0.15594	0.15397	0.12109	0.11809
Difference	kt	-0.00025	0.00279	-0.00005	0.00039	-0.00487	-0.00019	-0.00075

	%	-0.08	1.93	-0.03	0.25	-3.10	-0.16	-0.64
N_2O emissions		**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.04916	0.02186	0.02214	0.02304	0.02355	0.01791	0.01756
Submission 2018	kt	0.04912	0.02229	0.02213	0.02310	0.02282	0.01788	0.01744
Difference	kt	-0.00004	0.00042	-0.00001	0.00006	-0.00073	-0.00003	-0.00011
	%	-0.08	1.93	-0.03	0.25	-3.10	-0.16	-0.64

Tab. 3-22 Changes after recalculation in 1.A.2.a for Natural Gas

Fuel consumption		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	TJ	13 294.4	12 217.2	9 616.5	10 096.3	9 240.6	8 988.3
Submission 2018	TJ	13 349.3	12 266.6	9 657.4	10 137.9	9 280.3	9 026.8
Difference	TJ	54.9	49.4	40.9	41.6	39.7	38.5
	%	0.41	0.40	0.43	0.41	0.43	0.43
CO_2 emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	735.2	675.4	530.8	558.3	511.5	498.1
Submission 2018	kt	738.0	677.9	533.1	560.6	513.7	499.7
Difference	kt	2.8	2.5	2.3	2.3	2.2	1.6
	%	0.39	0.37	0.43	0.41	0.43	0.32
CH_4 emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.01330	0.01222	0.00962	0.01010	0.00924	0.00899
Submission 2018	kt	0.01335	0.01227	0.00966	0.01014	0.00928	0.00903
Difference	kt	0.00005	0.00004	0.00004	0.00004	0.00004	0.00004
	%	0.39	0.37	0.43	0.41	0.43	0.43
N_2O emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.00133	0.00122	0.00096	0.00101	0.00092	0.00090
Submission 2018	kt	0.00133	0.00123	0.00097	0.00101	0.00093	0.00090
Difference	kt	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
	%	0.39	0.37	0.43	0.41	0.43	0.43

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, 2016								
Structure of Fuels	**Activity data**	**CO_2**			**CH_4**		**N_2O**	
		EF	**OxF**	**Emissions**	**EF**	**Emissions**	**EF**	**Emissions**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O /TJ]**	**[kt]**
Coke	112.5	107.0	1.0	12.0	10.0	0.00112	1.5	0.00017
Natural Gas	2 222.7	55.4*)	1.0	123.1	1.0	0.00222	0.1	0.00022
Wood/Wood Waste	1.4	112.0	1.0	0.2	30.0	0.00004	4.0	0.00001
Total year 2016	**2 336.6**			**135.2**		**0.00339**		**0.00040**
Total year 2015	1 791.3			105.1		0.00282		0.00034
Index 2016/2015	1.30			1.29		1.20		1.17
Total year 1990	1 476.3			102.0		0.00572		0.00081
Index 2016/1990	1.58			1.33		0.59		0.49

*) *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.

2016							
Structure of Fuels	**Source of**	**Emission factors**			**Method used**		
	Activity data	**CO_2**	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
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, 2017), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Non-Ferrous Metals

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

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

Important facility belongs to this category is Kovohutě Příbram. The fraction of CO_2 emissions in subsector 1.A.2.b in CO_2 emissions in sector 1.A.2 equalled 1.5% in 2016. It contributed only 0.1% to CO_2 emissions in the whole Energy sector.

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

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

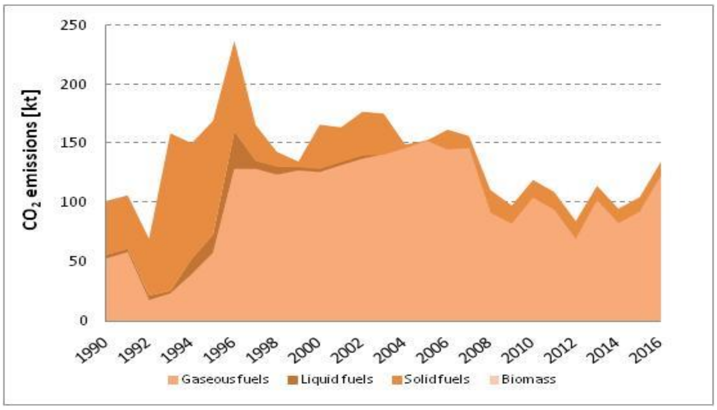

Fig. 3-13 Development of CO_2 emissions in source category 1.A.2.b

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

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

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

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

See chapter 3.2.5.

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

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

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

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

Tab. 3-23 Changes after recalculation in 1.A.2.b for Solid Fuels

Fuel consumption		2009	2011	2012	2013
Submission 2017	TJ	143.0	140.3	142.4	114.2
Submission 2018	TJ	142.7	140.0	142.0	113.9
Difference	TJ	-0.3	-0.3	-0.4	-0.3
	%	-0.23	-0.23	-0.25	-0.29
CO_2 emissions		2009	2011	2012	2013
Submission 2017	kt	15.3	15.0	15.2	12.2
Submission 2018	kt	15.3	15.0	15.2	12.2
Difference	kt	-0.03	-0.03	-0.04	-0.03
	%	-0.23	-0.23	-0.25	-0.29
CH_4 emissions		2009	2011	2012	2013
Submission 2017	kt	0.00143	0.00140	0.00142	0.00114
Submission 2018	kt	0.00143	0.00140	0.00142	0.00114
Difference	kt	0.00000	0.00000	0.00000	0.00000
	%	-0.23	-0.23	-0.25	-0.29
N_2O emissions		2009	2011	2012	2013
Submission 2017	kt	0.00021	0.00021	0.00021	0.00017
Submission 2018	kt	0.00021	0.00021	0.00021	0.00017
Difference	kt	0.00000	0.00000	0.00000	0.00000
	%	-0.23	-0.23	-0.25	-0.29

Tab. 3-24 Changes after recalculation in 1.A.2.b for Natural Gas

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	1 886.3	1 701.8	1 257.9	1 846.3	1 496.5	1 669.6
Submission 2018	TJ	1 894.1	1 708.7	1 263.3	1 854.0	1 502.9	1 676.7
Difference	TJ	7.8	6.9	5.4	7.6	6.4	7.1
	%	0.41	0.40	0.43	0.41	0.43	0.43
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	104.3	94.0	69.4	102.1	82.8	92.5
Submission 2018	kt	104.7	94.4	69.7	102.5	83.2	92.8
Difference	kt	0.4	0.4	0.3	0.4	0.4	0.3
	%	0.41	0.40	0.43	0.41	0.43	0.32
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00189	0.00170	0.00126	0.00185	0.00150	0.00167
Submission 2018	kt	0.00189	0.00171	0.00126	0.00185	0.00150	0.00168
Difference	kt	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
	%	0.41	0.40	0.43	0.41	0.43	0.43
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00019	0.00017	0.00013	0.00018	0.00015	0.00017
Submission 2018	kt	0.00019	0.00017	0.00013	0.00019	0.00015	0.00017
Difference	kt	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	%	0.41	0.40	0.43	0.41	0.43	0.43

After QA/QC activity data for Liquid Fuels in 2018 were updated.

Tab. 3-25 Changes after recalculation in 1.A.2.b for Liquid Fules in years 1994-2000 and 2005-2015

Fuel consumption		1994	1995	1996	1997	1998	1999	2000	2005	2006
Submission 2017	TJ	172.9	198.1	414.0	695.1	618.7	530.8	725.0	150.6	572.4
Submission 2018	TJ	173.7	0.0	0.0	92.9	92.3	42.4	42.5	0.0	0.0
Difference	TJ	0.8	-198.1	-414.0	-602.2	-526.4	-488.4	-682.5	-150.6	-572.4
	%	0.49	-100.00	-100.00	-86.64	-85.08	-92.01	-94.14	-100.00	-100.00
Fuel consumption		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	TJ	373.4	555.2	556.9	280.5	74.1	12.3	2.6	4.2	14.4
Submission 2018	TJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Difference	TJ	-373.4	-555.2	-556.9	-280.5	-74.1	-12.3	-2.6	-4.2	-14.4
	%	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
CO_2 emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2005**	**2006**
Submission 2017	kt	13.0	15.3	32.0	53.7	47.7	40.9	56.0	11.7	44.3
Submission 2018	kt	13.0	0.0	0.0	7.0	7.0	3.1	3.1	0.0	0.0
Difference	kt	0.1	-15.3	-32.0	-46.6	-40.7	-37.8	-52.8	-11.7	-44.3
	%	0.49	-100.00	-100.00	-86.87	-85.33	-92.32	-94.38	-100.00	-100.00
CO_2 emissions		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	28.9	43.0	43.1	21.7	5.7	1.0	0.2	0.3	1.1
Submission 2018	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Difference	kt	-28.9	-43.0	-43.1	-21.7	-5.7	-1.0	-0.2	-0.3	-1.1
	%	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
CH_4 emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2005**	**2006**
Submission 2017	kt	0.00052	0.00059	0.00124	0.00209	0.00186	0.00159	0.00217	0.00045	0.00172
Submission 2018	kt	0.00052	0.00000	0.00000	0.00028	0.00028	0.00013	0.00013	0.00000	0.00000
Difference	kt	0.00000	-0.00059	-0.00124	-0.00181	-0.00158	-0.00147	-0.00205	-0.00045	-0.00172
	%	0.49	-100.00	-100.00	-86.64	-85.08	-92.01	-94.14	-100.00	-100.00
CH_4 emissions		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.00112	0.00167	0.00167	0.00084	0.00022	0.00004	0.00001	0.00001	0.00004
Submission 2018	kt	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Difference	kt	-0.00112	-0.00167	-0.00167	-0.00084	-0.00022	-0.00004	-0.00001	-0.00001	-0.00004
	%	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
N_2O emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2005**	**2006**
Submission 2017	kt	0.00010	0.00012	0.00025	0.00042	0.00037	0.00032	0.00043	0.00009	0.00034
Submission 2018	kt	0.00010	0.00000	0.00000	0.00006	0.00006	0.00003	0.00003	0.00000	0.00000
Difference	kt	0.00000	-0.00012	-0.00025	-0.00036	-0.00032	-0.00029	-0.00041	-0.00009	-0.00034
	%	0.49	-100.00	-100.00	-86.64	-85.08	-92.01	-94.14	-100.00	-100.00
N_2O emissions		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.00022	0.00033	0.00033	0.00017	0.00004	0.00001	0.00000	0.00000	0.00001
Submission 2018	kt	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Difference	kt	-0.00022	-0.00033	-0.00033	-0.00017	-0.00004	-0.00001	0.00000	0.00000	-0.00001
	%	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00

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, 2016								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emissions	EF	Emissions	EF	Emissions
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
LPG	137.8	65.9	1	9.1	1.0	0.00014	0.1	0.00001
Fuel Oil - Low Sulphur	87.3	77.4	1	6.8	3.0	0.00026	0.6	0.00005
Other Oil	353.0	73.3	1	25.9	3.0	0.00106	0.6	0.00021
Other Bituminous Coal	1 150.2	94.5*)	0.971*)	105.5	10.0	0.01150	1.5	0.00173
Brown Coal + Lignite	7 907.0	99.2*)	0.985*)	770.9	10.0	0.07907	1.5	0.01186
Natural Gas	7 719.3	55.4*)	1	427.6	1.0	0.00772	0.1	0.00077
Wood/Wood Waste	59.4	112.0	1	6.7	30.0	0.00178	4.0	0.00024
Total year 2016	17413.9			1349.5		0.10139		0.01486
Total year 2015	18 271.0			1 391.4		0.09682		0.01435
Index 2016/2015	0.95			0.97		1.05		1.04
Total year 1990	33 576.7			2 996.3		0.26480		0.03975
Index 2016/1990	0.51			0.45		0.38		0.37

*) *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.

2016							
Structure of Fuels	Source for	Emission factors			Method used		
	Activity data	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
LPG	CzSO	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
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, 2017), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Chemical (including Petrochemical)

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

Chemicals: NACE Division 20

The fraction of CO_2 emissions in subsector 1.A.2.c in CO_2 emissions in sector 1.A.2 equalled 14.5% in 2016. It contributed 1.4% to CO_2 emissions in the whole Energy sector.

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

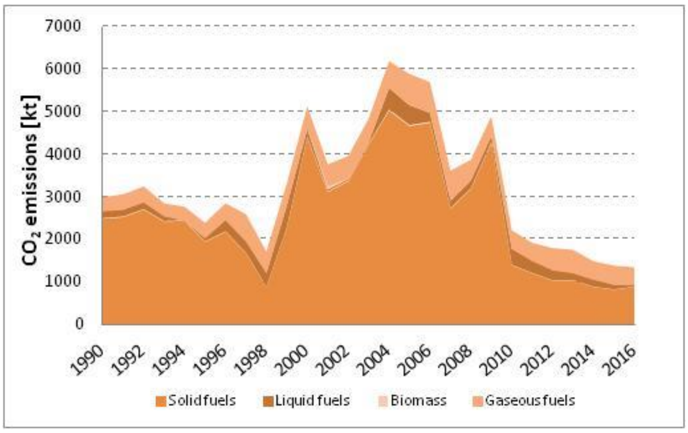

Fig. 3-14 Development of CO_2 emissions in source category 1.A.2.c

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

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

Given that in the IPCC 2006 Gl. (IPCC 2006) is used an updated approach to the allocation of feedstocks and non-energy use of fuels into IPPU. The new distribution of liquid fuels is to be considered as category specific methodological issue. This methodological approach is in the same time based on the new reallocation of fuel consumption for energy and non-energy use in the questionnaire from CzSO (2017). 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. 3-26 Changes after recalculation in 1.A.2.c for Solid Fuels

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	13 526.4	11 706.6	10 283.2	10 477.3	8 683.2	8 039.4
Submission 2018	TJ	14 392.4	12 315.1	10 564.8	10 641.5	9 054.3	8 365.7
Difference	TJ	866.0	608.5	281.6	164.2	371.1	326.3
	%	6.40	5.20	2.74	1.57	4.27	4.06
CO_2 emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	1316.2	1146.5	1003.7	1018.5	844.5	783.8
Submission 2018	kt	1391.4	1199.5	1028.2	1033.2	877.1	812.4
Difference	kt	75.2	53.1	24.5	14.7	32.6	28.6

	%	5.71	4.63	2.44	1.44	3.85	3.65
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.13526	0.11707	0.10283	0.10477	0.08683	0.08039
Submission 2018	kt	0.14392	0.12315	0.10565	0.10642	0.09054	0.08366
Difference	kt	0.00866	0.00608	0.00282	0.00164	0.00371	0.00326
	%	6.40	5.20	2.74	1.57	4.27	4.06
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.02029	0.01756	0.01542	0.01572	0.01302	0.01206
Submission 2018	kt	0.02159	0.01847	0.01585	0.01596	0.01358	0.01255
Difference	kt	0.00130	0.00091	0.00042	0.00025	0.00056	0.00049
	%	6.40	5.20	2.74	1.57	4.27	4.06

Tab. 3-27 Changes after recalculation in 1.A.2.c for Natural Gas

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	12 220.8	12 055.1	13 916.1	14 070.9	12 149.6	12 563.1
Submission 2018	TJ	8 024.7	7 716.4	9 488.3	9 836.9	7 839.9	8 182.0
Difference	TJ	-4 196.1	-4 338.6	-4 427.8	-4 234.0	-4 309.7	-4 381.1
	%	-34.34	-35.99	-31.82	-30.09	-35.47	-34.87
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	675.7	666.2	768.2	778.1	672.5	696.2
Submission 2018	kt	443.7	426.4	523.8	544.0	434.0	453.0
Difference	kt	-232.0	-239.8	-244.4	-234.2	-238.6	-243.3
	%	-34.34	-35.99	-31.82	-30.09	-35.47	-34.94
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.01222	0.01206	0.01392	0.01407	0.01215	0.01256
Submission 2018	kt	0.00802	0.00772	0.00949	0.00984	0.00784	0.00818
Difference	kt	-0.00420	-0.00434	-0.00443	-0.00423	-0.00431	-0.00438
	%	-34.34	-35.99	-31.82	-30.09	-35.47	-34.87
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00122	0.00121	0.00139	0.00141	0.00121	0.00126
Submission 2018	kt	0.00080	0.00077	0.00095	0.00098	0.00078	0.00082
Difference	kt	-0.00042	-0.00043	-0.00044	-0.00042	-0.00043	-0.00044
	%	-34.34	-35.99	-31.82	-30.09	-35.47	-34.87

After QA/QC activity data for Liquid Fuels in 2018 were updated.

Tab. 3-28 Changes after recalculation in 1.A.2.c for Liquid Fuels in years 1994-2000 and 2005-2015

Fuel consumption		1994	1995	1996	1997	1998	1999	2000	2005	2006
Submission 2017	TJ	46.8	939.8	3 128.3	3 046.5	3 852.0	6 205.4	1 734.4	5 930.7	2 177.9
Submission 2018	TJ	46.0	1 138.0	3 542.3	3 648.8	4 378.4	6 693.8	2 416.9	6 081.3	2 750.4
Difference	TJ	-0.8	198.1	414.0	602.2	526.4	488.4	682.5	150.6	572.4
	%	-1.81	21.08	13.24	19.77	13.66	7.87	39.35	2.54	26.28
Fuel consumption		2007	2008	2009	2010	2011	2012	2013	2014	2015
Submission 2017	TJ	1 991.2	1 946.2	1 349.8	4 933.8	3 930.5	3 384.4	2 410.0	2 314.4	1 617.1
Submission 2018	TJ	2 364.6	2 501.4	1 906.7	5 214.2	4 004.6	3 396.7	2 412.6	2 456.4	1 723.3
Difference	TJ	373.4	555.2	556.9	280.5	74.1	12.3	2.6	142.0	106.3
	%	18.75	28.53	41.26	5.68	1.89	0.36	0.11	6.14	6.57
CO_2 emissions		1994	1995	1996	1997	1998	1999	2000	2005	2006
Submission 2017	kt	3.6	72.7	242.1	235.8	298.1	480.3	134.2	459.0	168.6
Submission 2018	kt	3.6	88.1	274.2	282.4	338.9	518.1	187.1	470.7	212.9
Difference	kt	-0.1	15.3	32.0	46.6	40.7	37.8	52.8	11.7	44.3
	%	-1.74	21.08	13.24	19.77	13.66	7.87	39.35	2.54	26.28
CO_2 emissions		2007	2008	2009	2010	2011	2012	2013	2014	2015
Submission 2017	kt	154.1	150.6	104.5	366.4	290.1	249.0	176.8	169.8	118.9
Submission 2018	kt	183.0	193.6	147.6	388.1	295.8	250.0	177.0	179.2	126.0
Difference	kt	28.9	43.0	43.1	21.7	5.7	1.0	0.2	9.4	7.2

	%	18.75	28.53	41.26	5.93	1.98	0.38	0.12	5.54	6.03
CH_4 emissions		1994	1995	1996	1997	1998	1999	2000	2005	2006
Submission 2017	kt	0.00014	0.00282	0.00938	0.00914	0.01156	0.01862	0.00520	0.01779	0.00653
Submission 2018	kt	0.00014	0.00341	0.01063	0.01095	0.01314	0.02008	0.00725	0.01824	0.00825
Difference	kt	0.00000	0.00059	0.00124	0.00181	0.00158	0.00147	0.00205	0.00045	0.00172
	%	-1.81	21.08	13.24	19.77	13.66	7.87	39.35	2.54	26.28
CH_4 emissions		2007	2008	2009	2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00597	0.00584	0.00405	0.01480	0.01179	0.01015	0.00723	0.00694	0.00485
Submission 2018	kt	0.00709	0.00750	0.00572	0.01564	0.01201	0.01019	0.00724	0.00709	0.00499
Difference	kt	0.00112	0.00167	0.00167	0.00084	0.00022	0.00004	0.00001	0.00015	0.00013
	%	18.75	28.53	41.26	5.68	1.89	0.36	0.11	2.16	2.78
N_2O emissions		1994	1995	1996	1997	1998	1999	2000	2005	2006
Submission 2017	kt	0.00003	0.00056	0.00188	0.00183	0.00231	0.00372	0.00104	0.00356	0.00131
Submission 2018	kt	0.00003	0.00068	0.00213	0.00219	0.00263	0.00402	0.00145	0.00365	0.00165
Difference	kt	0.00000	0.00012	0.00025	0.00036	0.00032	0.00029	0.00041	0.00009	0.00034
	%	-1.81	21.08	13.24	19.77	13.66	7.87	39.35	2.54	26.28
N_2O emissions		2007	2008	2009	2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00119	0.00117	0.00081	0.00296	0.00236	0.00203	0.00145	0.00139	0.00097
Submission 2018	kt	0.00142	0.00150	0.00114	0.00313	0.00240	0.00204	0.00145	0.00140	0.00099
Difference	kt	0.00022	0.00033	0.00033	0.00017	0.00004	0.00001	0.00000	0.00002	0.00002
	%	18.75	28.53	41.26	5.68	1.89	0.36	0.11	1.17	1.84

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, 2016								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emissions	EF	Emissions	EF	Emissions
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
Fuel Oil - Low Sulphur	43.7	77.4	1	3.4	3.0	0.00013	0.6	0.00003
Brown Coal + Lignite	1 569.1	99.2*)	0.985*)	153.0	10.0	0.01569	1.5	0.00235
Natural Gas	4 461.7	55.4*)	1	247.2	1.0	0.00446	0.1	0.00045
Wood/Wood Waste	18 017.3	112.0	1	2 017.9	30.0	0.54052	4.0	0.07207
Gaseous Biomass	8 364.1	55.4	1	456.7	1.0	0.00836	0.1	0.00084
Total year 2016	**32455.9**			**404.17**		**0.56917**		**0.07573**
Total year 2015	33 166			440.86		0.54104		0.07193
Index 2016/2015	0.98			0.92		1.05		1.05
Total year 1990	25 900			2 285		0.18784		0.02890
Index 2016/1990	1.25			1.77		3.03		2.62

*) *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.

		2016					
Structure of Fuels	**Source of**	**Emission factors**			**Method used**		
	Activity data	**CO_2**	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Fuel Oil - Low Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Wood/Wood Waste	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Gaseous Biomass	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

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

In the CzSO Questionnaire (CzSO, 2017), 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

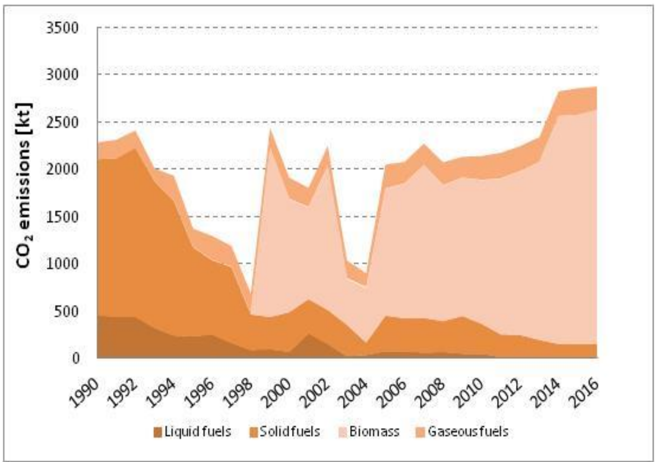

Fig. 3-15 Development of CO_2 emissions in source category 1.A.2.d

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

Pulp, paper and print: NACE Divisions 17 and 18

The fraction of CO_2 emissions in subsector 1.A.2.d in CO_2 emissions in sector 1.A.2 equalled 4.3% in 2016. It contributed 0.5% to CO_2 emissions in the whole Energy sector.

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

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

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

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

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

See chapter 3.2.5.

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

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

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

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

Tab. 3-29 Changes after recalculation in 1.A.2.d for Solid Fuels

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	3 109.4	2 385.9	2 414.3	1 881.2	1 480.4	1 398.9
Submission 2018	TJ	3 309.2	2 513.4	2 477.8	1 921.4	1 595.3	1 493.7
Difference	TJ	199.8	127.5	63.5	40.2	115.0	94.8
	%	6.43	5.34	2.63	2.14	7.77	6.77
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	302.3	234.1	233.5	183.3	146.4	138.0
Submission 2018	kt	319.6	245.2	239.1	186.9	156.4	146.2
Difference	kt	17.3	11.1	5.5	3.6	10.0	8.3
	%	5.74	4.75	2.36	1.94	6.85	5.99
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.03109	0.02386	0.02414	0.01881	0.01480	0.01399
Submission 2018	kt	0.03309	0.02513	0.02478	0.01921	0.01595	0.01494
Difference	kt	0.00200	0.00127	0.00064	0.00040	0.00115	0.00095
	%	6.43	5.34	2.63	2.14	7.77	6.77
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00466	0.00358	0.00362	0.00282	0.00222	0.00210
Submission 2018	kt	0.00496	0.00377	0.00372	0.00288	0.00239	0.00224
Difference	kt	0.00030	0.00019	0.00010	0.00006	0.00017	0.00014
	%	6.43	5.34	2.63	2.14	7.77	6.77

Tab. 3-30 Changes after recalculation in 1.A.2.d for Natural Gas

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	3 109.4	2 385.9	2 414.3	1 881.2	1 480.4	1 398.9
Submission 2018	TJ	4 559.2	4 885.9	4 829.5	4 766.8	4 710.7	5 045.4
Difference	TJ	18.8	19.8	20.6	19.6	20.2	21.6
	%	0.41	0.40	0.43	0.41	0.43	0.43
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	252.1	270.0	266.6	263.6	260.7	279.6
Submission 2018	kt	253.1	271.1	267.7	264.7	261.9	280.5
Difference	kt	1.0	1.1	1.1	1.1	1.1	0.9
	%	0.41	0.40	0.43	0.41	0.43	0.32
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00456	0.00489	0.00483	0.00477	0.00471	0.00505
Submission 2018	kt	0.00458	0.00491	0.00485	0.00479	0.00473	0.00507
Difference	kt	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	%	0.41	0.40	0.43	0.41	0.43	0.43
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00046	0.00049	0.00048	0.00048	0.00047	0.00050
Submission 2018	kt	0.00046	0.00049	0.00049	0.00048	0.00047	0.00051
Difference	kt	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	%	0.41	0.40	0.43	0.41	0.43	0.43

After QA/QC activity data for Liquid Fuels in 2018 were updated.

Tab. 3-31 Changes after recalculation in 1.A.2.d for Liquid Fuels in years 1994-2013

Fuel consumption		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Submission 2017	TJ	4 332	4 592	4 964	3 140	2 789	2 398	3 397	4 269	2 590	799
Submission 2018	TJ	3 167	3 054	3 317	2 141	1 219	1 329	964	3 480	2 038	360

Difference	TJ	-1 165	-1 538	-1 647	-998	-1 570	-1 068	-2 433	-789	-552	-439
	%	-26.89	-33.49	-33.17	-31.80	-56.28	-44.56	-71.63	-18.47	-21.32	-54.95
Fuel consumption		**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Submission 2017	TJ	732	2 525	1 043	760	785	728	700	217	202	205
Submission 2018	TJ	515	1 034	1 046	837	923	700	701	228	210	210
Difference	TJ	-218	-1 491	3	78	138	-28	1	11	7	5
	%	-29.74	-59.06	0.33	10.24	17.55	-3.91	0.15	5.30	3.66	2.56
CO_2 emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Submission 2017	kt	335	355	384	243	215	183	262	329	198	61
Submission 2018	kt	245	236	256	165	94	101	73	268	157	28
Difference	kt	-90	-119	-127	-77	-122	-83	-188	-61	-41	-34
	%	-26.91	-33.51	-33.19	-31.85	-56.43	-45.08	-71.96	-18.53	-20.70	-54.69
CO_2 emissions		**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Submission 2017	kt	56	192	80	59	61	56	54	17	16	16
Submission 2018	kt	40	80	80	65	71	54	54	18	16	16
Difference	kt	-17	-111	0	6	11	-2	0	1	1	0
	%	-29.44	-58.21	0.58	10.24	17.55	-3.91	0.58	5.32	3.66	2.56
CH_4 emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Submission 2017	kt	0.0130	0.0138	0.0149	0.0094	0.0084	0.0069	0.0101	0.0127	0.0077	0.0024
Submission 2018	kt	0.0095	0.0092	0.0100	0.0064	0.0037	0.0037	0.0028	0.0103	0.0060	0.0011
Difference	kt	-0.0035	-0.0046	-0.0049	-0.0030	-0.0047	-0.0032	-0.0073	-0.0024	-0.0017	-0.0013
	%	-26.89	-33.49	-33.17	-31.80	-56.28	-46.34	-72.28	-18.60	-21.57	-54.95
CH_4 emissions		**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Submission 2017	kt	0.0022	0.0076	0.0030	0.0023	0.0024	0.0022	0.0021	0.0007	0.0006	0.0006
Submission 2018	kt	0.0015	0.0031	0.0030	0.0025	0.0028	0.0021	0.0021	0.0007	0.0006	0.0006
Difference	kt	-0.0007	-0.0045	0.0000	0.0002	0.0004	-0.0001	0.0000	0.0000	0.0000	0.0000
	%	-29.74	-59.06	0.34	10.24	17.55	-3.91	2.07	5.30	3.66	2.56
N_2O emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Submission 2017	kt	0.0026	0.0028	0.0030	0.0019	0.0017	0.0014	0.0020	0.0025	0.0015	0.0005
Submission 2018	kt	0.0019	0.0018	0.0020	0.0013	0.0007	0.0007	0.0006	0.0021	0.0012	0.0002
Difference	kt	-0.0007	-0.0009	-0.0010	-0.0006	-0.0009	-0.0006	-0.0015	-0.0005	-0.0003	-0.0003
	%	-26.89	-33.49	-33.17	-31.80	-56.28	-46.80	-72.44	-18.64	-21.64	-54.95
N_2O emissions		**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Submission 2017	kt	0.0004	0.0015	0.0006	0.0005	0.0005	0.0004	0.0004	0.0001	0.0001	0.0001
Submission 2018	kt	0.0003	0.0006	0.0006	0.0005	0.0006	0.0004	0.0004	0.0001	0.0001	0.0001
Difference	kt	-0.0001	-0.0009	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
	%	-29.74	-59.06	0.34	10.24	17.55	-3.91	2.56	5.30	3.66	2.56

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

Currently there are no planned improvements in this category.

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

3.2.15.1 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, 2016									
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**		
	data	**EF**	**OxF**	**Emissions**	**EF**	**Emissions**	**EF**	**Emissions**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
LPG	91.9	65.9	1	6.1	1	0.00009	0.1	0.00001
Heating and Other Gasoil	85.2	74.1	1	6.3	3	0.00026	0.6	0.00005
Fuel Oil - Low Sulphur	87.3	77.4	1	6.8	3	0.00026	0.6	0.00005
Fuel Oil - High Sulphur	39.5	77.4	1	3.1	3	0.00012	0.6	0.00002
Other Bituminous Coal	559.5	94.4*)	0.971*)	51.3	10	0.00560	1.5	0.00084
Brown Coal + Lignite	1 446.0	100.2*)	0.985*)	141.0	10	0.01446	1.5	0.00217
Coke	196.8	107	1	21.1	10	0.00197	1.5	0.00030
Natural Gas	14 153.2	55.4*)	1	784.1	1	0.01415	0.1	0.00142
Wood/Wood Waste	465.5	112	1	52.1	30	0.01396	4	0.00186
Gaseous Biomass	8 821.5	54.6	1	481.7	1	0.00882	0.1	0.00088
Total year 2016	**25 946**			**1020.49**		**0.05969**		**0.00760**
Total year 2015	26 335			1018.41		0.06544		0.00837
Index 2016/2015	0.99			1.00		0.91		0.91
Total year 1990	37 616			2 988.2		0.21342		0.03226
Index 2016/1990	0.69			0.52		0.28		0.24

*) *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.

2016							
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Heating and Other Gasoil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - Low Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - High Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other 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, 2017), 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

The fraction of CO_2 emissions in subsector 1.A.2.e in CO_2 emissions in sector 1.A.2 equalled 11% in 2016. It contributed 1.1% to CO_2 emissions in the whole Energy sector.

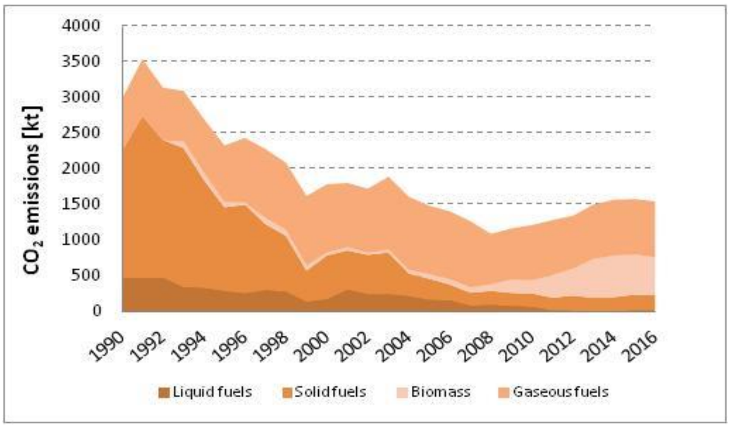

Fig. 3-16 Development of CO_2 emissions from fossil fuels combustion in source category 1.A.2.e

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

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

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

3.2.15.2 Methodological issues (CRF 1.A.2.e)

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

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

See chapter 3.2.5.

3.2.15.4 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.

3.2.15.5 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. 3-32 Changes after recalculation in 1.A.2.e for Solid Fuels

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	1 808.3	1 705.1	2 100.9	1 909.7	1 977.9	2 248.4
Submission 2018	TJ	1 947.4	1 794.8	2 150.2	1 914.2	2 012.8	2 255.5
Difference	TJ	139.0	89.7	49.3	4.5	34.9	7.1
	%	7.69	5.26	2.34	0.24	1.76	0.31
CO_2 emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	176.1	166.3	206.0	186.7	192.7	218.6
Submission 2018	kt	188.5	174.4	210.3	187.2	195.8	219.3

Difference	kt	12.4	8.1	4.3	0.5	3.1	0.7
	%	7.05	4.90	2.07	0.25	1.61	0.33
CH_4 emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.01808	0.01705	0.02101	0.01910	0.01978	0.02248
Submission 2018	kt	0.01947	0.01795	0.02150	0.01914	0.02013	0.02255
Difference	kt	0.00139	0.00090	0.00049	0.00005	0.00035	0.00007
	%	7.69	5.26	2.34	0.24	1.76	0.31
N_2O emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.00271	0.00256	0.00315	0.00286	0.00297	0.00337
Submission 2018	kt	0.00292	0.00269	0.00323	0.00287	0.00302	0.00338
Difference	kt	0.00021	0.00013	0.00007	0.00001	0.00005	0.00001
	%	7.69	5.26	2.34	0.24	1.76	0.31

Tab. 3-33 Changes after recalculation in 1.A.2.e for Natural Gas

Fuel consumption		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	TJ	14 006.8	13 863.7	13 410.0	13 743.4	14 087.6	13 962.5
Submission 2018	TJ	14 064.6	13 919.7	13 467.1	13 800.0	14 148.1	14 022.3
Difference	TJ	57.8	56.1	57.1	56.6	60.5	59.8
	%	4.13	4.04	4.26	4.12	4.29	4.28
CO_2 emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	774.4	766.1	740.2	760.0	779.8	773.8
Submission 2018	kt	777.6	769.2	743.4	763.2	783.1	776.3
Difference	kt	3.2	3.1	3.2	3.1	3.3	2.5
	%	4.13	4.04	4.26	4.12	4.29	3.23
CH_4 emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.01401	0.01386	0.01341	0.01374	0.01409	0.01396
Submission 2018	kt	0.01406	0.01392	0.01347	0.01380	0.01415	0.01402
Difference	kt	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
	%	4.13	4.04	4.26	4.12	4.29	4.28
N_2O emissions		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.00140	0.00139	0.00134	0.00137	0.00141	0.00140
Submission 2018	kt	0.00141	0.00139	0.00135	0.00138	0.00141	0.00140
Difference	kt	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
	%	4.13	4.04	4.26	4.12	4.29	4.28

After QA/QC activity data for Liquid Fuels in 2018 were updated.

Tab. 3-34 Changes after recalculation in 1.A.2.e for Liquid Fuels in years 1994-2012 and 2014-2015

Fuel consumption		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Submission 2017	TJ	4 165	3 287	2 638	3 819	3 613	1 766	2 032	3 976	3 295	3 237	2 872
Submission 2018	TJ	4 434	3 818	3 381	4 081	3 807	1 919	2 417	4 116	3 303	3 257	2 896
Difference	TJ	269	531	743	261	194	153	386	139	8	20	24
	%	6.46	16.16	28.16	6.85	5.37	8.64	18.99	3.50	0.23	0.61	0.84
Fuel consumption		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2014**	**2015**	
Submission 2017	TJ	2 177	1 721	1 001	1 051	812	783	288	250	171	300	
Submission 2018	TJ	2 215	2 131	1 156	1 305	1 110	939	312	255	175	314	
Difference	TJ	38	411	156	254	298	156	24	5	4	14	
	%	1.76	23.87	15.55	24.19	36.69	19.90	8.29	1.97	2.43	4.79	
CO_2 emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Submission 2017	kt	318	252	204	287	271	132	151	302	250	248	221
Submission 2018	kt	338	293	262	307	286	144	181	313	251	250	223
Difference	kt	21	41	57	20	15	12	30	11	1	2	2

	%	6.55	16.31	28.18	7.04	5.54	8.94	19.80	3.56	0.23	0.61	0.83
CO_2 emissions		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2014**	**2015**	
Submission 2017	kt	167	132	77	80	62	60	21	18	12	22	
Submission 2018	kt	170	164	89	100	85	72	23	19	12	23	
Difference	kt	3	32	12	20	23	12	2	0	0	1	
	%	1.75	24.03	15.71	24.59	37.49	20.26	8.63	2.07	2.67	5.13	
CH_4 emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Submission 2017	kt	0.0125	0.0098	0.0079	0.0115	0.0108	0.0051	0.0057	0.0116	0.0095	0.0094	0.0085
Submission 2018	kt	0.0133	0.0114	0.0101	0.0122	0.0114	0.0056	0.0069	0.0120	0.0095	0.0095	0.0086
Difference	kt	0.0008	0.0016	0.0022	0.0008	0.0006	0.0005	0.0012	0.0004	0.0000	0.0001	0.0001
	%	6.46	16.31	28.16	6.85	5.37	8.95	20.21	3.61	0.24	0.62	0.85
CH_4 emissions		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2014**	**2015**	
Submission 2017	kt	0.0064	0.0051	0.0029	0.0030	0.0023	0.0022	0.0008	0.0007	0.0003	0.0007	
Submission 2018	kt	0.0066	0.0063	0.0034	0.0037	0.0031	0.0027	0.0008	0.0007	0.0003	0.0008	
Difference	kt	0.0001	0.0012	0.0005	0.0008	0.0009	0.0005	0.0001	0.0000	0.0000	0.0000	
	%	1.78	24.30	16.04	25.69	39.68	21.08	9.28	2.24	3.78	6.01	
N_2O emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Submission 2017	kt	0.0025	0.0019	0.0016	0.0023	0.0022	0.0010	0.0011	0.0023	0.0019	0.0019	0.0017
Submission 2018	kt	0.0027	0.0023	0.0020	0.0024	0.0023	0.0011	0.0014	0.0024	0.0019	0.0019	0.0017
Difference	kt	0.0002	0.0003	0.0004	0.0002	0.0001	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000
	%	6.46	16.35	28.16	6.85	5.37	9.04	20.54	3.64	0.24	0.63	0.85
N_2O emissions		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2014**	**2015**	
Submission 2017	kt	0.0013	0.0010	0.0006	0.0006	0.0004	0.0004	0.0001	0.0001	0.0001	0.0001	
Submission 2018	kt	0.0013	0.0013	0.0007	0.0007	0.0006	0.0005	0.0002	0.0001	0.0001	0.0001	
Difference	kt	0.0000	0.0002	0.0001	0.0002	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	
	%	1.79	24.41	16.17	26.09	40.50	21.39	9.56	2.32	4.39	6.43	

3.2.15.6 Category-specific planned improvements (CRF 1.A.2.e)

Currently there are no planned improvements in this category.

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

3.2.16.1 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, 2016								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emissions**	**EF**	**Emissions**	**EF**	**Emissions**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
LPG	107.2	65.86	1	7.1	1	0.00011	0.1	0.00001
Heating and Other Gasoil	255.6	74.1	1	18.9	3	0.00077	0.6	0.00015
Fuel Oil - Low Sulphur	43.7	77.4	1	3.4	3	0.00013	0.6	0.00003
Fuel Oil - High Sulphur	158.0	77.4	1	12.2	3	0.00047	0.6	0.00009
Other Oil	39.2	73.3	1	2.9	3	0.0	0.6	0.0
Antracit	251.8	98.3	1	24.8	10	0.0	1.5	0.0
Other Bituminous Coal	251.8	94.47*)	0.971*)	430.4	10	0.04694	1.5	0.00704

1.A.2.f, 2016								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emissions	EF	Emissions	EF	Emissions
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
Brown Coal + Lignite	4 693.9	99.02*)	0.985*)	30.0	10	0.00308	1.5	0.00046
Coke	307.7	107	1	105.3	10	0.00984	1.5	0.00148
Coal Tars	984.1	80.7	1	66.7	10	0.00826	1.5	0.00124
Cove Oven Gas	64.6	44.4	1	2.9	1	0.00006	0.1	0.00001
Natural Gas	23 061.4	55.40*)	1	1 277.6	1	0.02306	0.1	0.00231
Other fuels - liquid	3 035.4	84.26*)	1	255.8	30	0.09106	4	0.01214
Other fuels - solid	2 020.7	97.68*)	1	197.4	30	0.06062	4	0.00808
Wood/Wood Waste	106.4	112	1	11.9	30	0.00319	4	0.00043
Total year 2016	**35955.7**			**2437.8**		**0.25023**		**0.03387**
Total year 2015	35 337.4			2 356.1		0.19726		0.02687
Index 2016/2015	1.00			1.04		1.27		1.26
Total year 1990	59 962.4			4 527.1		0.29373		0.04487
Index 2016/1990	0.59			0.54		0.85		0.75

*) *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.

2016							
Structure of Fuels	Source of Activity data	Emission factors			Method used		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Heating and Other Gasoil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - Low Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - High Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other Oil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Antracit	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, 2017), 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

The fraction of CO_2 emissions in subsector 1.A.2.f in CO_2 emissions in sector 1.A.2 equalled 26.2% in 2016. It contributed 2.6% to CO_2 emissions in the whole Energy sector.

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

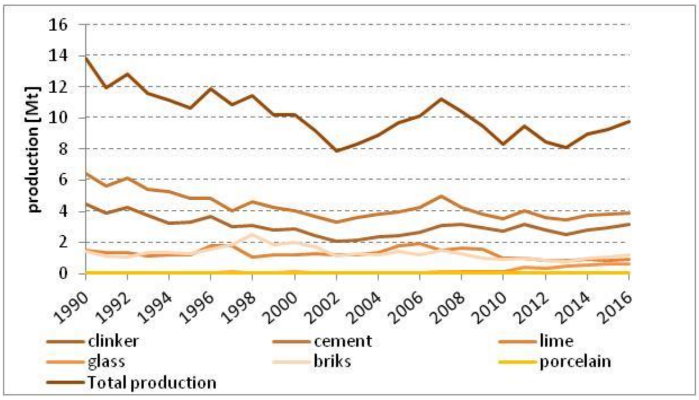

Fig. 3-17 Production of the most important mineral products

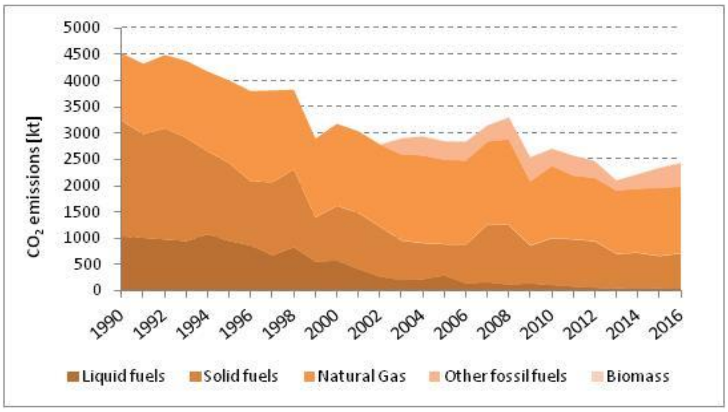

Fig. 3-18 Development of CO_2 emissions in source category 1.A.2.f

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

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

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

3.2.16.2 Methodological issues (CRF 1.A.2.f)

The category of Non-Metallic Minerals reports consumption of alternative fuels (Other fuels). The compilation consumption balance and the determination of the emission factors are different from the procedures used for other fuels, as described in section 3.2.4. The basic source of information is the ETS database, where the emission factors for different types of alternative fuels are available. At the same time, data from the REZZO national emission database are used, where data are available on the consumption of alternative fuels in the whole time series since 2003. The resulting processed data on consumption of alternative fuels is further corrected according to the data on the server of the Union of cement and lime manufacturers (www.svcement.cz). Alternative fuel consumption is shown in Tab. 3-35.

Tab. 3-35 Consumption of alternative fuels in sector 1.A.2.f

[TJ/year]	2003	2004	2005	2006	2007	2008	2009
Solid fuels	2 424	3 200	3 517	3 398	3 726	5 037	5 537
Liquid fuels	1 266	1 156	589	1 014	240	557	682
Total	3 690	4 356	4 105	4 412	3 966	5 594	6 219
[TJ/year]	2010	2011	2012	2013	2014	2015	2016
Solid fuels	3 224	3 885	3 055	1 137	3 234	3 576	3 035
Liquid fuels	708	661	394	1 181	18	1 017	2 021
Total	3 932	4 546	3 449	2 318	3 252	4 593	5 056

Emission factors for calculating CO_2 emissions vary according to composition of the individual types of fuel (solid, liquid fuels). As a solid alternative fuels are used variety of sorted waste, used tires, animal meal, etc. Among the alternative liquid fuels are included mainly used oils, waste petroleum products, or even rendered fats. The resulting emission factor corresponds to the relative representation of individual types of fuels. In Tab. 3-36 is shown an overview of emission factors used for solid and liquid alternative fuels in different years.

Tab. 3-36 CO_2 emission factors used in the consumption of alternative fuels in sector 1.A.2.f

[t CO_2/TJ]	2003	2004	2005	2006	2007	2008	2009
Solid fuels	95.5	87.6	44.2	77.2	17.5	40.1	44.0
Liquid fuels	212.2	279.9	311.4	287.2	291.6	381.2	419.0
[t CO_2/TJ]	2010	2011	2012	2013	2014	2015	2016
Solid fuels	57.5	51.2	30.5	91.9	1.3	80.7	255.8
Liquid fuels	274.8	333.3	293.8	105.5	278.2	306.5	197.4

For the calculation of CH_4 and N_2O emissions were used default emission factors in line with the IPCC methodology 2006 (IPCC 2006), for the entire time series 2003-2016 (Tab. 3-37).

Tab. 3-37 Emission factors for CH_4 and N_2O emissions used in the consumption of alternative fuels sector 1.A.2.f

EF [kg/TJ]	CH_4	N_2O
Solid fuels	30	4
Liquid fuels	30	4

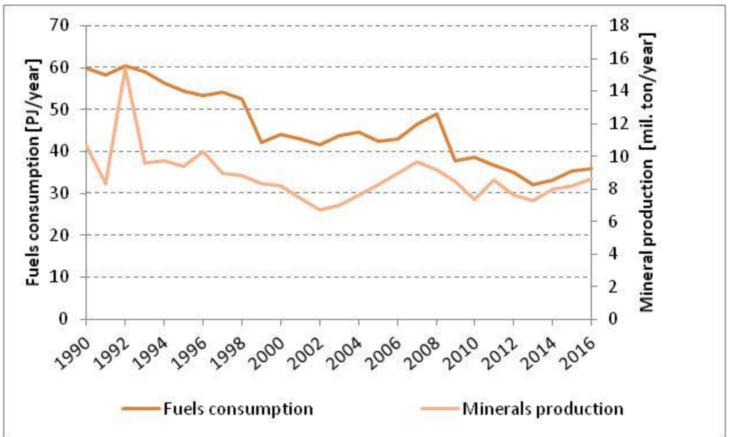

Fig. 3-19 Trends in production of mineral products compared with the development of fuel consumption in the sector 1.A.2.f

3.2.16.3 Uncertainties and time-series consistency (CRF 1.A.2.f)

See chapter 3.2.5.

3.2.16.4 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.

3.2.16.5 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. 3-38 Changes after recalculation in 1.A.2.f for Solid Fuels

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	8 535.3	9 228.4	9 000.2	7 488.4	7 436.9	6 787.7
Submission 2018	TJ	9 538.2	9 738.4	9 641.3	7 152.2	7 423.4	6 653.9
Difference	TJ	1 002.9	510.0	641.1	-336.3	-13.5	-133.8
	%	11.75	5.53	7.12	-4.49	-0.18	-1.97
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	803.7	853.4	829.3	683.9	682.3	623.8
Submission 2018	kt	896.0	903.2	890.3	659.9	685.1	614.9
Difference	kt	92.2	49.7	61.0	-23.9	2.8	-8.8
	%	11.47	5.83	7.36	-3.50	0.41	-1.41
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.08494	0.09178	0.08943	0.07431	0.07381	0.06729
Submission 2018	kt	0.09497	0.09688	0.09584	0.07095	0.07367	0.06596
Difference	kt	0.01003	0.00510	0.00641	-0.00336	-0.00013	-0.00134
	%	11.81	5.56	7.17	-4.53	-0.18	-1.99
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.01274	0.01376	0.01341	0.01114	0.01107	0.01009
Submission 2018	kt	0.01424	0.01453	0.01437	0.01064	0.01105	0.00989
Difference	kt	0.00150	0.00076	0.00096	-0.00050	-0.00002	-0.00020
	%	11.81	5.56	7.17	-4.53	-0.18	-1.99

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

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	24 884.2	21 985.1	21 788.4	21 727.3	22 092.4	23 396.2
Submission 2018	TJ	24 986.9	22 074.0	21 881.2	21 816.8	22 187.3	23 496.3
Difference	TJ	102.8	88.9	92.7	89.5	94.9	100.1
	%	0.41	0.40	0.42	0.41	0.43	0.43
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	1 375.8	1 214.9	1 202.7	1 201.6	1 222.9	1 296.6
Submission 2018	kt	1 381.5	1 219.8	1 207.8	1 206.5	1 228.1	1 300.8
Difference	kt	5.7	4.9	5.1	4.9	5.3	4.2
	%	0.41	0.40	0.42	0.41	0.43	0.32
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.02488	0.02199	0.02179	0.02173	0.02209	0.02340
Submission 2018	kt	0.02499	0.02207	0.02188	0.02182	0.02219	0.02350
Difference	kt	0.00010	0.00009	0.00009	0.00009	0.00009	0.00010
	%	0.41	0.40	0.42	0.41	0.43	0.43
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00249	0.00220	0.00218	0.00217	0.00221	0.00234
Submission 2018	kt	0.00250	0.00221	0.00219	0.00218	0.00222	0.00235
Difference	kt	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
	%	0.41	0.40	0.42	0.41	0.43	0.43

After QA/QC activity data for Liquid Fuels in 2018 were updated.

Tab. 3-40 Changes after recalculation in 1.A.2.f for Liquid Fuels in years 1994-2013 and 2015

Fuel consumption		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Submission 2017	TJ	12 532	10 361	9 096	7 451	9 040	5 876	4 750	3 529	3 021	2 248	2 610
Submission 2018	TJ	13 922	12 246	11 161	8 770	10 739	7 138	7 421	5 338	3 494	2 634	2 796
Difference	TJ	1 390	1 885	2 065	1 319	1 699	1 262	2 671	1 809	473	386	186
	%	11.09	18.20	22.70	17.70	18.80	21.47	56.22	51.26	15.65	17.18	7.13
Fuel consumption		2005	2006	2007	2008	2009	2010	2011	2012	2013	2015	
Submission 2017	TJ	2 709	1 665	1 991	1 430	1 503	1 272	972	729	565	587	
Submission 2018	TJ	3 740	1 801	2 022	1 477	1 736	1 386	983	689	571	594	
Difference	TJ	1 032	136	31	47	233	114	11	-40	5	8	
	%	38.09	8.19	1.56	3.29	15.53	8.99	1.09	-5.50	0.93	1.32	
CO_2 emissions		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Submission 2017	kt	967	800	700	571	695	452	364	269	228	172	200
Submission 2018	kt	1 075	946	860	673	827	550	570	409	264	201	215
Difference	kt	108	146	160	102	132	98	207	140	36	30	14
	%	11.12	18.23	22.82	17.87	18.91	21.60	56.83	52.02	15.58	17.31	7.12
CO_2 emissions		2005	2006	2007	2008	2009	2010	2011	2012	2013	2015	
Submission 2017	kt	206	127	153	108	114	95	73	55	42	43	
Submission 2018	kt	284	138	155	112	132	104	74	52	43	44	
Difference	kt	78	10	2	4	18	9	1	-3	0	1	
	%	37.77	8.22	1.58	3.36	15.84	9.32	1.14	-5.43	0.96	1.33	
CH_4 emissions		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Submission 2017	kt	0.0376	0.0311	0.0273	0.0224	0.0271	0.0176	0.0141	0.0104	0.0088	0.0066	0.0077
Submission 2018	kt	0.0418	0.0367	0.0335	0.0263	0.0322	0.0214	0.0221	0.0158	0.0102	0.0077	0.0083
Difference	kt	0.0042	0.0057	0.0062	0.0040	0.0051	0.0038	0.0080	0.0054	0.0014	0.0012	0.0006
	%	11.09	18.20	22.70	17.70	18.80	21.47	56.96	52.17	16.15	17.67	7.21
CH_4 emissions		2005	2006	2007	2008	2009	2010	2011	2012	2013	2015	
Submission 2017	kt	0.0080	0.0049	0.0059	0.0041	0.0044	0.0037	0.0028	0.0021	0.0016	0.0016	
Submission 2018	kt	0.0111	0.0053	0.0060	0.0042	0.0051	0.0040	0.0029	0.0020	0.0016	0.0016	
Difference	kt	0.0031	0.0004	0.0001	0.0001	0.0007	0.0003	0.0000	-0.0001	0.0000	0.0000	
	%	38.52	8.35	1.59	3.44	15.85	9.31	1.13	-5.74	0.98	1.47	
N_2O emissions		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Submission 2017	kt	0.0075	0.0062	0.0055	0.0045	0.0054	0.0035	0.0028	0.0021	0.0017	0.0013	0.0015
Submission 2018	kt	0.0084	0.0073	0.0067	0.0053	0.0064	0.0043	0.0044	0.0032	0.0020	0.0015	0.0017
Difference	kt	0.0008	0.0011	0.0012	0.0008	0.0010	0.0008	0.0016	0.0011	0.0003	0.0002	0.0001
	%	11.09	18.20	22.70	17.70	18.80	21.47	57.14	52.40	16.27	17.79	7.23
N_2O emissions		2005	2006	2007	2008	2009	2010	2011	2012	2013	2015	
Submission 2017	kt	0.0016	0.0010	0.0012	0.0008	0.0009	0.0007	0.0006	0.0004	0.0003	0.0003	
Submission 2018	kt	0.0022	0.0011	0.0012	0.0008	0.0010	0.0008	0.0006	0.0004	0.0003	0.0003	
Difference	kt	0.0006	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	
	%	38.64	8.39	1.59	3.48	15.93	9.39	1.14	-5.81	1.00	1.52	

3.2.16.6 Category-specific planned improvements (CRF 1.A.2.f)

Currently there are no planned improvements in this category.

3.2.17 Manufacturing industries and construction – Other (1.A.2.g)

3.2.17.1 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, 2016								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emissions	EF	Emissions	EF	Emissions
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
LPG	1 102.7	65.86*)	1	72.6	1	0.00110	0.1	0.00011
Heating and Other Gasoil	309.8	74.1	1	66.3	3	0.00268	0.6	0.00054
Fuel Oil - Low Sulphur	894.6	77.4	1	43.9	3	0.00170	0.6	0.00034
Fuel Oil - High Sulphur	567.6	77.4	1	15.3	3	0.00059	0.6	0.00012
Anthracite	56.0	98.3	1	5.5	10	0.00345	1.5	0.00008
Other Bitumenous Coal	31.1	94.47*)	0.971*)	2.9	10	0.00031	1.5	0.00005
Brown Coal + Lignite	846.1	99.02*)	0.985*)	82.5	10	0.00846	1.5	0.00127
Coke	196.8	107	1	21.1	10	0.00197	1.5	0.00030
Cove Oven Gas	24.9	44.4	1	1.1	1	0.00002	0.1	0.00000
Natural Gas	34 230.9	55.40*)	1	1 896.4	1	0.03423	0.1	0.00342
Wood/Wood Waste	10 325.1	112	1	1 156.4	30	0.30975	4	0.04130
Gaseous Biomass	261.4	54.6	1	14.3	1	0.00026	0.1	0.00003
Total year 201	**48734.6**			**2207.87**		**0.36454**		**0.04755**
Total year 201	49 884.3			2381.26		0.32708		0.04412
Index 2016/2015	0.98			0.93		1.11		1.08
Total year 1990	301 656.3			23170.72		1.97324		0.29944
Index 2016/1990	0.16			0.09		0.18		0.16

*) *Country specific data*

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

2016							
Structure of Fuels	Source of	Emission factors			Method used		
	Activity data	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Heating and Other Gasoil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - Low Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - High Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Antracit	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.

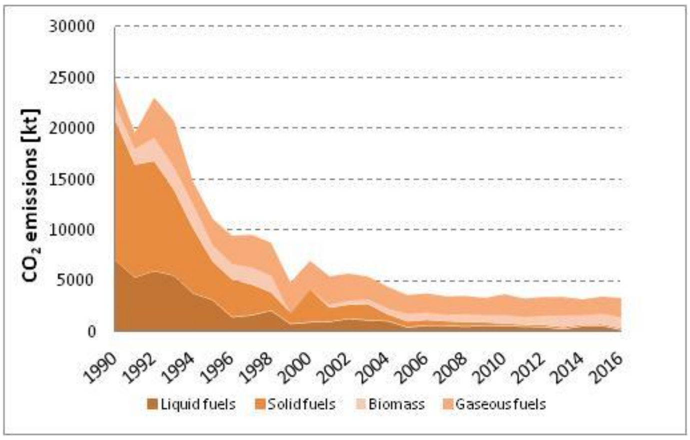

Fig. 3-20 Development of CO_2 emissions in source category 1.A.2.g

In the CzSO Questionnaire (CzSO, 2017), 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)

There are embodied the fuels of economic part according to NACE Rev. 2 Other: NACE Divisions 05 – 09, 13 – 16, 21 – 22, 25 – 33 and 41 – 43.

The fraction of CO_2 emissions in subsector 1.A.2.f in CO_2 emissions in sector 1.A.2 equalled 23.7% in 2016. It contributed 2.3% to CO_2 emissions in the whole Energy sector. Overall emissions have exhibited a decrease since 1990. At the beginning of the period, solid Fuels were of major importance, but this has constantly decreased until 2016. Liquid fuels have also constantly decreased in importance since 1990. Natural Gas is also important fuel in this category.

The graph in Fig. 3-20 shows that the beginning of the period was characterised by highly energy-intensive types of industrial processes in this category. Social changes occurring in the Czech Republic in the early 90s resulted in energy-saving measures being introduced by newly privatized enterprises. Together, these influences led to an end to inefficient production and suppression of consumption, particularly of fossil fuels, which were the dominant fuels at the beginning of the period and virtually disappeared by 2005, when they were replaced by biomass. At the same time, the importance of liquid fuels decreased. All this was reflected very significantly by a decline in the CO_2 emissions (and other greenhouse gases). This is the category with the largest relative decrease in CO_2 emissions from 1990 to 2016 (90% decrease).

3.2.17.2 Methodological issues (CRF 1.A.2.g)

Sector specific methodological approaches were not used, the general approaches are given in chapter 3.2.4.

3.2.17.3 Uncertainties and time-series consistency (CRF 1.A.2.g)

See chapter 3.2.5.

3.2.17.4 Category-specific QA/QC and verification (CRF 1.A.2.g)

See chapter 3.2.6.

3.2.17.5 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. 3-41 Changes after recalculation in 1.A.2.g for Solid Fuels

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	2 165.2	1 546.8	1 483.3	1 461.9	1 435.9	1 353.2
Submission 2018	TJ	2 264.9	1 620.8	1 517.4	1 506.7	1 152.9	1 172.6
Difference	TJ	99.7	73.9	34.0	44.7	-283.0	-180.6
	%	4.60	4.78	2.29	3.06	-19.71	-13.34
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	191.7	146.2	144.4	143.8	141.9	133.5
Submission 2018	kt	200.5	152.6	147.4	147.7	113.4	115.2
Difference	kt	8.9	6.4	3.0	3.9	-28.5	-18.3
	%	4.63	4.41	2.05	2.72	-20.09	-13.71
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.01813	0.01428	0.01434	0.01428	0.01404	0.01324
Submission 2018	kt	0.01917	0.01502	0.01468	0.01473	0.01121	0.01144
Difference	kt	0.00104	0.00074	0.00034	0.00045	-0.00283	-0.00181
	%	5.75	5.18	2.37	3.13	-20.16	-13.63
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00270	0.00213	0.00215	0.00214	0.00210	0.00198
Submission 2018	kt	0.00286	0.00225	0.00220	0.00221	0.00168	0.00171
Difference	kt	0.00016	0.00011	0.00005	0.00007	-0.00042	-0.00027
	%	5.80	5.19	2.38	3.14	-20.18	-13.65

Tab. 3-42 Changes after recalculation in 1.A.2.g for Natural Gas

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	36 835.1	32 608.3	33 520.6	32 799.5	28 146.5	30 055.8
Submission 2018	TJ	36 987.2	32 740.2	33 663.2	32 934.5	28 267.3	30 184.4
Difference	TJ	152.1	131.9	142.7	135.1	120.9	128.6
	%	0.41	0.40	0.43	0.41	0.43	0.43
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	2 036.5	1 801.9	1 850.3	1 813.9	1 558.0	1 665.7
Submission 2018	kt	2 044.9	1 809.2	1 858.2	1 821.3	1 564.7	1 671.1
Difference	kt	8.4	7.3	7.9	7.5	6.7	5.4
	%	0.41	0.40	0.43	0.41	0.43	0.32
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.03684	0.03261	0.03352	0.03280	0.02815	0.03006
Submission 2018	kt	0.03699	0.03274	0.03366	0.03293	0.02827	0.03018
Difference	kt	0.00015	0.00013	0.00014	0.00014	0.00012	0.00013
	%	0.41	0.40	0.43	0.41	0.43	0.43
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00368	0.00326	0.00335	0.00328	0.00281	0.00301
Submission 2018	kt	0.00370	0.00327	0.00337	0.00329	0.00283	0.00302
Difference	kt	0.00002	0.00001	0.00001	0.00001	0.00001	0.00001
	%	0.41	0.40	0.43	0.41	0.43	0.43

After QA/QC activity data for Liquid Fuels in 2018 were updated.

Tab. 3-43 Changes after recalculation in 1.A.2.g for Liquid Fuels in years 1994-2015

Fuel consumption		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Submission 2017	TJ	50 500	42 685	20 281	22 100	28 086	10 535	13 239	14 629	17 429	15 540	14 352
Submission 2018	TJ	50 006	41 806	19 120	21 518	27 762	10 189	12 616	13 469	17 500	15 573	14 360
Difference	TJ	-494	-879	-1 161	-582	-323	-346	-623	-1 160	72	33	8
	%	-0.98	-2.06	-5.73	-2.63	-1.15	-3.28	-4.71	-7.93	0.41	0.21	0.05
Fuel consumption		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	TJ	5 728	8 816	8 340	7 242	9 010	8 212	7 002	6 531	3 724	7 510	8 234
Submission 2018	TJ	6 150	8 265	8 076	6 803	8 507	7 770	6 956	6 517	3 671	7 677	8 166
Difference	TJ	422	-551	-264	-439	-503	-442	-46	-15	-53	166	-68
	%	7.36	-6.24	-3.17	-6.06	-5.58	-5.38	-0.66	-0.23	-1.43	2.21	-0.83
CO_2 emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Submission 2017	kt	3 812	3 188	1 526	1 666	2 105	796	982	1 079	1 279	1 135	1 045
Submission 2018	kt	3 774	3 120	1 436	1 621	2 080	770	933	990	1 283	1 137	1 046
Difference	kt	-38	-68	-90	-45	-25	-27	-48	-90	5	2	1
	%	-1.00	-2.13	-5.89	-2.70	-1.19	-3.36	-4.91	-8.32	0.38	0.21	0.05
CO_2 emissions		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	414	651	622	537	669	614	521	482	275	545	600
Submission 2018	kt	445	608	602	503	630	580	517	481	271	558	595
Difference	kt	31	-43	-20	-34	-39	-34	-4	-1	-4	12	-5
	%	7.42	-6.56	-3.29	-6.33	-5.82	-5.52	-0.69	-0.24	-1.44	2.26	-0.79
CH_4 emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Submission 2017	kt	0.1515	0.1277	0.0603	0.0660	0.0835	0.0307	0.0368	0.0407	0.0495	0.0429	0.0394
Submission 2018	kt	0.1500	0.1251	0.0568	0.0643	0.0826	0.0296	0.0349	0.0372	0.0497	0.0430	0.0394
Difference	kt	-0.0015	-0.0026	-0.0035	-0.0017	-0.0010	-0.0010	-0.0019	-0.0035	0.0002	0.0001	0.0000
	%	-0.98	-2.06	-5.78	-2.64	-1.16	-3.38	-5.08	-8.55	0.43	0.23	0.06
CH_4 emissions		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.0133	0.0249	0.0243	0.0212	0.0267	0.0240	0.0205	0.0188	0.0104	0.0202	0.0232
Submission 2018	kt	0.0146	0.0232	0.0235	0.0199	0.0252	0.0227	0.0204	0.0187	0.0103	0.0207	0.0231
Difference	kt	0.0013	-0.0017	-0.0008	-0.0013	-0.0015	-0.0014	-0.0001	0.0000	-0.0002	0.0005	-0.0001
	%	9.49	-6.64	-3.27	-6.22	-5.66	-5.68	-0.67	-0.24	-1.53	2.46	-0.48
N_2O emissions		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Submission 2017	kt	0.0303	0.0255	0.0120	0.0132	0.0167	0.0061	0.0072	0.0080	0.0098	0.0084	0.0077
Submission 2018	kt	0.0300	0.0250	0.0113	0.0128	0.0165	0.0059	0.0068	0.0073	0.0098	0.0084	0.0077
Difference	kt	-0.0003	-0.0005	-0.0007	-0.0003	-0.0002	-0.0002	-0.0004	-0.0007	0.0000	0.0000	0.0000
	%	-0.98	-2.07	-5.79	-2.65	-1.16	-3.41	-5.19	-8.73	0.44	0.24	0.06
N_2O emissions		**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Submission 2017	kt	0.0025	0.0049	0.0048	0.0042	0.0053	0.0048	0.0041	0.0037	0.0021	0.0039	0.0046
Submission 2018	kt	0.0027	0.0046	0.0047	0.0039	0.0050	0.0045	0.0041	0.0037	0.0020	0.0040	0.0046
Difference	kt	0.0003	-0.0003	-0.0002	-0.0003	-0.0003	-0.0003	0.0000	0.0000	0.0000	0.0001	0.0000
	%	10.23	-6.74	-3.29	-6.26	-5.68	-5.76	-0.68	-0.24	-1.55	2.54	-0.39

3.2.17.6 Category-specific planned improvements (CRF 1.A.2.g)

Currently there are no planned improvements in this category.

3.2.18 Transport (1.A.3)

For the purposes of calculations of greenhouse gas emissions, the categories of transport modes and vehicle categories did not change compared to 2008. The criteria for inclusion of certain vehicle categories in a particular category consist of the transport mode, the fuel used and the type of emission standard that the particular vehicle must meet (in road transport). The categories of vehicles for non-road transport are not as detailed.

The data required for statistical analysis of fuel consumption 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 also traffic surveys (Traffic census) and the research activities of CDV.

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, 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)

3.2.18.1 Methodological issues

The methodology in the Czech Republic employs emission factors in [g.kg^{-1}] of fuel not in [g.TJ^{-1}] of energy, because the country-specific measured data of every greenhouse gas or pollutant in the internal database are in this unit. The main reason why the emission factors are in [g.kg^{-1}] of fuel is based on the fact that consumption of every fuel is monitored in units of weight. The emission data calculated for the CRF Reporter are affected by a calorific value (which is variable in different years) of a particular fuel and the fuel consumption for the CRF Reporter must be converted from weight to energy units (using the calorific value). So the time series of IEF depends partially on the trend of calorific values and in this case mostly on emission factors of different vehicle technologies (due to EURO emission standard). Emission factors of individual transport categories are always given for current submission year. All calorific values used for calculations in a transport sector are presented within the Chapter 3 (Energy).

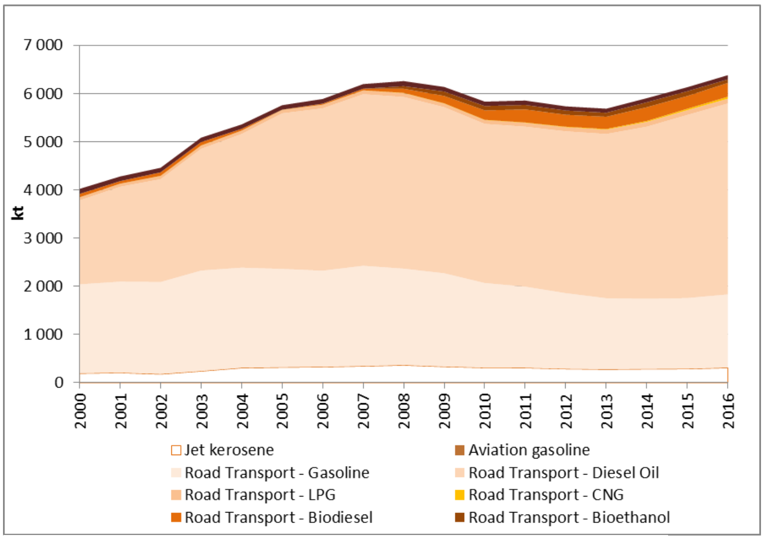

Fig. 3-21 Annual fuel consumption by all modes of transport

In the table below are displayed activity data by all modes of transport, and its graphical comparison is shown in Fig. 3-21. Mobile sources used for other purposes than transport (gasoline-powered lawn mowers, chain saws, construction machinery, etc.) make a smaller contribution to the increasing consumption of gasoline and diesel oil.

Tab. 3-44 Fuel consumption by all modes of transport

Year	Aviation		Road Transport						Railways	Navigation
	Aviation gasoline	Jet kerosene	Gasoline	Diesel oil	LPG	CNG	Biodiesel	Bioethanol	Diesel oil	Diesel oil
	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]
2000	3	192	1 845	1 741	62	2	70	0	104	5
2001	2	205	1 888	1 968	63	2	52	0	97	8
2002	3	177	1 908	2 133	64	5	73	0	94	4
2003	3	238	2 084	2 525	65	5	70	0	92	4
2004	3	306	2 077	2 772	68	3	36	0	91	6
2005	2	318	2 039	3 228	70	3	3	0	92	5
2006	2	326	1 994	3 369	72	3	20	2	96	6
2007	2	342	2 081	3 558	77	4	34	0	95	5
2008	2	362	2 001	3 561	80	5	85	54	105	4
2009	2	331	1 936	3 445	74	6	154	91	95	5
2010	2	310	1 755	3 301	77	7	196	90	92	4
2011	1	307	1 684	3 318	78	8	271	94	90	3
2012	2	286	1 569	3 356	86	10	248	87	87	5
2013	2	276	1 474	3 406	89	15	253	83	85	2
2014	2	283	1 455	3 570	98	21	284	102	86	3
2015	3	287	1 465	3 799	98	31	264	98	83	3
2016	3	309	1519	3960	99	42	286	74	86	4

3.2.18.2 Aviation(CRF 1.A.3.a, 1.D.1.a)

Burning processes in air transport are very different from those in land and water transport. This is caused by operation in a wider range of atmospheric conditions (i.e. substantial changes in atmospheric pressure, air temperature and humidity). These variables change vertically with altitude and horizontally with air masses. Category 1.A.3.a (emissions from domestic civil aviation) and 1.D.1.a (international civil aviation) are reported with respect to the individual flight phases: LTO (Landing/Take-off: 0-3,000 feet) and Cruise (above 3,000 feet). Emissions from military aircraft are not included in this category but are reported under 1.A.5.b Military: Mobile Combustion.

3.2.18.2.1 Methodological issues

Aircraft emissions have been estimated on the basis of overall fuel consumption in aviation. It is very important to distinguish between domestic and international flights. CZSO provides values for fuel consumption for these two categories separately. These are the values for “fuel sold”, not “fuel used”. Every year CDV makes its own estimate of fuel used in the Czech Republic by domestic aviation. Emission estimates are based on overall fuel consumption by domestic flights. The activity data is obtained from the Transport Yearbook published every year by the Ministry of Transport. The process of estimating emissions is based on fuel consumption of aviation gasoline and jet kerosene obtained from the Czech Statistical Office (CZSO). This fuel consumption is:

- For aviation gasoline, considered to be used fully by domestic flights

- For jet kerosene, consumption is divided between domestic and international flights using the ratio between transport performance in domestic and international aviation calculated on the basis of data from the Transport yearbook published every year by the Ministry of Transport

The next step is to define the ratio between fuel consumption during LTO and during Cruise flight modes (see Tab. 3-45). Emissions are estimated by multiplying the consumption of jet kerosene and aviation gasoline by the ratio of consumption of a flight phase and by the emission factors (EF).

Tab. 3-45 Ratio of fuel consumption between LTO and the Cruise flight mode

Fuel	Flight mode	Ratio
Jet Kerosene	LTO	0.15
	CRUISE	0.85
Aviation gasoline	LTO	0.1
	CRUISE	0.9

Activity data

Activity data are obtained from CZSO and are divided between LTO and Cruise flight modes according to the ratio in Tab. 3-45. The total consumption of jet kerosene in the Czech Republic is divided into five categories (Civil Aviation, International Aviation, Army, Industry and Commercial and Public Services). Jet kerosene consumption as well as the relevant emissions from the categories of Army, Industry, Commercial and Public Services is not reported in the CRF tables in Transport sector 1A3, but in sectors 1A5b, 1A2f and 1A4a respectively. The other two categories (Civil Aviation and International Aviation) are divided on the basis of expert judgement in the whole time period when main criterion is a combination of transport performance of air passenger transport (only a small number of domestic lines between the main Czech airports) and transport performance of air freight transport (MoT, 2016). Compared to international flights, regular domestic flights using jet kerosene correspond to a very small percentage in the Czech Republic. Regular domestic flights (11 TJ) using kerosene are represented by a very small percentage in the Czech Republic compared to international flights (13 368 TJ). In the

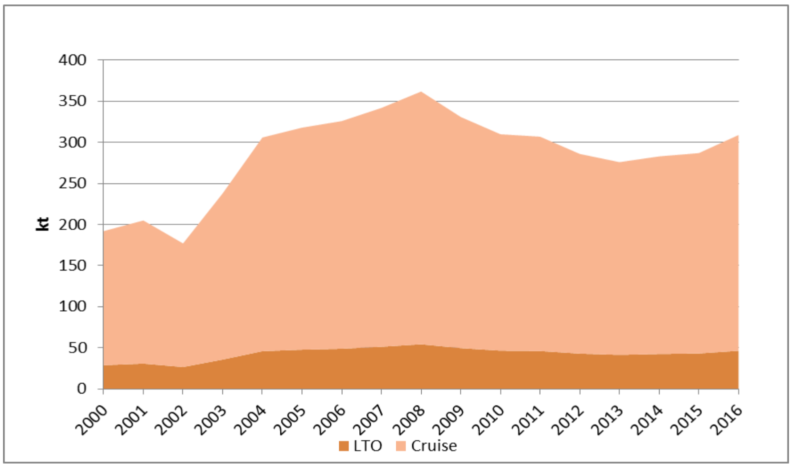

Fig. 3-22 Annual jet kerosene consumption in aviation

domestic aviation category, the IEA data (1472 TJ) also include kerosene consumption reported to IEA by CZSO (divided in CRF into the categories of Army, Industry, Commercial and Public Services and not used for aviation or transport). Tab. 3-46 ((on the ERT recommendation) shows the distribution of kerosene consumption in the CRF Reporter in comparison with IEA data. As can be seen from the next table, the total sums of kerosene (CRF vs. IEA) are identical or nearly identical in most cases. Tab. 3-47 gives jet kerosene consumption according flight mode.

Tab. 3-46 Distribution of the jet kerosene consumption in the CRF Reporter and IEA data [TJ]

Year	CRF Reporter				IEA data		
	Domestic Aviation (1.A.3.a)	Internat. Aviation (1.D.1.a)	Mobile(aviation component) (1.A.5.b.i)	Total CRF	Internat. Aviation	Domestic Aviation	Total IEA
1990	19	7 325	0	7 344	7 344	0	7 344
1991	20	6 020	0	6 040	6 040	0	6 040
1992	29	6 967	0	6 996	6 996	0	6 996
1993	31	5 792	0	5 823	5 823	0	5 823
1994	49	7 208	0	7 257	7 257	0	7 257
1995	15	7 805	0	7 820	7 820	0	7 820
1996	41	5 866	0	5 907	5 603	304	5 907
1997	54	6 759	0	6 812	5 217	1 595	6 812
1998	50	7 991	0	8 041	4 902	3 139	8 041
1999	48	7 520	0	7 568	5 633	1 935	7 568
2000	22	8 234	0	8 256	6 665	1 591	8 256
2001	24	8 750	0	8 774	6 762	2 012	8 774
2002	19	7 556	770	8 346	6 976	1 370	8 346
2003	24	10 163	556	10 743	8 432	2 311	10 743
2004	35	13 062	685	13 782	12 070	1 712	13 782
2005	37	13 573	728	14 338	13 182	1 156	14 338
2006	46	14 070	563	14 679	14 073	606	14 679
2007	46	14 763	1 126	15 936	14 462	1 472	15 934
2008	31	15 644	1 083	16 758	14 895	1 862	16 757
2009	45	14 287	1 169	15 501	14 246	1 256	15 501
2010	36	13 387	866	14 290	13 120	1 169	14 289
2011	22	13 272	1 516	14 810	12 990	1 819	14 809
2012	17	12 367	736	13 121	12 297	823	13 120
2013	19	11 931	650	12 599	11 864	736	12 600
2014	12	12 241	686	12 859	12 254	693	12 974
2015	14	12 413	1 386	13 206	12 341	1472	13 813
2016	11	13 368	1 634	14 246	13 250	1645	14 895

Tab. 3-47 Jet kerosene consumption according to the flight mode

Jet kerosene consumption	Domestic Flights LTO [kt]	International Flights LTO [kt]	Domestic Flights Cruise [kt]	International Flights Cruise [kt]
2000	0.05	28.8	0.45	163.2
2001	0.06	30.7	0.54	174.3
2002	0.05	26.5	0.45	150.5
2003	0.06	35.7	0.54	202.3
2004	0.08	45.9	0.72	260.1
2005	0.09	47.7	0.81	270.3
2006	0.11	48.8	0.99	277.2
2007	0.11	51.2	0.99	290.8
2008	0.07	54.3	0.63	307.7
2009	0.10	49.6	0.90	281.4
2010	0.08	46.5	0.72	263.5
2011	0.05	46.0	0.45	261.0
2012	0.04	42.9	0.36	243.1
2013	0.05	41.4	0.45	234.6
2014	0.03	42.4	0.27	240.6
2015	0.03	43.0	0.27	244.0
2016	0.03	46.3	0.24	262.7

Emission factors

Under Tier 1, the emission factors for CO_2, N_2O and CH_4 are based on the calorific value of the fuel (updated every year by the Czech Oil Questionnaire for EEA) and EF (kg/TJ) stated in the IPCC Guidelines for aviation.

Tab. 3-48 Emission factors for CO_2, N_2O and CH_4 from aviation in the current year in [g.kg^{-1}] of fuel

Subsector	Fuel type	EF CO_2 [g.kg^{-1}]	EF N_2O [g.kg^{-1}]	EF CH_4 [g.kg^{-1}]
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

Emissions

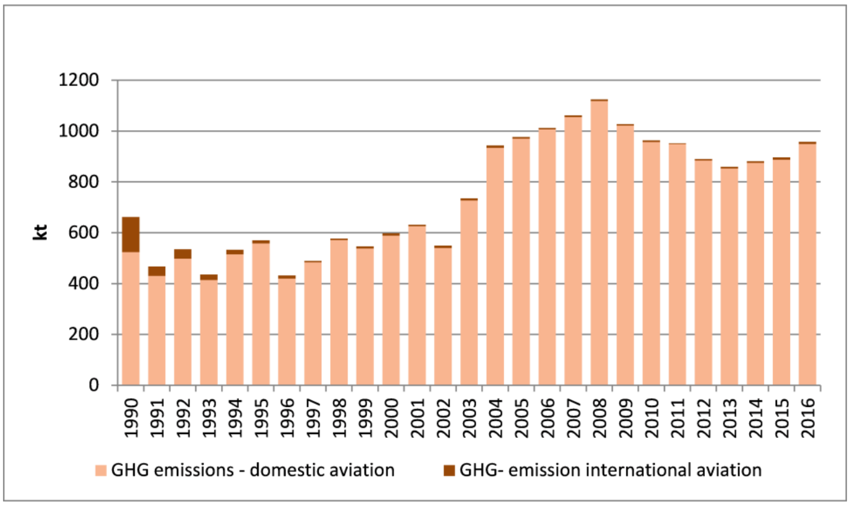

Fig. 3-23 Emissions of CO_2. N_2O and CH_4 from aviation

CO_2 emissions from domestic air 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 aviation gasoline and CO_2 emissions from aviation gasoline are limited to small aircrafts used in agriculture and in sports and recreational activities.

The total consumption by military and domestic transport (estimated on the basis of the number of flights, distances between destinations and specific fuel consumption per the 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.

3.2.18.2.2 Uncertainties and time-series consistency

Uncertainty in civil aviation was calculated according to the EMEP/EEA air pollutant emission inventory guidebook 2016. The uncertainty given here was evaluated for all the time series (1990 – 2016) and both flight stages. The combined uncertainties of national emissions within aviation for particular pollutants are given in Tab. 3-49.

Tab. 3-49 Uncertainty data for aviation from uncertainty analysis

IPCC Source Category	Gas	Base year emissions (1990) [kt]	Year t emissions (2016) [kt]	Activity data uncertainty [%]	Emission factor uncertainty [%]	Combined uncertainty [%]
1A3aii Civil Aviation-Aviation Gasoline	CO_2	138.1	9.2	4.0	3.9	5.6
1A3aii Civil Aviation-Jet Kerosene	CO_2	1.4	0.8	4.0	3.2	5.1
1D1a International Aviation-Jet Kerosene	CO_2	523.7	955.8	4.0	3.2	5.1
1A3aii Civil Aviation-Aviation Gasoline	CH_4	0.0	0.0	4.0	78.5	78.7
1A3aii Civil Aviation-Jet Kerosene	CH_4	0.0	0.0	4.0	78.5	78.6
1D1a International Aviation-Jet Kerosene	CH_4	0.1	0.2	4.0	78.5	78.6
1A3aii Civil Aviation-Aviation Gasoline	N_2O	1.2	0.0	4.0	110.0	110.1
1A3aii Civil Aviation-Jet Kerosene	N_2O	0.0	0.0	4.0	110.0	110.1
1D1a InternationalAviation-Jet Kerosene	N_2O	4.4	8.1	4.0	110.0	110.1

3.2.18.3 Road Transportation (CRF 1.A.3.b)

This category covers all GHG emissions from motor road traffic in the Czech Republic. It includes all private as well as public transport except agricultural and forestry transport and military transport, which are reported in separate categories. Estimations are made for the following vehicle categories: passenger cars (PCs), light duty vehicles (LDVs), heavy duty vehicles (HDVs), buses and motorcycles (MCs). For calculation purposes, the vehicle categories were broken down by type of fuel and EURO norms.

3.2.18.3.1 Methodological issues

The appropriate distribution is necessary for assigning of a relevant emission factor. Sector 1A3b Road Transportation is split into five subsectors:

- 1.A.3.b i Passenger Cars
- 1.A.3.b ii Light Duty Vehicles
- 1.A.3.b iii Heavy Duty Vehicles
- 1.A.3.b iv Mopeds & Motorcycles

In this submission, the activity data and greenhouse gas emission estimates for subsector 1.A.3.b.ii Light Duty Trucks 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 large number of passenger cars are registered in the Central Vehicle Register as light duty vehicles, because of a fixed partition between the passenger cabin and the trunk space according to the former definition in the Czech legislation. The division of these mixed data into two subsectors is included in the current Improvement plan.

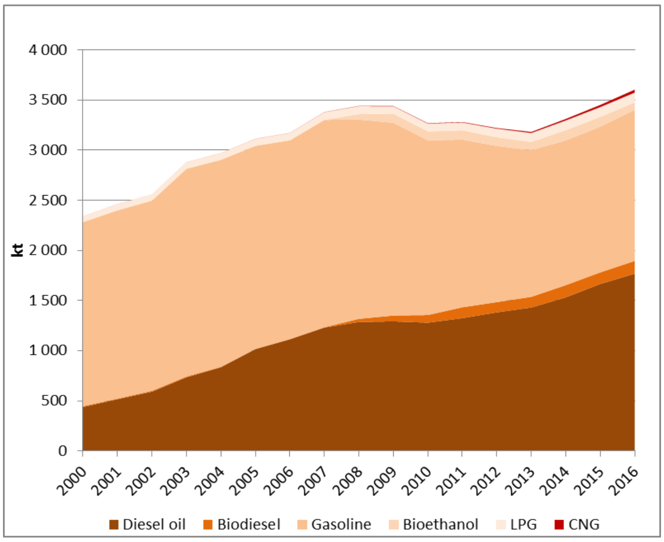

Fig. 3-24 Trend of fuel consumption by PCs

Activity data

Activity data for road transport (see Tab. 3-50) are based on the official energy balance of the Czech Republic prepared by CZSO. Fig. 3-24 and Fig. 3-25 depict the trend in fuel consumption by LDvs and HDVs. Consumption of most of fuels increased compared to 2013. There was a decrease in the consumption of biodiesel fuel between 2014 and 2015, but fuel consumption increased again in 2016 to 128 kt. This was a reaction to a decrease in the price by almost 10 % compared to the previous years. The consumption of bioethanol fuel decreased from 2010, where the only significant exception was 2014. Fig. 3-26 shows the majority of CNG consumption by buses and its sharply increasing trend from 2012. The total consumption of gasoline, diesel oil, LPG, CNG and biofuels was taken from the statistical surveys of CzSO. The next step consisted in separation of these types of fuel consumption according to the vehicle categories mentioned above and then according to their transport outputs from the last National Traffic Census, which is updated once per five year period in the Czech Republic; the last one was carried out in 2016. The most important feature is the annual sale of fuels expressed as units of weight because the emission factor values are expressed in $g.kg^{-1}$ in the CDV database. The parameters necessary for distribution of this amount of fuels are the transport mode, fuel type, weight of the vehicle and the occurrence of equipment with a more or less effective catalytic system. Some activity data necessary for calculations of fuel distribution are provided by the Ministry of Transport in the transport yearbooks and traffic surveys (Traffic census) and by the CDV´s research activities. Some sources 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 source of information is the Czech source administrated by the Czech Gas Association and the second one is obtained from the Natural & bio Gas Vehicle Association Europe. The most important sources of information for distribution of the dynamic structure (emission standards) of the vehicle fleet on the roads in the Czech Republic are particularly CDV´s research activities, the large number of traffic surveys, the traffic census every five years and also aggregate outcomes of studies as well as the aggregate outcomes of studies prepared every 5 years for The Road and Motorway Directorate of the Czech

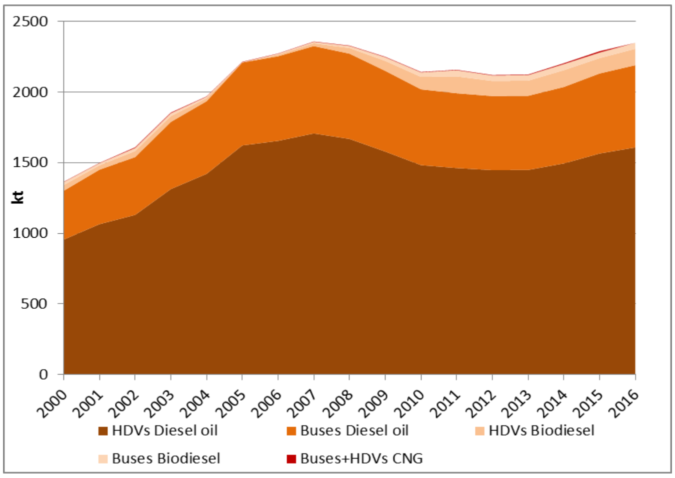

Fig. 3-25 Trend of fuel consumption of CNG by HDVs and Buses

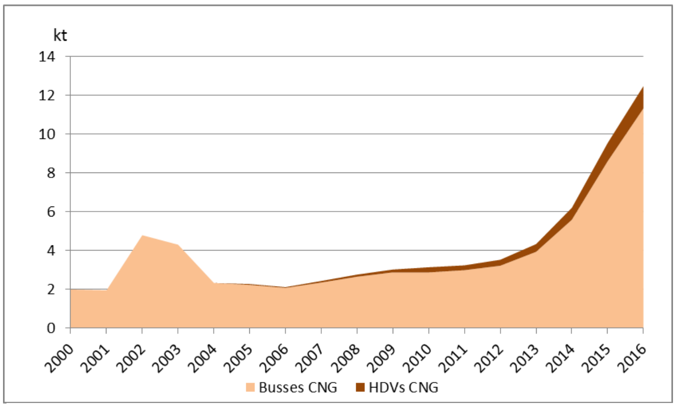

Fig. 3-26 Trend in consumption of CNG fuel by HDVs and Buses

Republic. The last of these was completed in 2016 (Karel et al., 2016).

Tab. 3-50 Fuel consumption in road transport in the Czech Republic

Year	Gasoline [kt]	Diesel oil [kt]	LPG [kt]	CNG [kt]	Biodiesel [kt]	Bioethanol [kt]
2000	1 845	1 741	62	2	70	0
2001	1 888	1 968	63	2	52	0
2002	1 908	2 133	64	5	73	0
2003	2 084	2 525	65	5	70	0
2004	2 077	2 772	68	3	36	0
2005	2 039	3 228	70	3	3	0
2006	1 994	3369	72	3	20	2
2007	2 081	3 558	77	4	34	0
2008	2 001	3 561	80	5	85	54
2009	1 936	3 445	74	6	154	91
2010	1 755	3 301	77	7	196	90
2011	1 684	3 318	78	8	271	94
2012	1 569	3 356	86	10	248	87
2013	1 474	3 406	89	15	253	83
2014	1 455	3 570	98	21	284	102
2015	1 465	3 799	98	31	264	98
2016	1 519	3 960	99	42	286	74

Emission factors

The emission factors are derived from the internal database of the Transport Research Centre (CDV), which contains the default emission factors taken from the IPCC and EIG databases (CO_2 and N_2O), and also those that have a country-specific character (CH_4). The calculated emission factor of biomass was taken as the weighted average for gasoline and diesel oil, taking into account the actual vehicle fleet on the roads (recommended by ERT). The calculation of biomass emission factors of other greenhouse gases also takes into account the amount of renewable components in fuels. The CDV methodology employs emission factors only in [$g.kg^{-1}$] of fuel because the country-specific measured data are in this unit. In the 2019 submission (year 2017), COPERT 5 methodology will be implemented for the current year, and during subsequent years the necessary recalculations will be made.

EF s CO_2 are Tier 1 based on the calorific value of the fuel (actualized every year by the Czech Oil Questionnaire for EEA) and EF (kg/TJ) stated in the IPCC Guidelines.

CH_4 EFs were the IPCC default values and, from 2004, the country-specific values as the CDV became part of the emission inventory team. CS EFs are at the Tier 2 level (different road vehicles produce different amounts of methane). EFs are 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).

N_2O EFs are also CS. Because of the large differences between national N_2O measurement results and the values recommended in the IPCC methodology, a special verification including a statistical evaluation has been performed. The resultant values of the N_2O emission factors from mobile sources approach the recommended IPCC values. The N_2O emission factors of vehicles with diesel engines and of vehicles with gasoline engines without catalysts are not very high and were adopted from the methodical instructions in the standard manner (IPCC default values). The situation is more complex for vehicles with gasoline engines 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 that 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. This 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 a combination of measurements performed for some cars typically used in the Czech Republic with widely used EF values taken from the literature (Dufek, 2005). Consequently, control measurements of N_2O emissions of the commonest cars were performed for the Czech passenger vehicle fleet (Skoda Felicia, Fabia and Octavia) during 2004 – 2006. These corrections brought the results closer to those obtained by using the IPPC emission factors when compared to the older data, thus leading to better harmonization of the results of the nitrous oxide emission inventory per energy unit with those obtained in other countries. The locally measured data for N_2O emissions in exhaust gases were verified by assigning 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 statistical evaluation of the 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). In Current state, gasoline PCs and gasoline motorcycles N_2O EFs were changed in 2000 – 2014 on the basis of the ESD review held in 2016. On recommendation, original country specific EFs were replaced by Tier 1 EFs given in the 2016 EMEP/EEA emission inventory guidebook.

Tab. 3-51 Emission factors for CO_2, N_2O and CH_4 for road transport in the current year in [$g.kg^{-1}$] of fuel

Vehicle type	Fuel type	European emission standard	EF CO_2 [$g.kg^{-1}$]	EF N_2O [$g.kg^{-1}$]	EF CH_4 [$g.kg^{-1}$]
Motorcycles	Gasoline	PRE-EURO and higher	3 063	0.06	4.10
Motorcycles	Bioethanol	PRE-EURO and higher	1 912	0.02	0.08
PC+LDT	Gasoline	PRE-EURO	3 063	0.2	0.90
PC+LDT	Gasoline	EURO I and EURO II	3 063	0.2	0.40
PC+LDT	Gasoline	EURO III and higher	3 063	0.2	0.10
PC+LDT	Diesel Oil	PRE-EURO	3 183	0.10	0.08
PC+LDT	Diesel Oil	EURO I and EURO II	3 183	0.20	0.08
PC+LDT	Diesel Oil	EURO III and higher	3 183	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	4.56
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	3 183	0.10	0.60
HDT	Diesel Oil	EURO I and EURO II	3 183	0.20	0.20
HDT	Diesel Oil	EURO III and higher	3 183	0.25	0.15
HDT	CNG	PRE-EURO and higher	2 697	0.15	4.56
HDT	FAME	PRE-EURO and higher	2 620	0.02	0.06
Bus	Diesel Oil	EURO II and older	3 183	0.18	0.60
Bus	Diesel Oil	EURO III and higher	3 183	0.10	0.15
Bus	CNG	PRE-EURO and higher	2 697	0.15	4.56
Bus	FAME	PRE-EURO and higher	2 620	0.02	0.06

CO_2 emissions

Carbon dioxide emissions were calculated on the basis of the total consumption of the individual automotive fuels used in transport (i.e. gasoline, diesel oil, LPG, CNG and biofuels) and on the basis of emission factors for the weight of CO_2 corresponding to 1 kg of burned fuel. Consumption of fuels was further divided into the following categories of means of transport on the basis of statistics on transport output:

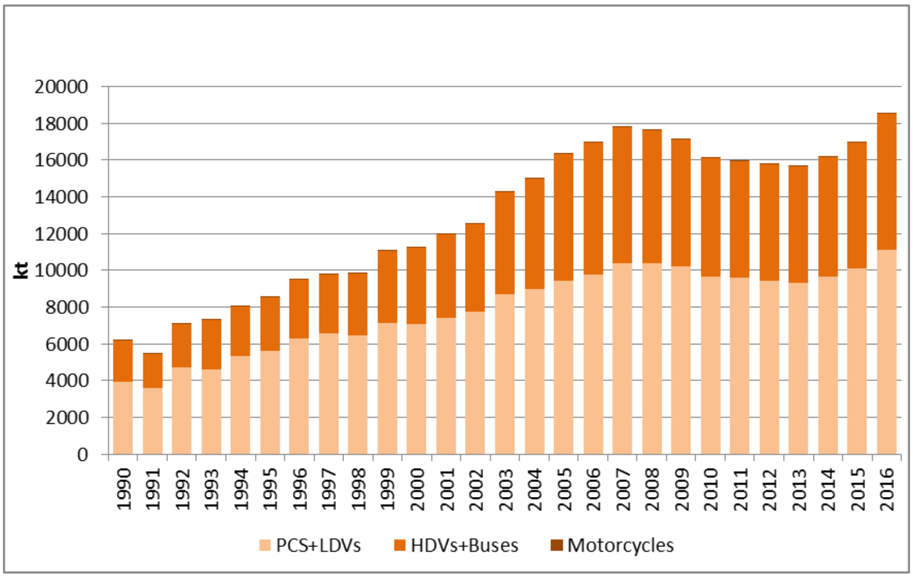

Fig. 3-27 Emissions of CO_2 from road transport according subsectors

- 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).

A gradually increasing contribution of transport to total CO_2 emissions in the Czech Republic became evident during the 1990's and this trend continued until 2007. Individual road and freight transport make the greatest contribution to energy consumption in road transport. The amount of sold fuels is monitored annually and constitutes the main input data for calculations of energy consumption. Trends in CO_2 emission production according subcategories are shown in Fig. 3-27.

In 2008, for the first time, emissions of carbon dioxide from road transport recorded a decrease, which started a downward trend continuing 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 a consequence of the global economic crisis. The downward trend in fuel consumption is evaluated very favourably from the viewpoint of greenhouse gas emissions.

The continuous downward trend in 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 in fuel consumption in years 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 tendency in increasing CO_2 emissions was supported by the almost 10 % lower prices of diesel fuel and gasoline in 2016. The greenhouse gas emission balance reflects not only the scenario of the consumption of alternative fuels, but also the scenario of trends in the road transport infrastructure, the further construction of the throughway network in different variants, urban bypasses etc.

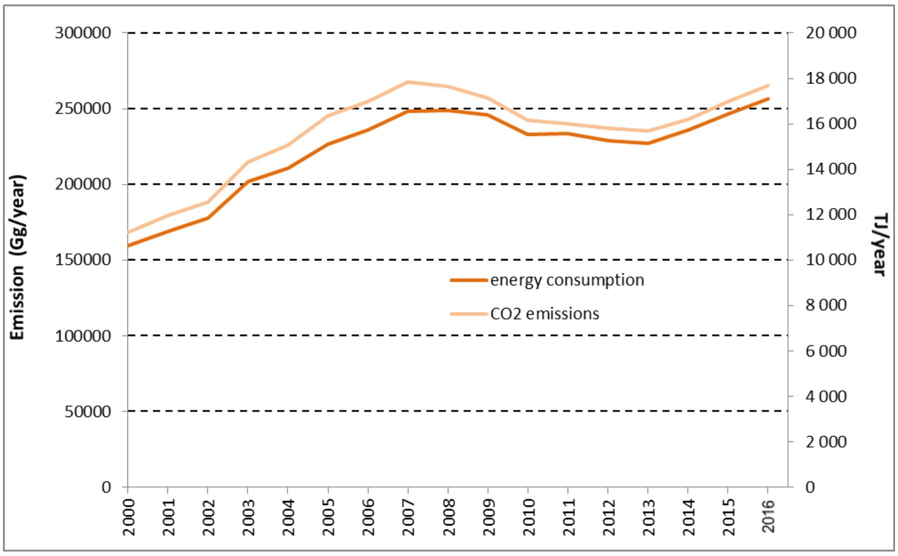

Fig. 3-28 Comparison of energy consumption and CO_2 emissions from road transport

The consumption of gasoline fluctuated around 2 mil. tonnes from 2002 to 2009, but has started to decline significantly since 2010. It even reached a value of 1,455 kilotonnes in 2014. This decline is caused especially by the downward trend in the average fuel consumption of modern passenger cars. In 2016, gasoline consumption reached 1,519 kilotonnes (this increase is caused by the almost 10 % lower prices of gasoline). Since 2008, the consumption of gasoline has also included the consumption of bioethanol, which has been added to all gasoline in an 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 and both values will remain unchanged in the coming years. The share of biofuels in fossil fuels is also increasing (6.8 % in 2010 and 8.5 % in 2015). These facts (the reduction in consumption and increasing share of bio-components) have a favourable impact on CO_2 emissions.

According to Fig. 3-28, the emissions of CO_2 from road transportation follow the trend in energy consumption. There are no disproportions. CO_2 emissions are dependent on the ratio between energy consumption in a particular type of fuel. Small fluctuation can be caused by the fact that the EFs are calculated on the basis of the slightly variable calorific value of a particular fuel. These values are published every year (by CZSO).

CH_4 emissions

The Czech Republic has been very successful in stabilizing and decreasing methane emissions derived from road transport-related greenhouse gas emissions. Trends in CH_4 emission production according to subcategories are shown in The annual trends in these emissions are constantly decreasing and are very similar to those for other hydrocarbons emissions, which are limited in accordance with EURO regulations. New vehicles must fulfil 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

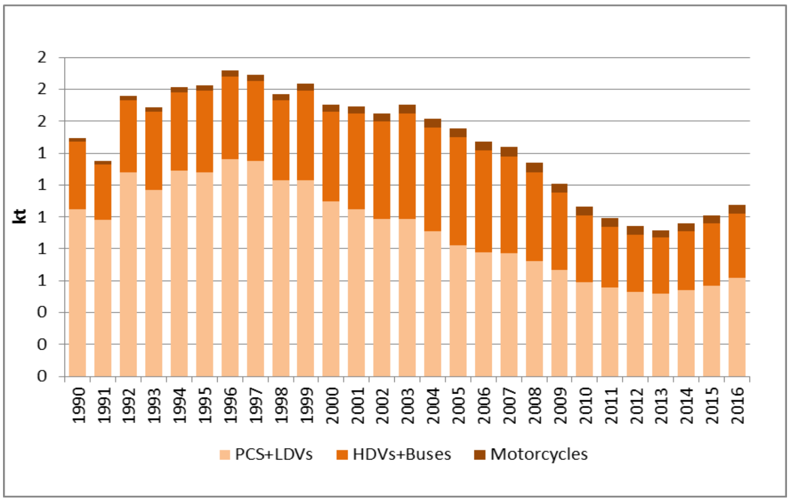

Fig. 3-29 Emissions of CH_4 from road transport according subsectors

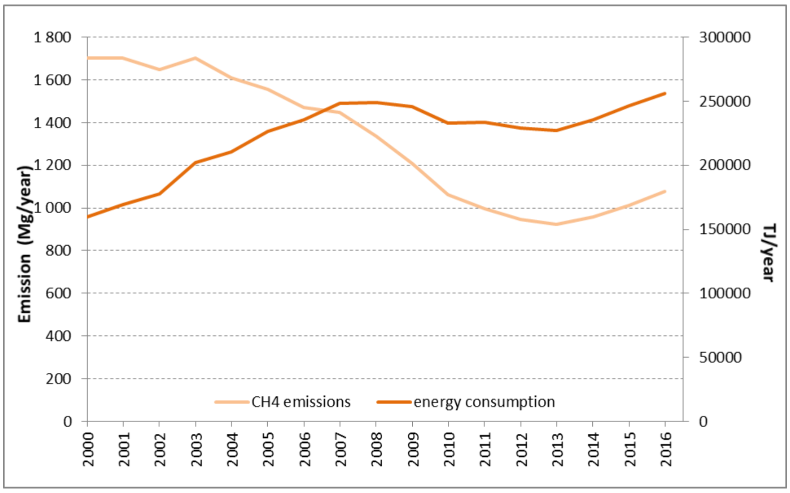

Fig. 3-30 Comparison of energy consumption and CH_4 emissions from road transport

older vehicles are frequently used in the construction and food industries (Adamec et al., 2005a). Since 2014, a slight increase in CH_4 emissions has been recorded. This is mainly because purchase of a large number of CNG buses (supported from national funds), overall growth of the economy and transport of goods and persons.

Fig. 3-30 shows the opposite trend in emission production of CH_4 and energy consumption in road transportation. The continuous decrease started in 2000 when the EURO 3 standard was implemented. Starting in that year, THC had their own limit value. The decrease in the following years was intensified by toughening the THC limits in 2005 by the EURO 4 standard. Another cause of the downward trend is the increasing ratio of diesel passenger cars in the car fleet over the past few years, which produce less CH_4. This trend changed in 2014 when an increase in CH_4 emissions began due to the purchase of a large number of CNG buses by cities and regions in the Czech Republic with high air pollution. In 2016, the increase in fuel consumption continued, caused by lower fuel prices compared to the previous years, leading to an increase of CH4 emissions. This increase was mitigated by the modernization of the car fleet in the Czech Republic.

N_2O emissions

Trends in N_2O emission production according subsectors are shown in Fig. 3-31. Nitrous oxide emissions decreased in 2008, similar to carbon dioxide emissions, as a consequence of reduced consumption of gasoline and diesel oil. New vehicles exhibit higher emissions compared to older models because they are equipped with 3-way catalytic converters which reduce only NO_X emissions but not N_2O emissions. However, this effect is suppressed in new vehicles as a consequence of their lower fuel consumption. Between 2008 and 2013, N_2O emissions decreased similar to carbon dioxide emissions. In 2014 and 2015, nitrous oxide emissions increased slightly. This was caused by the higher consumption of diesel fuel, which is influenced by progress in the national economy and by an increase in the transportation of goods and material. Another factor is the higher consumption of CNG connected with the purchase of CNG buses supported from national funds. The increase in fuel consumption is continuing in 2016, caused by lower fuel prices compared to previous years, leading to an increase in CH4 emissions. This increase is mitigated by modernisation of the car fleet in the Czech Republic.

Road transport was identified as a key source of N_2O emissions over the past 5 years, as the share of vehicles with high N_2O emissions has been increasing in this period. Consequently, N_2O emissions from mobile sources represent a somewhat more important contribution than CH_4 emissions.

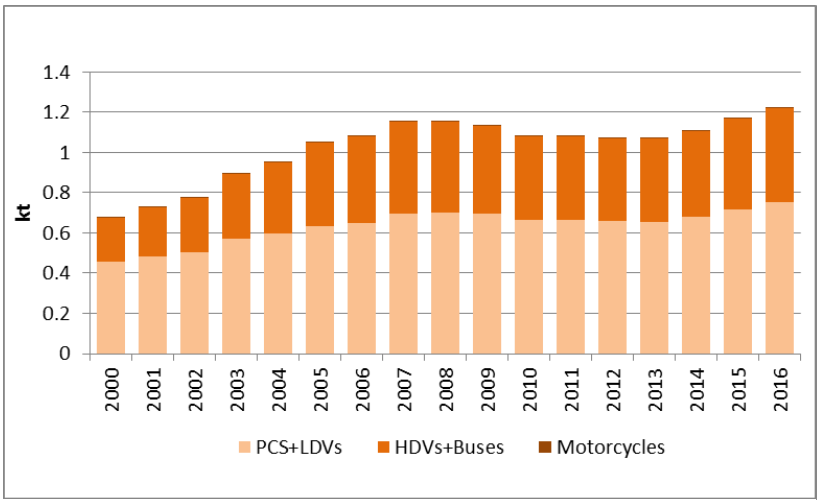

Fig. 3-31 Emissions of N_2O from road transport according subsectors

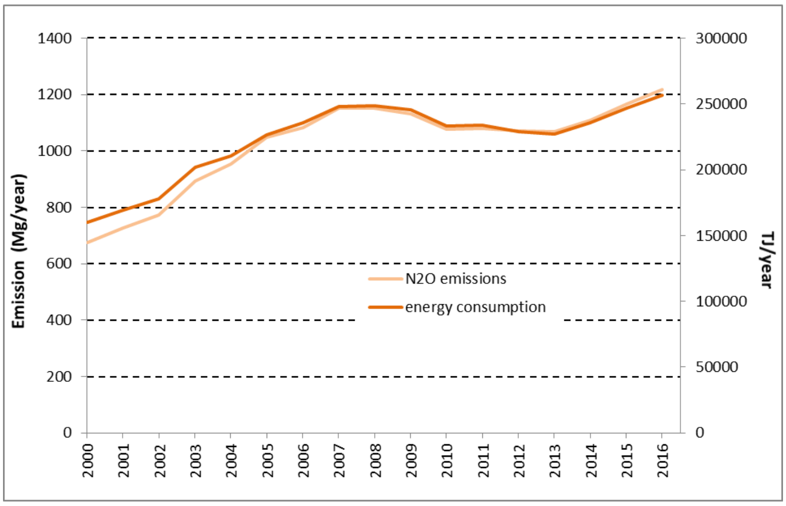

Fig. 3-32 Comparison of energy consumption and N2O emissions from road transport

In calculation of N_2O emissions from mobile sources, the most important source according to the IPCC methodology seems to be passenger automobile transport, especially gasoline-fuelled passenger cars with catalysts. The vehicle categories for the nitrous oxide calculation are the same as for methane (see above).

shows a higher increase in N_2O emissions from road transport until 2005 compared to the trend in energy consumption. This phenomenon is caused by replacing older technologies of catalysts with high production of N_2O by new ones with higher EURO standards, which are more effective. The implementation of the EURO V standard for trucks in 2008 and EURO 5 standard for passenger cars in 2009 toughened the limits for NO_x. As a result and because of the impact of the recent economic crisis (reduced transport of goods), a decrease in N_2O emissions was observed in the following years, which was more intense than the decrease in energy consumption.

3.2.18.3.2 Uncertainties and time-series consistency

Uncertainty in road transport was calculated according to the EMEP/EEA air pollutant emission inventory guidebook 2016. The uncertainty given here has been evaluated for all the time series (2000 – 2016) and reported categories. Combined uncertainties of national emissions in aviation for particular pollutants are given in Tab. 3-52.

Tab. 3-52 Uncertainty data for road transport from uncertainty analysis

IPCC Source Category	Gas	Base year emissions (1990) [kt CO_2 eq.]	Year t emissions (2016) [kt CO_2 eq.]	Activity data uncertainty [%]	Emission factor uncertainty [%]	Combined uncertainty [%]
1A3bi PC+LDV-Gasoline	CO_2	3468.7	4612	3	4	5
1A3bi PC+LDV-Diesel Oil	CO_2	1548.9	5628	3	1.5	3.3
1A3bi PC+LDV-LPG	CO_2	0	299.8	3	3.2	4.4
1A3bi PC+LDV Gaseous Fuels	CO_2	0	79.6	3	3.2	4.4
1A3bi PC+LDV Biomass	CO_2	0	474.8	3	2.5	3.9
1A3biii HDV-Diesel Oil	CO_2	7344.6	6977.2	3	1.5	3.3
1A3biii HDV-Gaseous Fuels	CO_2	0	33.6	3	3.2	4.4
1A3biii HDV-Biomass	CO_2	0	414.7	3	1.5	3.3
1A3biv Motorcycles-Gasoline	CO_2	18.4	39.9	3	4	5
1A3biv Motorcycles-Biomass	CO_2	0	1.2	3	4	5
1A3bi PC+LDV-Gasoline	CH_4	26	5.5	3	157.5	157.5
1A3bi PC+LDV-DieselOil	CH_4	1	3.7	3	101.3	101.3
1A3bi PC+LDV-LPG	CH_4	0	2.5	3	809.8	809.8
1A3bi PC+LDV Gaseous Fuels	CH_4	0	3.4	3	809.8	809.8
1A3bi PC+LDV Biomass	CH_4	0	0.3	3	123.2	123.2
1A3biii HDV-Diesel Oil	CH_4	35	8.5	3	157.5	157.5
1A3biii HDV-Gaseous Fuels	CH_4	0	1.4	3	809.8	809.8
1A3biii HDV-Biomass	CH_4	0	0.2	3	101.3	101.3
1A3biv Motorcycles-Gasoline	CH_4	0.6	1.3	3	151.7	151.7
1A3biv Motorcycles-Biomass	CH_4	0	0	3	151.7	151.7
1A3bi PC+LDV-Gasoline	N_2O	106.7	7.8	3	133.8	133.8

1A3bi PC+LDV-DieselOil	N_2O	14.7	10.9	3	137.2	137.2
1A3bi PC+LDV-LPG	N_2O	0	0	3	1266.7	1266.7
1A3bi PC+LDV Gaseous Fuels	N_2O	0	0.1	3	1266.7	1266.7
1A3bi PC+LDV Biomass	N_2O	0	0.1	3	135.8	135.9
1A3biii HDV-DieselOil	N_2O	84.3	136.5	3	137.2	137.2
1A3biii HDV-Gaseous Fuels	N_2O	0	0.6	3	1266.7	1266.7
1A3biii HDV-Biomass	N_2O	0	1	3	97.9	97.9
1A3biv Motorcycles-Gasoline	N_2O	0.1	31.5	3	156.9	156.9
1A3biv Motorcycles-Biomass	N_2O	0	0.1	3	156.9	156.9

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

3.2.18.4.1 Methodological issues

The Czech railway sector is undergoing a long-term modernization process to make electricity the main energy source for rail transport. The use of electricity instead of diesel fuel to power locomotives has been continually increasing and electricity now provides 86 % of all railway traffic volumes. The energy consumption share of locomotives powered by electricity is 54 %. Railway power stations for generation of traction current are allocated to the stationary component of the energy sector (1.A.1.a) and are not included in the following text. In the energy inputs used by trains, diesel fuel is the only energy source that plays a significant role, apart from electric power.

Activity data

Regular railway operations use only diesel fuel. Coal is used solely for historical rides and the percentage of its consumption is negligible. In general, fuel consumption by railways has had a slight decreasing trend since 2000. The only exception is the 2006 – 2008 period. After this, the increase stopped because of the economic crisis and replacement of diesel-powered locomotives by electric ones.

Tab. 3-53 Fuel consumption by railways

Diesel Oil consumption [kt]			
2000	104	**2009**	95
2001	97	**2010**	92
2002	94	**2011**	90
2003	92	**2012**	87
2004	91	**2013**	85
2005	92	**2014**	86
2006	96	**2015**	83
2007	95	**2016**	86
2008	105		

Emission factors

The emission factors for CO_2, N_2O and CH_4 are Tier 1, based on calorific value of fuel (actualized every year by the Czech Oil Questionnaire for EEA) and EF (kg/TJ) stated in the IPCC Guidelines for railways.

Tab. 3-54 Emission factors of CO_2, N_2O and CH_4 from non-road transport in current year in [g.kg-1] of fuel

Transport type	Fuel type	EF CO_2 [$g.kg^{-1}$]	EF N_2O [$g.kg^{-1}$]	EF CH_4 [$g.kg^{-1}$]
Railways	Diesel Oil	3 183	1.23	0.18

Emissions

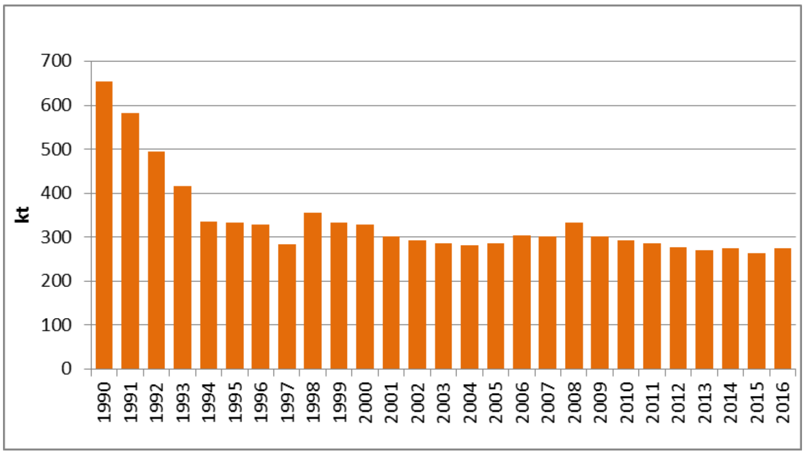

Fig. 3-33 Trend in emissions of CO_2, CH_4 and N_2O from railways

Emissions from railways are strongly dependent on fuel consumption. Emissions of GHG are given in Fig. 3-33. The sharpest decrease in emissions occurred before 1994. This was connected with a decrease in freight transport, because of significantly lower coal mining intensity compared to the period before 1989. Another factor was electrification of the core network and modernisation of rolling stock during these years. In the following years, GHG emissions increased slightly between 2004 and 2008 in relation to economic growth. After 2008, a decrease in emissions was recorded in relation to the economic crisis. After 2013, emissions of GHG from railways oscillated around 270 kt, depending on transport performance on the railways in the current year.

3.2.18.4.2 Uncertainties and time-series consistency

Uncertainties for railways were calculated according to the EMEP/EEA air pollutant emission inventory guidebook 2016. The uncertainties given here have been evaluated for all of the time series (2000 – 2016) and for all the reported categories. The combined uncertainties of national emissions within aviation for particular pollutants are given in Tab. 3-55.

Tab. 3-55 Uncertainty data for railways from uncertainty analysis

IPCC Source Category	Gas	Base year emissions (1990) [kt CO_2 eq.]	Year t emissions (2016) [kt CO_2 eq.]	Activity data uncertainty [%]	Emission factor uncertainty [%]	Combined uncertainty [%]
1A3c Railways-Diesel Oil	CO_2	653.9	273.7	5.0	1.5	5.2
1A3c Railways-Diesel Oil	CH_4	0.9	0.4	5.0	157.5	157.5
1A3c Railways-Diesel Oil	N_2O	75.2	31.5	5.0	137.2	137.3

3.2.18.5 Domestic Navigation (CRF 1.A.3.d)

3.2.18.5.1 Methodological issues

Primary data on fuels available via CZSO or other statistics do not allow differentiation into national and international inland navigation on inland waterways in the Czech Republic. Therefore, for the time being, all the activity data are allocated to NFR 1.A.3.d ii - National Navigation (Shipping) and to sub-sector 1.A.3.d ii (b) - National inland navigation.

Activity data

Fuel consumption by national navigation is very low (see Tab. 3-56). CZSO provides only data related to diesel oil consumption by the recreational fleet, which basically represent most of fuel consumption by national navigation in the Czech Republic. The Czech Republic no longer has a merchant fleet.

Tab. 3-56 Fuel consumption by rnational navigation

Diesel Oil consumption [kt]			
2000	5	**2009**	5
2001	8	**2010**	4
2002	4	**2011**	3
2003	4	**2012**	5
2004	6	**2013**	2
2005	5	**2014**	3
2006	6	**2015**	3
2007	5	**2016**	4
2008	4		

Emission factors

The emission factors for CO_2, N_2O and CH_4 are Tier 1 based on the calorific value of the fuel (updated every year by the Czech Oil Questionnaire for EEA) and EF (kg/TJ) stated in the IPCC Guidelines for navigation.

Tab. 3-57 Emission factors of CO_2, N_2O and CH_4 from national navigation in the current year in [g.kg^{-1}] of fuel

Transport type	Fuel type	EF CO_2 [g.kg^{-1}]	EF N_2O [g.kg^{-1}]	EF CH_4 [g.kg^{-1}]
Water-borne navigation	Diesel Oil	3 183	0.09	0.30

Emissions

Emissions from national inland navigation are greatly dependent on fuel consumption. Emissions of GHG are given in following figure:

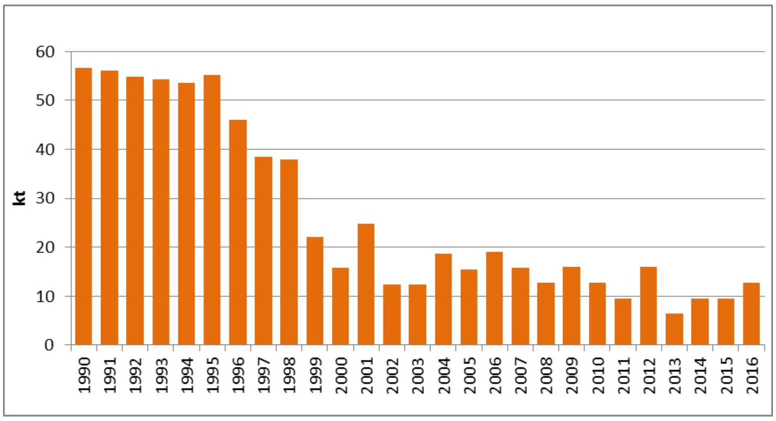

Fig. 3-34 Trend in emissions of CO_2, CH_4 and N_2O from domestic navigation

3.2.18.6 Uncertainties and time-series consistency

Uncertainties for railways were calculated according to the 2016 EMEP/EEA air pollutant emission inventory guidebook. The uncertainties given here have been evaluated for the whole time series (2000 – 2016) and for all the reported categories. The combined uncertainties of national emissions within aviation for particular pollutants are given in Tab. 3-58.

Tab. 3-58 Uncertainty data for national navigation from uncertainty analysis

IPCC Source Category	Gas	Base year emissions (1990) [kt CO_2 eq.]	Year t emissions (2016) [kt CO_2 eq.]	Activity data uncertainty [%]	Emission factor uncertainty [%]	Combined uncertainty [%]
1A3dii Domestic navigation-Diesel Oil	CO_2	56.6	12.7	5	157.5	157.5
1A3dii Domestic navigation-Diesel Oil	CH_4	0.13	0.03	5	157.5	157.5
1A3dii Domestic l navigation-Diesel Oil	N_2O	0.46	0.10	5	157.5	157.5

3.2.18.7 Other Transportation (CRF 1.A.3.e)

The consumption of Natural Gas for powering transit gas pipeline compressors is included in this subcategory under mobile combustion sources but it is, in fact, stationary combustion. This consumption is reported in the IEA – CzSO (CzSO, 2017) Questionnaire in the Transport Sector section under the item:

- Pipeline Transport

This includes fuels of economic part according to NACE Rev. 2 Pipeline Transport: NACE Divisions 35.22, 49.50.

3.2.18.8 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, completeness and to identify and address errors. All QC activities are 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 in CDV by comparing activity data with international and European databases and third person checks.

An inventory compiler is responsible for coordinating the institutional and procedural arrangements of inventory activities. These activities include data collection from CZSO, deciding on usage of emissions factors (according to CS or EIG) and estimation of emissions from mobile sources. The uncertainty assessment is also carried out by the inventory compiler. The last step is documentation and archiving of the 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 in 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 have closely cooperated in the sphere of energy and fuel consumption data as well as specific energy data used in calculations in units [$MJ.kg^{-1}$] of fuel. Iin close cooperation with CzSO, CHMI ensures that the Transport Research Centre works with the most updated data about total energy and specific energy consumption.

a. QA/QC activities

QC Activities:

- Checking criteria for selection of the activity data; emission factors and other estimated.
- 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 a plan for the QC procedure and is responsible for its implementation.

The compiler of the mobile source inventory:

- performs the emission calculations from transport in the emission model,
- provides for data import in the NFR table,
- is responsible for the storing documents,
- carries out auto-control and control of data consistency,
- performs the uncertainty calculation,
- introduces improvements.

The third person check (Mr. Jiri Dufek, MOTRAN RESEARCH , s.r.o.)

- 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 first calculations which are compared with previous years regarding to a trend in data from previous years. Where there are discrepancies, the activity data are consulted with CZSO and inaccuracies are corrected. CZSO provides the final activity data during the autumn. Then the final calculations are made. QC is also carried out by the inventory compiler and then by a person responsible for compilation of the Transport Yearbook at CDV and Mr. Jiri Dufek from MOTRAN RESEARCH. Every error is described, documented and recorded. The next quality control is carried out by an expert at CHMI. The last step in QC consists in European reviews. QA is carried out on the 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. Stage 1 review questions are processed during the second half of March. Stage 2 review questions are processed during May and June.

3.2.18.9 Recalculations and improvements

3.2.18.9.1 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

The values of diesel oil consumption in 2015 for 1.A.3.d Domestic navigation were updated by CZSO. See Tab. 3-59 for the recalculations.

Tab. 3-59 Updated values for Domestic navigation in 2015

1.A.3.d Domestic navigation - 2015	Original value	Updated value
Diesel consumption [TJ]	171.77	128.83
CO_2 emissions [kt]	12.73	9.55
CH_4 emission [t]	1.20	0.90
N_2O emission [t]	0.34	0.26

This Year the NIR Transport chapter was newly structured according the categories of transport and new graphs and figures were added. The process of calculation of fuel used in CZ by domestic and international aviation was described in more detail in chapter 3.2.17.2.1 . These improvements were introduced as a reaction to the in – country review (September, 2017). This should contribute to better transparency of the report.

3.2.18.10 Source-specific planned improvements, including tracking of those identified in the review process

The planned improvements are related mainly to performance of projects to measure country-specific emission factors in key categories of road transportation. The greatest emphasis will be placed on acquisition of sufficient data for CO_2 and N_2O emission calculations and refinement of methodologies for each category of transport. The Tier 2 approach to estimating CO_2 emissions from liquid fuels in road transportation, employing a country-specific carbon content for fuels, should be implemented by 2019. The next improvement is to split activity data for PC and LDT to their own categories and implementing COPERT 5 for the conditions in the Czech Republic by the end of the 2018.

3.2.19 Other Sectors – Commercial/Institutional (1.A.4.a)

3.2.19.1 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, 2016								
Structure of Fuels	**Activity data [TJ]**	**CO_2 EF [t CO_2/TJ]**	**OxF**	**Emissions [kt]**	**CH_4 EF [kg CH_4/TJ]**	**Emissions [kt]**	**N_2O EF [kg N_2O/TJ]**	**Emissions [kt]**
LPG	275.7	65.86*)	1	18.2	5	0.00138	0.1	0.00003
Other kerosene	85.6	71.9	1	6.2	10	0.00086	0.6	0.00005
Heating and Other Gasoil	127.8	74.1	1	9.5	10	0.00128	0.6	0.00008
Fuel Oil - Low Sulphur	237.0	77.4	1	18.3	10	0.00237	0.6	0.00014
Fuel Oil - High Sulphur	79.0	77.4	1	6.1	10	0.00079	0.6	0.00005
Other Bituminous Coal	50.6	94.45*)	0.971*)	2.3	10	0.00025	1.5	0.00004
Brown Coal + Lignite	24.9	98.99*)	0.985*)	90.4	10	0.00927	1.5	0.00139
Coke	927.2	107	1	9.0	10	0.00084	1.5	0.00013

Natural Gas	48 652.3	55.40*)	1	2 695.3	5	0.24326	0.1	0.00487
Wood/Wood Waste	653.0	112	1	73.1	300	0.19590	4	0.00261
Gaseous Biomass	881.0	54.6	1	48.1	5	0.00441	0.1	0.00009
Total year 2016	**52027.8**			**2855.2**		**0.46060**		**0.00947**
Total year 2015	51 166.6			2810.01		0.45870		0.00951
Index 2016/2015	1.02			1.02		1.00		1.00
Total year 1990	121 435.7			10 023.6		1.01660		0.10207
Index 2016/1990	0.43			0.30		0.45		0.09

*) *Country specific data*

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

2016							
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
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
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Waste - fossil fraction	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Gaseous Biomass	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

The whole category 1.A.4 includes emissions which are not included in the 1.A.1 and 1.A.2 categories. They can be generally defined as heat production processes for internal consumption.

The main driving force for CO_2 emissions in category 1.A.4 is energy consumption for purposes of space heating. The fluctuations in consumption then can be ascribed to differences in cold winter periods. The trend of decreasing CO_2 emissions is a result of higher standards for new buildings and of successful execution of energy-efficiency-oriented modernisations of existing buildings. The trend has also been supported by shifting to fuels with lower CO_2 emissions (emission factors). The importance of Solid Fuels at the beginning of the period constantly decreases in time. On the other hand, the consumption of Natural Gas increased during the period as well as Biomass consumption. Liquid Fuels play a minor role in this category.

CO_2 emissions produced in category 1.A.4.a represent in 2016 23% of whole 1.A.4, which is 3% of CO_2 emissions from the Energy sector 1.A.

The 1.A.4.a subcategory includes all combustion sources that utilize heat combustion for heating production halls and operational buildings in institutions, commercial facilities, services and trade.

In the CzSO Questionnaire (CzSO, 2017), 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)

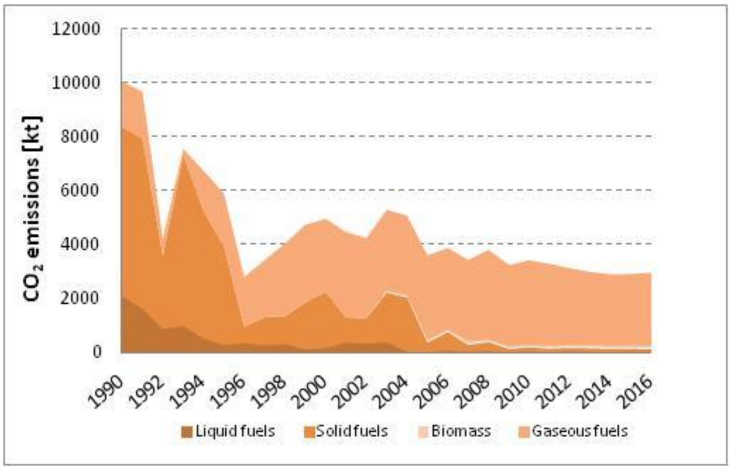

Fig. 3-35 Development of CO_2 emissions in source category 1.A.4.a

Last point is included under 1.A.4.a Commercial/Institutional on the basis of an agreement with CzSO. There are embodied the fuels of economic part according to NACE Rev. 2 Commercial/Institutional: NACE Divisions 35 excluding 1.A.1.a and 1.A.3.e, 36 – 39, 45 – 99 excluding 1.A.3.e and 1.A.5.a.

Fig. 3-35 shows that at the beginning of the period in the subsector 1.A.4.a predominated the consumption of fossil fuels, which was coupled with liquid fuels, and gradually substituted primarily with natural gas. The share of biofuels in this subsector is a minority. The overall decrease in fuel consumption is about 50%, which resulted in a decrease in CO_2 emissions by about 65%. Higher decrease in emissions than the one in the fuel consumption is determined by the changes in the structure of fuels in favour of natural gas.

Outlier values in the fuel consumption are apparent at the beginning of the time series. This unusual trend will be the subject of detailed revision of the activity data. This aspect is also included in the Improvement plan.

3.2.19.2 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 amount of these fossil fuels is given in Tab. 3-60 in TJ.

Tab. 3-60 Quantities of fuels used in the sector transport in stationary sources

Year	2002	2003	2004	2005	2006	2007	2008	2009
TJ/year	12.7	35.2	33.7	35.9	12.4	12.5	12.2	12.3
Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
TJ/year	12.5	37.3	37.3	12.7	35.2	33.7	16.3	

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.

3.2.19.3 Uncertainties and time-series consistency (CRF 1.A.4.a)

See chapter 3.2.5.

3.2.19.4 Category-specific QA/QC and verification (CRF 1.A.4.a)

See chapter 3.2.6.

3.2.19.5 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. 3-61 Changes after recalculation in 1.A.4.a for Solid Fuels

Fuel consumption		2011	2012	2013	2014	2015
Submission 2017	TJ	1 375.8	1 324.7	1 380.8	1 110.6	976.9
Submission 2018	TJ	1 342.7	1 290.0	1 369.5	1 220.2	1 080.4
Difference	TJ	-33.1	-34.8	-11.3	109.6	103.6
	%	-2.40	-2.62	-0.82	9.86	10.60
CO_2 emissions		2011	2012	2013	2014	2015
Submission 2017	kt	135.9	130.4	135.1	109.6	96.4
Submission 2018	kt	131.4	126.0	133.8	118.8	105.2
Difference	kt	-4.5	-4.4	-1.4	9.2	8.9
	%	-3.29	-3.40	-1.00	8.37	9.23
CH_4 emissions		2011	2012	2013	2014	2015
Submission 2017	kt	0.01376	0.01325	0.01381	0.01111	0.00977
Submission 2018	kt	0.01343	0.01290	0.01369	0.01220	0.01080
Difference	kt	-0.00033	-0.00035	-0.00011	0.00110	0.00104
	%	-2.40	-2.62	-0.82	9.86	10.60
N_2O emissions		2011	2012	2013	2014	2015
Submission 2017	kt	0.00206	0.00199	0.00207	0.00167	0.00147
Submission 2018	kt	0.00201	0.00193	0.00205	0.00183	0.00162
Difference	kt	-0.00005	-0.00005	-0.00002	0.00016	0.00016
	%	-2.40	-2.62	-0.82	9.86	10.60

Tab. 3-62 Changes after recalculation in 1.A.4.a for Natural Gas

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	52 904.9	50 898.9	47 280.2	45 087.8	43 803.3	43 668.0
Submission 2018	TJ	56 706.1	54 884.0	51 347.8	48 971.2	47 768.8	47 692.8
Difference	TJ	3 801.3	3 985.1	4 067.7	3 883.4	3 965.5	4 024.8
	%	7.19	7.83	8.60	8.61	9.05	9.22
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	2925.0	2812.7	2609.9	2493.4	2424.6	2420.1
Submission 2018	kt	3135.1	3032.9	2834.4	2708.2	2644.1	2640.4
Difference	kt	210.2	220.2	224.5	214.8	219.5	220.3
	%	7.19	7.83	8.60	8.61	9.05	9.10
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.26452	0.25449	0.23640	0.22544	0.21902	0.21834
Submission 2018	kt	0.28353	0.27442	0.25674	0.24486	0.23884	0.23846
Difference	kt	0.01901	0.01993	0.02034	0.01942	0.01983	0.02012
	%	7.19	7.83	8.60	8.61	9.05	9.22
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00529	0.00509	0.00473	0.00451	0.00438	0.00437
Submission 2018	kt	0.00567	0.00549	0.00513	0.00490	0.00478	0.00477
Difference	kt	0.00038	0.00040	0.00041	0.00039	0.00040	0.00040
	%	7.19	7.83	8.60	8.61	9.05	9.22

3.2.19.6 Category-specific planned improvements (CRF 1.A.4.a)

Detailed research of data at the beginning of 90s is planned for the future submissions.

3.2.20 Other Sectors – Residential (1.A.4.b)

3.2.20.1 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, 2016								
Structure of Fuels	**Activity data [TJ]**	**CO_2 EF [t CO_2/TJ]**	**CO_2 OxF**	**CO_2 Emissions [kt]**	**CH_4 EF [kg CH_4/TJ]**	**CH_4 Emissions [kt]**	**N_2O EF [kg N_2O/TJ]**	**N_2O Emissions [kt]**
LPG	1 975.7	65.9*)	1	130.1	5	0.00988	0.1	0.00020
Other Bituminous Coal	9 147.2	94.0*)	0.971*)	834.5	300	2.74415	1.5	0.01372
Brown Coal + Lignite	26 794.3	96.2*)	0.985*)	2 538.8	300	8.03828	1.5	0.04019
Coke	865.3	107	1	92.6	300	0.25960	1.5	0.00130
Brown Coal Briquets	2 371.2	97.5	0.985*)	227.6	300	0.71136	1.5	0.00356
Natural Gas	83 669.7	55.4*)	1	4 635.3	5	0.41835	0.1	0.00837
Wood/Wood Waste	74 395.0	112	1	8 332.2	300	22.31850	4	0.29758
Charcoal	423.5	112	1	47.4	200	0.08471	1	0.00042
Total year 2016	**199 641.8**			**8458.97**		**34.58482**		**0.36534**
Total year 2015	191 011.2			8043.34		34.49875		0.36177
Index 2016/2015	1.05			1.05		1.00		1.01
Total year 1990	251 958.4			18374.87		60.61958		0.41486
Index 2016/1990	0.79			0.46		0.57		0.88

*) *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.

2016							
Structure of Fuels	**Source for Activity data**	**Emission factors CO_2**	**Emission factors CH_4**	**Emission factors N_2O**	**Method used CO_2**	**Method used CH_4**	**Method used N_2O**
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Other 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.

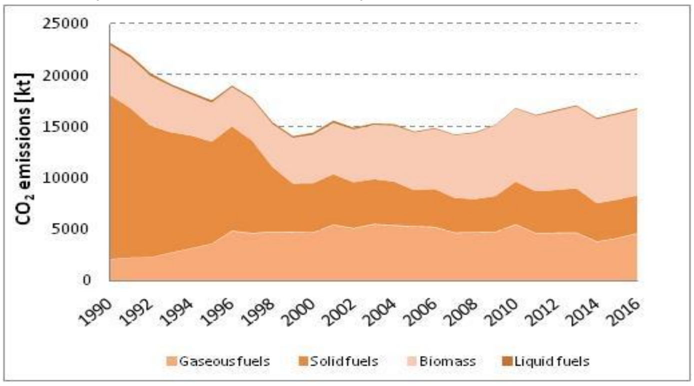

Fig. 3-36 Development of CO_2 emissions in source category 1.A.4.b

In the CzSO Questionnaire (CzSO, 2017), the consumption of the individual kinds of fuels in this sector is reported in capture Other Sector under the item:

Residential

The fraction of CO_2 emissions in subsector 1.A.4.b in CO_2 emissions in sector 1.A.4 equalled 68% in 2016. It contributed 9% to CO_2 emissions in the whole Energy sector 1.A.

At the beginning of the period, a majority of households in the Czech Republic used coal as a heating fuel (mainly brown coal + lignite). This habit has changed over time and Natural Gas began to be used more than Solid Fuels. The same trend appears in the institutional sphere. The number of households using biomass for heating (biomass boilers) in the Czech Republic has increased in the last few years. This trend is also apparent in the Fig. 3-36.

The graph shows that at the beginning of the period in the subsector 1.A.4.b dominated consumption of fossil fuels, which have been gradually substituted primarily by natural gas, but also biofuels (in the case of households, it is mainly firewood). The share of liquid fuels (LPG) is negligible. Small annual fluctuations in fuel consumption are to be attributed to the average annual temperatures. Throughout the sector Residential, a slight decrease can be observed in fuel consumption, which was affected by the replacement of old boilers with more modern with higher efficiency and most importantly building insulations, which is controlled by the national programs "Green Savings". Increasing share of biomass has a positive effect on reducing CO_2 emissions, which are included in total greenhouse gas emissions. While the total fuel consumption declines in this subsector generally slightly (only about 20%), CO_2 emissions from the combustion of fossil fuels decreased by about 50%.

3.2.20.2 Methodological issues (CRF 1.A.4.b)

No specific methodological approaches were applied - general approaches are given in section 3.2.4.

3.2.20.3 Uncertainties and time-series consistency (CRF 1.A.4.b)

See chapter 3.2.5.

3.2.20.4 Category-specific QA/QC and verification (CRF 1.A.4.b)

See chapter 3.2.6.

3.2.20.5 Category-specific recalculations (CRF 1.A.4.b)

Improvement

The activity data and emission factors in 1A4b were refined for some Solid Fuels, specifically, Lignite, Bitumenous Coal, Brown Coal Briquets and Coke. We employed the new net caloric values provided by CHMI. These data were obtained from a long-term study of the distribution network for Solid Fuels used in the Czech Republic. The data better describe the characteristics of burning fuels in this category than the data used in previous submissions.

The whole time series (1990 – 2015) was recalculated. Consequently, emissions were also recalculated. As a result of these recalculations, the values for CO_2 emissions increased in the whole time series compared to the previous submission. The values for CH_4 and N_2O emissions increased in the whole time series compared to the previous submission; for details, see Tab. 3-63.

Tab. 3-63 Changes after recalculation in 1.A.4.b for Solid Fuels

Fuel consumption		1990	1991	1992	1993	1994	1995	1996	1997	1998
Submission 2017	TJ	137 361	124 382	105 389	95 696	88 350	79 313	79 727	70 001	49 765
Submission 2018	TJ	166 588	152 604	134 159	123 002	115 473	104 736	107 360	94 894	66 618
Difference	TJ	29 228	28 222	28 771	27 306	27 124	25 424	27 633	24 894	16 853
	%	21.28	22.69	27.30	28.53	30.70	32.05	34.66	35.56	33.86
Fuel consumption		**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Submission 2017	TJ	38 240	38 044	38 459	35 036	34 991	34 333	28 791	33 507	26 884
Submission 2018	TJ	49 901	50 605	51 847	47 088	45 943	44 766	37 027	39 008	35 589
Difference	TJ	11 661	12 561	13 388	12 052	10 952	10 433	8 235	5 501	8 705

	%	30.50	33.02	34.81	34.40	31.30	30.39	28.60	16.42	32.38
Fuel consumption		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
Submission 2017	TJ	27 010	30 276	37 015	32 852	35 645	40 164	29 774	30 074	
Submission 2018	TJ	33 964	36 974	43 854	43 178	44 104	45 716	39 680	39 840	
Difference	TJ	6 954	6 698	6 840	10 325	8 460	5 552	9 906	9 766	
	%	25.75	22.12	18.48	31.43	23.73	13.82	33.27	32.47	
CO_2 emissions		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2017	kt	13 500	12 157	10 328	9 386	8 663	7 773	7 804	6 855	4 858
Submission 2018	kt	16038	14609	12834	11760	11019	9982	10206	9017	6319
Difference	kt	2538	2452	2506	2375	2356	2208	2402	2162	1461
	%	15.82	16.78	19.52	20.19	21.38	22.12	23.53	23.97	23.12
CO_2 emissions		**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Submission 2017	kt	3 725	3 712	3 755	3 426	3 429	3 353	2 801	3 221	2 621
Submission 2018	kt	4735	4800	4918	4472	4376	4260	3519	3699	3378
Difference	kt	1 009.71	1088	1163	1046	948	907	717	479	757
	%	21.33	22.67	23.64	23.40	21.65	21.29	20.39	12.94	22.41
CO_2 emissions		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
Submission 2017	kt	2 623	2 934	3 556	3 193	3 435	3 842	2 887	2 906	
Submission 2018	kt	3227	3513	4150	4091	4170	4324	3748	3756	
Difference	kt	604	579	594	898	735	482	861	850	
	%	18.71	16.49	14.31	21.96	17.63	11.14	22.97	22.63	
CH_4 emissions		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2017	kt	38.6705	34.6133	29.3182	26.8203	24.9423	22.2847	23.9182	21.0002	14.9296
Submission 2018	kt	47.4388	43.0800	37.9494	35.0122	33.0794	29.9117	32.2081	28.4683	19.9854
Difference	kt	8.7683	8.4667	8.6312	8.1918	8.1371	7.6271	8.2900	7.4681	5.0558
	%	22.67	24.46	29.44	30.54	32.62	34.23	34.66	35.56	33.86
CH_4 emissions		**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Submission 2017	kt	11.4719	11.4132	11.5376	10.5107	10.4972	10.2999	8.6374	10.0520	8.0651
Submission 2018	kt	14.9703	15.1814	15.5540	14.1263	13.7828	13.4299	11.1080	11.7023	10.6766
Difference	kt	3.4984	3.7682	4.0164	3.6156	3.2856	3.1300	2.4706	1.6503	2.6115
	%	30.50	33.02	34.81	34.40	31.30	30.39	28.60	16.42	32.38
CH_4 emissions		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
Submission 2017	kt	8.1029	9.0828	11.1044	9.8557	10.6934	12.0491	8.9322	9.0222	
Submission 2018	kt	10.1892	11.0921	13.1563	12.9533	13.2312	13.7147	11.9041	11.9520	
Difference	kt	2.0863	2.0093	2.0520	3.0976	2.5379	1.6656	2.9719	2.9297	
	%	25.75	22.12	18.48	31.43	23.73	13.82	33.27	32.47	
N_2O emissions		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2017	kt	0.1940	0.1738	0.1472	0.1346	0.1251	0.1118	0.1196	0.1050	0.0746
Submission 2018	kt	0.2378	0.2161	0.1903	0.1755	0.1658	0.1499	0.1610	0.1423	0.0999
Difference	kt	0.0438	0.0423	0.0432	0.0410	0.0407	0.0381	0.0414	0.0373	0.0253
	%	22.60	24.36	29.32	30.43	32.52	34.11	34.66	35.56	33.86
N_2O emissions		**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Submission 2017	kt	0.0574	0.0571	0.0577	0.0526	0.0525	0.0515	0.0432	0.0503	0.0403
Submission 2018	kt	0.0749	0.0759	0.0778	0.0706	0.0689	0.0671	0.0555	0.0585	0.0534
Difference	kt	0.0175	0.0188	0.0201	0.0181	0.0164	0.0156	0.0124	0.0083	0.0131
	%	30.50	33.02	34.81	34.40	31.30	30.39	28.60	16.42	32.38
N_2O emissions		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
Submission 2017	kt	0.0405	0.0454	0.0555	0.0493	0.0535	0.0602	0.0447	0.0451	
Submission 2018	kt	0.0509	0.0555	0.0658	0.0648	0.0662	0.0686	0.0595	0.0598	
Difference	kt	0.0104	0.0100	0.0103	0.0155	0.0127	0.0083	0.0149	0.0146	
	%	25.75	22.12	18.48	31.43	23.73	13.82	33.27	32.47	

3.2.20.6 Category-specific planned improvements (CRF 1.A.4.b)

Currently there are no planned improvements in this category.

3.2.21 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, 2016								
Structure of Fuels	Activity data [TJ]	CO_2 EF [t CO_2/TJ]	OxF	Emissions [kt]	CH_4 EF [kg CH_4/TJ]	Emissions [kt]	N_2O EF [kg N_2O/TJ]	Emissions [kt]
LPG	183.8	65.86*)	1	12.1	5	0.00092	0.1	0.00002
Gasoline	279.9	69.3	1	19.4	6.90*)	0.00193	19.27*)	0.00539
Diesel Oil	13 545.8	74.1	1	1 003.7	5.43*)	0.07361	4.94*)	0.06691
Fuel Oil - Low Sulphur	79.0	77.4	1	6.1	10	0.00079	0.6	0.00005
Other Bituminous Coal	24.9	94.45*)	0.971*)	2.3	300	0.00748	1.5	0.00008
Brown Coal + Lignite	252.9	98.99*)	0.985*)	24.6	300	0.07586	1.5	0.00004
Coke	28.1	107	1	3.0	300	0.00843	1.5	0.00038
Natural Gas	2 571.1	55.40*)	1	142.4	5	0.01286	0.1	0.00026
Wood/Wood Waste	406.0	112	1	45.5	300	0.12180	4	0.00162
Gaseous Biomass	5 741.0	54.6	1	313.5	5	0.02871	0.1	0.00057
Total year 2016	**23 112.5**			**1213.5**		**0.33238**		**0.07532**
Total year 2015	21 771.0			1197.22		0.33640		0.07499
Index 2016/2015	1.06			1.01		0.99		1.00
Total year 1990	47 622.9			3 790.2		5.41374		0.08558
Index 2016/1990	0.49			0.32		0.06		0.88

*) *Country specific data*

The high emission of CH_4 in 1990 is mainly due to the high consumption of other bituminous coal and lignite in the early periods, that have high emission factors (300 kg CH_4/TJ) compared to other fuels. At the end of the period there was a significant decrease in the consumption of solid fossil fuels.

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

2016							
Structure of Fuels	Source for Activity data	Emission factors CO_2	Emission factors CH_4	Emission factors N_2O	Method used CO_2	Method used CH_4	Method used N_2O
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
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. (IPCC 2006), 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, 2017), the consumption of the individual kinds of fuels in this sector is reported in capture Industry Sector under the item:

- Agriculture/Forestry
- Fishing

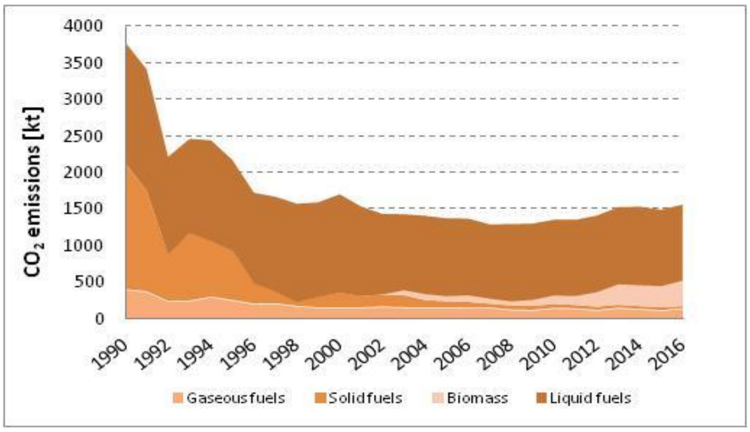

Fig. 3-37 Development of CO_2 emissions in source category 1.A.4.c

The distribution of fuels is done according to their nature - motor fuels are allocated to the subcategory 1.A.4.c.ii, all other fuels -into subcategory 1.A.4.c.i. This division is subsequently agreed annually with the CzSO during mutual consultation.

There are embodied the fuels of economic part according to NACE Rev. 2 Agriculture/Forestry/Fisheries: NACE Divisions 01 – 03.

The fraction of CO_2 emissions in subsector 1.A.4.c in CO_2 emissions in sector 1.A.4 equalled 10% in 2016. It contributed 1.3% to CO_2 emissions in the whole Energy sector.

Development of fuel consumption and the corresponding CO_2 emissions throughout the subcategory 1.A.4.c are visible on Fig. 3-37.

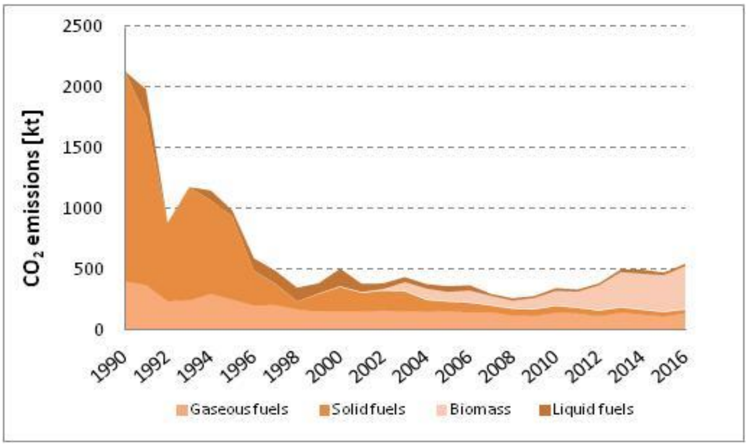

Fig. 3-38 Development of CO_2 emissions in source category 1.A.4.c.i

From the graph on Fig. 3-37 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 Fig. 3-38 and Fig. 3-39 are represented CO_2 emissions arising from stationary off-road transportation and other mechanisms in the agriculture, forestry and fisheries.

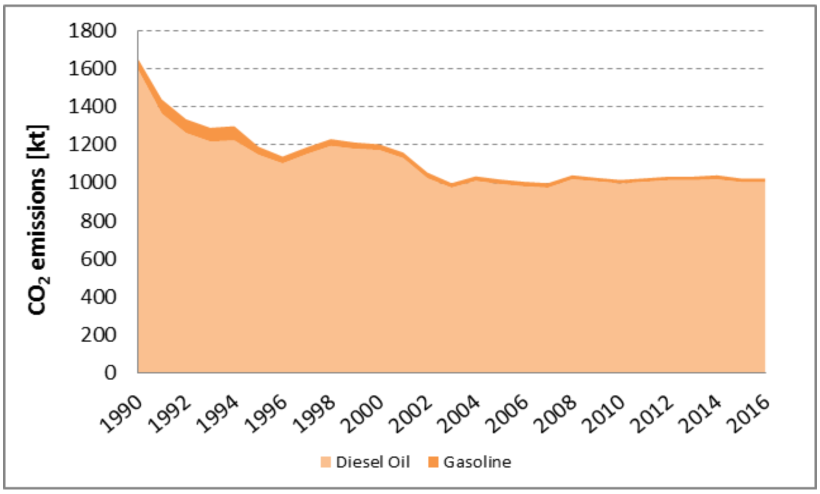

Fig. 3-39 Development of CO_2 emissions in source category 1.A.4.c.ii

In the stationary sources decreased decisively consumption of fossil solid and liquid fuels. The role of natural gas throughout the period was virtually stable and at the end of the period is evident an increased use of biofuels, especially biogas, produced in the biogas stations, built on individual agricultural farms.

To the mobile sources and other mechanisms are to a large extent attributed the consumption of diesel fuels, motor gasoline has minor importance, other fuels are virtually absent. During the period, a noticeable decrease in fuel consumption roughly in the first half of the period is observed, which was caused by higher technical level of engines and especially a decline in demand in all subsectors for agricultural products.

3.2.21.1 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.

3.2.21.2 Uncertainties and time-series consistency (CRF 1.A.4.c)

See chapter 3.2.5.

3.2.21.3 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.

3.2.21.4 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. 3-64 Changes after recalculation in 1.A.4.c.i for Solid Fuels

Fuel consumption		2010	2011	2012	2013	2014	2015
Submission 2017	TJ	500.5	397.6	394.5	404.6	325.6	319.1
Submission 2018	TJ	546.0	464.6	453.6	417.5	393.4	381.7
Difference	TJ	45.5	67.0	59.1	12.8	67.8	62.5
	%	9.09	16.85	14.99	3.17	20.82	19.60
CO_2 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	48.9	39.0	38.6	39.1	32.1	31.4
Submission 2018	kt	52.8	44.9	43.8	40.2	38.0	36.8
Difference	kt	3.9	5.8	5.2	1.1	5.9	5.5
	%	8.08	14.97	13.34	2.85	18.42	17.38
CH_4 emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.15014	0.11927	0.11835	0.12139	0.09768	0.09573
Submission 2018	kt	0.16379	0.13937	0.13609	0.12524	0.11802	0.11450
Difference	kt	0.01365	0.02010	0.01774	0.00385	0.02034	0.01876
	%	9.09	16.85	14.99	3.17	20.82	19.60
N_2O emissions		2010	2011	2012	2013	2014	2015
Submission 2017	kt	0.00075	0.00060	0.00059	0.00061	0.00049	0.00048
Submission 2018	kt	0.00082	0.00070	0.00068	0.00063	0.00059	0.00057
Difference	kt	0.00007	0.00010	0.00009	0.00002	0.00010	0.00009
	%	9.09	16.85	14.99	3.17	20.82	19.60

3.2.21.5 Improvements (CRF 1.A.4.c)

Currently there are no planned improvements in this category.

3.2.22 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, 2016								
Structure of Fuels	Activity data [TJ]	CO_2 EF [t CO_2/TJ]	OxF	Emissions [kt]	CH_4 EF [kg CH_4/TJ]	Emissions [kt]	N_2O EF [kg N_2O TJ]	Emissions [kt]
Gasoline	324.1	69.3	1	22.5	6.90*)	0.00224	19.27*)	0.00624
Kerosene Jet Fuel	1 645.4	71.5	1	117.5	14.38*)	0.02364	10.26*)	0.01686
Diesel Oil	3 436.6	74.1	1	254.6	5.43*)	0.01867	4.94*)	0.01698
Total year 2016	**5403.9**			**394.6**		**0.04455**		**0.04008**
Total year 2015	5 046.6			368.9		0.04028		0.03676
Index 2016/2015	1.07			1.07		1.11		1.09
Total year 1990	n.a			n.a		n.a		n.a
Index 2016/1990	-			-		-		-

*) *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.

2016							
Structure of Fuels	Source of Activity data	Emission factors CO_2	CH_4	N_2O	Method used CO_2	CH_4	N_2O
Gasoline	CzSO	D	CS	CS	Tier 1	Tier 2	Tier 2
Kerosene Jet Fuel	CzSO	D	CS	CS	Tier 1	Tier 2	Tier 2
Diesel Oil	CzSO	D	CS	CS	Tier 1	Tier 2	Tier 2

Given that all stationary sources have been reported in subsectors 1.A.1., 1.A.2. and 1.A.4., in this subsector (starting with this submission) will be reported only mobile sources, which were not disclosed in the subsectors 1.A.3. and 1.A.4.c.

In accordance with the IPCC 2006 Gl. (IPCC 2006), 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).

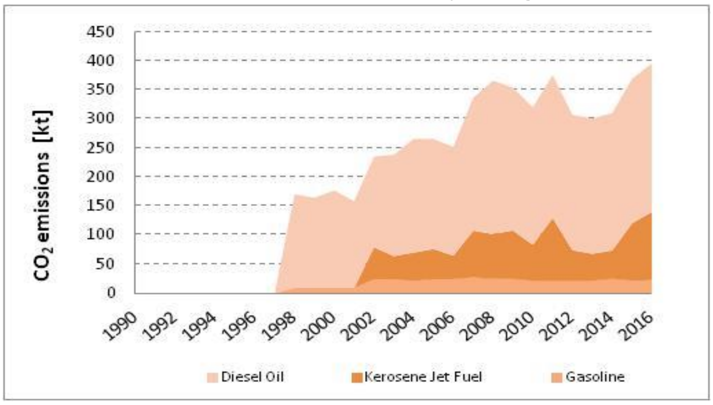

Fig. 3-40 Development of CO_2 emissions in source category 1.A.5.b.

The fraction of CO_2 emissions in subsector 1.A.5 in 2016 contributed 0.4% to CO_2 emissions in the whole Energy sector 1.A.

Development of fuel consumption and the corresponding CO_2 emissions throughout the subcategory 1.A.5.b. are seen in Fig. 3-40. 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. 3-40 shows that a decisive proportion has diesel oil, another significant share is appertain to kerosene jet fuel (mainly army), the proportion of gasoline is minor.

3.2.22.1 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.

3.2.22.2 Uncertainties and time-series consistency (CRF 1.A.5.b)

See chapter 3.2.5.

3.2.22.3 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.

3.2.22.4 Category-specific recalculations (CRF 1.A.5.b)

No recalculations performed in this submission.

3.2.22.5 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)

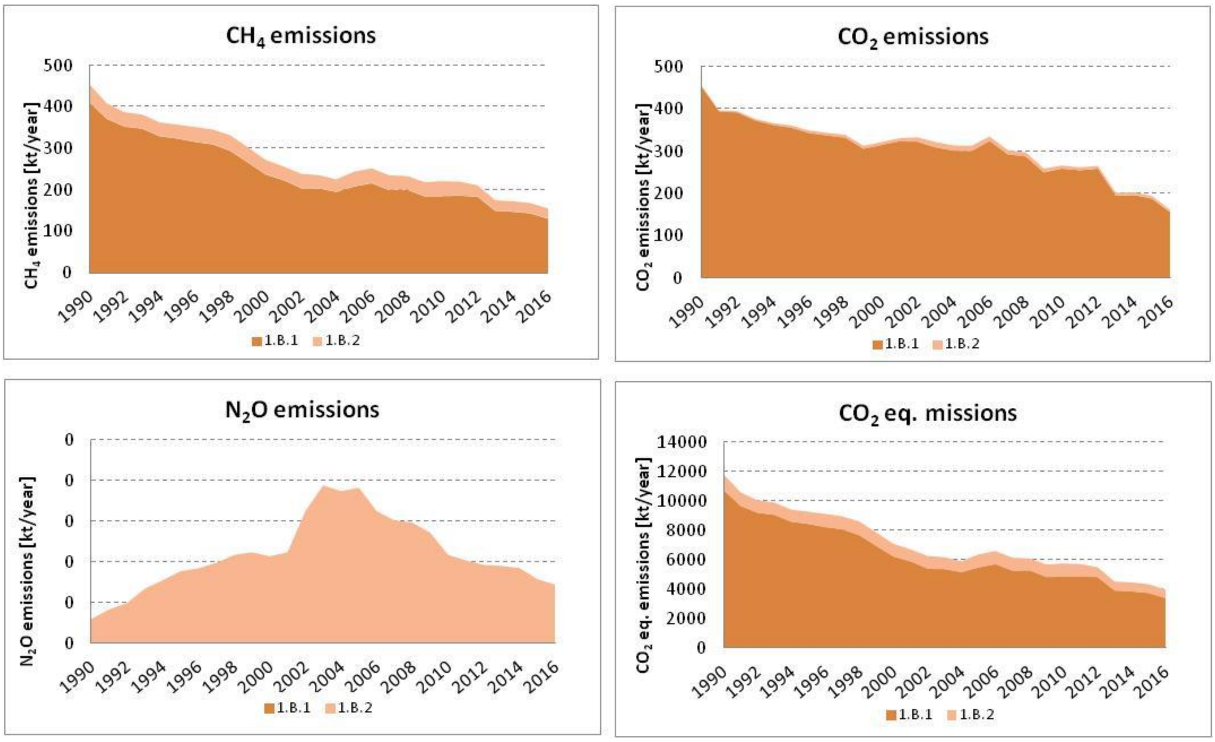

Fig. 3-41 GHG emissions trends from Fugitive emissions from fuels [kt/year]

Mining, treatment and all handling of fossil fuels are sources of fugitive emissions. In the Czech Republic, CH_4 emissions from underground mining of Hard Coal are significant, while emissions from surface mining of Brown Coal, Oil and Gas production, transmission, storage and distribution are less important.

The current inventory includes CH_4 emissions for the following categories:

- 1.B.1 Solid fuels
- 1.B.2 Oil and Natural Gas

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

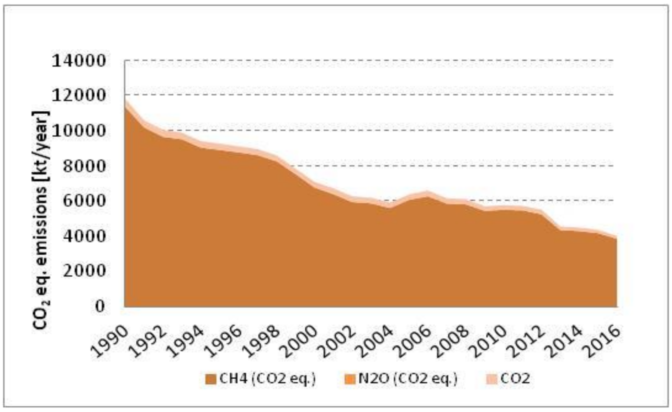

Fig. 3-42 The share of individual GHG emissions from the total emissions, expressed as CO_2 eq. (1.B.)

Development of individual emissions of greenhouse gases in sector 1.B is shown on the graphs in Fig. 3-41.

Sector 1.B is dominated by methane emissions from subcategory 1.B.1. - Solid fuels, while emissions from sector 1.B.2. - Oil and Natural gas represents on average 15% of the total emissions. CO_2 emissions arise primarily in subcategory 1.B.1 - Solid fuels (share of the subcategory 1.B.2 has low importance- about 2% of total CO_2 emissions). N_2O emissions originate only from the subsector 1.B.2.a - Oil and there are insignificant.

The importance of individual greenhouse gases from the total emissions, expressed as CO_2 equivalent, is visible from Fig. 3-42.

From the graphs on Fig. 3-41 and Fig. 3-42 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 2016, the decrease of total GHG emissions is 68.3% 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. (IPCC 2006):

- 1.B.1.a Coal mining and handling
  - 1.B.1.a.1 Underground mines
    - 1.B.1.a1.i Mining
    - 1.B.1.a.1.ii Post-mining seam gas emissions
    - 1.B.1.a.1.iii Abandoned underground mines
  - 1.B.1.a.2 Surface mines
    - 1.B.1.a.2.i Mining
    - 1.B.1.a.2.ii Post-mining seam gas emissions
- 1.B.1.b Solid fuel transformation
- 1.B.1.c Other

3.3.1.1 Category description (CRF 1.B.1)

The structure of the sector, corresponding activity data, used emission factors and emissions of individual greenhouse gases are shown in the following outline.

1.B.1, 2016								
Structure of sector		**Activity data**	**CH_4 EF**	**Emissions**	**CO_2 EF**	**Emissions**	**N_2O EF**	**Emissions**
		[Gg]	**[kg CH_4/t]**	**[kt]**	**[t CO_2/t]**	**[kt]**	**[kg N_2O/t]**	**[kt]**
1.B.1.a	Coal mining/handl.	45 434		130.39		156.46		NO
1.B.1.a.1	Underground mines	6 900		76.18		156.46		NA
1.B.1.a.1.i	Mining		8.75	60.38	22.7	156.46	NA	NA
1.B.1.a.1.ii	Post-mining activ.		1.675	11.56	NA	NA	NA	NA
1.B.1.a.1.iii	Abandoned mines	+)		4.24		NA	NA	NA
1.B.1.a.2	Surface mines	38 528		54.21		NA		NA
1.B.1.a.2.i	Mining		1.34	51.63	NA	NA	NA	NA
1.B.1.a.2.ii	Post-mining activ.		0.067	2.58	NA	NA	NA	NA
1.B.1.b	Solid fuel transformation	6.00	30	0.18	NO	NE	NA	NA
Total year 2016				**391.34**		**156.46**		**NA**
Total year 2015				143.25		188.53		NA
Index 2016/2015				2.73		0.83		NA
Total year 1990				412.93		456.24		NA
Index 2016/1990				0.95		0.34		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.

2016								
Structure of sector		**Source of Activity data**	**Emission factors**			**Method used**		
			CH_4	**CO_2**	**N_2O**	**CH_4**	**CO_2**	**N_2O**
1.B.1.a	Coal mining/handl.	CzSO				Tier 1-2	Tier 1-2	-
1.B.1.a.1	Underground mines	CzSO				Tier 1-2	Tier 1-2	-
1.B.1.a.1.i	Mining	CzSO	CS	CS	NA	Tier 2	Tier 2	-
1.B.1.a.1.ii	Post-mining activ.	CzSO	D	D	NA	Tier 1	Tier 1	-
1.B.1.a.1.iii	Abandoned mines	various+)	D	D	NA	Tier 1	Tier 1	-
1.B.1.a.2	Surface mines	CzSO				Tier 1	Tier 1	-
1.B.1.a.2.i	Mining	CzSO	D	D	NA	Tier 1	Tier 1	-
1.B.1.a.2.ii	Post-mining activ.	CzSO	D	D	NA	Tier 1	Tier 1	-
1.B.1.b	Solid fuel transformation	FAOSTAT	D	D	NA	Tier 1	Tier 1	-

+) Methodology and emission factors are explained in 3.3.1.2.

The source category 1.B.1 Solid Fuels consists of three sub – source categories: source category 1B.1.a Coal mining and Handling, source category 1.B.1.b Coal transformation and source category 1.B.1.c Other.

The main process that emits more than 80% of methane emissions from the category 1.B.1 Solid Fuels category is underground mining of Hard Coal in the Ostrava-Karviná area. A lesser source consists in Brown Coal mining by surface methods and post-mining treatment of Hard and Brown Coal. Coal mining (especially Hard Coal mining) is accompanied by an occurrence of methane. Methane, as a product of the coal-formation process, is physically bonded to the coal mass or is present as the free gas in pores and cracks in the coal and in the surrounding rocks.

Besides methane, during mining of coal mass a certain amount of carbon dioxide is released, that accompanies methane in the firedamp. CO_2 is reported only for the underground mining of hard coal, for surface mining of lignite emission factor is not available.

The proportion of subcategory 1.B.2 - Solid fuel transformation in the total emissions of greenhouse gases is quite minor. Subcategory 1.B.1.c - Other is not used, because for reporting the previous subcategories are used.

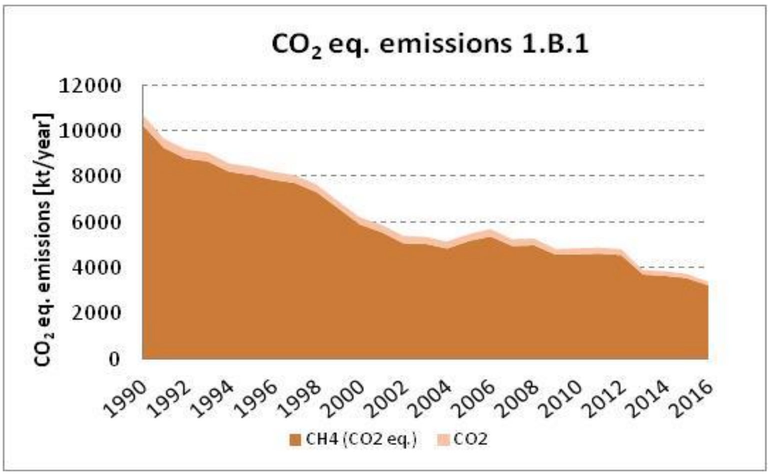

Fig. 3-43 The trend of GHG emissions and the relationship between emissions of CO_2 and CH_4 (1.B.1)

The graph on Fig. 3-43 shows the time trend of total emissions of greenhouse gases in the entire subsector 1.B.1. The chart also demonstrates the share of CO_2 emissions in the total GHG emissions, which on average makes about 5%.

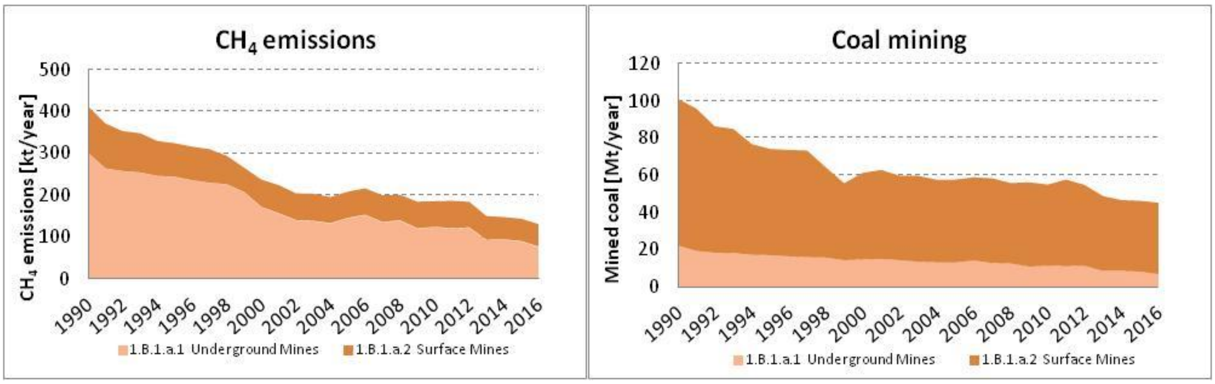

Fig. 3-44 The ratio of methane emissions from Underground mines and Surface mines and the corresponding development of mining of Hard Coal and Lignite (1.B.1)

The contribution of the individual subsectors to the total emissions of CH_4, depending on the volume of mining from underground mines (hard coal) and surface mines (lignite) in category 1.B.1 is shown on the graph in Fig. 3-44.

The Czech Republic has historically mined and is still mining large volumes of lignite, primarily for energy purposes. Hard coal is used for energy purposes, as well as for the production of metallurgical coke. Hard coal mining, although its volume is about 20% of the total volume, is accompanied by considerably more significant CH_4 emissions than mining of lignite.

3.3.1.1.1 Coal Mining and Handling (CRF 1.B.1.a)

In the Czech Republic, mainly Hard Coal is mined in underground mines (i.e. Hard Coal: Coking Coal and Bituminous Coal). Currently, underground mines are in operation in the Ostrava-Karviná coalmining area. In the past, Hard Coal was also mined in the vicinity of the city of Kladno. These mines were closed in 2003. Brown Coal is mined in only one underground mine in the Northern Bohemia. Emissions from this mine are reported together with surface mining of Brown Coal – Lignite in subcategory 1.B.1.a.2 Surface Mines.

Data for mining of various types of coal are taken from the CzSO report for the IEA/EUROSTAT (the report CZECH_COAL.xls). For control purposes are used data from the miners yearbooks issued by the State Mining Administration and the Employers' Association of Mining and Oil Industries.

Underground Mines (CRF 1.B.1.a.1)

In underground Hard Coal mining, CH_4 is released from the coal mass and from the surrounding rocks into the mine air and must be removed to the surface to prevent formation of dangerous concentrations in the mine.

Underground Mining Activities (1.B.1.a.1.i)

Hard-coal mining is the principal source of fugitive emissions of CH_4. The mine ventilation must be regulated according to the amounts of gas released to keep its concentration on safe level. At the end of 1950’s mine gas removal systems were introduced in opening new mines and levels in the Ostrava – Karviná coal-mining area, which permitted separate exhaustion of partial methane released in the mining activity in the mixture containing the mine air. The total amount of methane emitted can be balanced quite accurately from the methane concentrations in the mine air and their total annual volume.

Post-Mining Activities (1.B.1.a.1.ii)

The activity data are the same as in category 1.B.1.a.1.i Mining Activities. It is assumed that the entire mined volume undergoes manipulation during which residual methane is released.

Abandoned underground mines (1.B.1.a.1.iii)

Abandoned underground mines in the Czech Republic are located in Kladno Basin (near Kladno, 30 km northwest of Prague) and in the Ostrava-Karvina coalfield - OKR (North Moravia). In terms of methane emissions are relevant only abandoned mines in OKR. Coal mining in the Kladno Basin was terminated in 2002. In these mines methane was absent, so the methane emissions estimate is made only from OKR mines.

In the Ostrava-Karvina coalfield coal has been extracted for more than two hundred years. Crucial decline of mining in this area started in 1991, but the closure of mines occurred in the 20s of the 20th century.

Ostrava mines have always been significant sources of coal seam gas and in terms of mine safety regulations they were categorized under the mines with greatest threat of occurrence of methane. Methane is observed more than 100 years and reached its peak in the sixties when was the maximum in mining in Ostrava. At that time, exceeded the daily amount of gas is 500 thousand. m^3 CH_4. The gas was discharged from the mines using ventilation with 17 air pits and mine degassing. Amount on the gas in abandoned mines today, after the destruction of almost all pits, is stabilized at around 40 thousand. m^3 CH_4 per day. Based on the amount of methane escaped in recent years and using the international experience, can be forecasted that the gas will continue to be released from the underground spaces in Ostrava for a number of years.

Parts of abandoned mines have CH_4 recovery systems. There is company, which has established mining areas for mining of fire-damp in Ostrava-Karviná area. In the abandoned mines there are automatic suction devices and firedamp stations. Firedamp arises from abandoned mining pits and surface boreholes into abandoned areas. Mined firedamp is used at the place of mining in autonomous cogeneration units (aggregate for electricity energy production with an ignition combustion engine)(http://www.dpb.cz/).

Surface Mines (CRF 1.B.1.a.2)

Surface Mining Activities (1.B.1.a.2.i)

Lignite (Brown Coal) is mined in surface mines in the Czech Republic. Lignite is mined primarily in the Northern Bohemia area. Small parts of very young Lignite mines are located in Southern Moravia.

Prior to the commencement of surface mining in northern Bohemia, where today a decisive amount of lignite in the Czech Republic is mined, there were underground mines. The abundance of methane in these mines has never been a problem. If there was an explosion in the mines, it was caused by swirling of coal dust. Surface mining began in the 50s of the 20th century and in the period after 1990 the underground mines were already not in use.

Post-Mining Activities (1.B.1.a.2.ii)

The activity data are the same as in category 1.B.1.a.2.i Mining Activities. It is assumed that the entire mined volume undergoes treatment during which residual methane is released.

3.3.1.1.2 Solid Fuel Transformation (CRF 1.B.1.b)

Production of Coke from Coking Coal

Fugitive methane emissions from coal treatment prior to the actual coking process are listed under 1.B.1.a.1.ii Post-Mining Activities. Emissions from the actual production of Coke are given under 2. Industry.

Production of briquettes from Brown Coal

Fugitive methane emissions from coal treatment prior to the actual briquetting process are listed under 1.B.1.a.1.ii Post-Mining Activities. CO_2 emissions from the actual production of briquettes are included in subcategory 1.A.2.g.

Production of charcoal

CH_4 emissions from charcoal production were estimated by using EF provided by the Revised 1996 Guidelines (IPCC, 1997); the value of 1000 kg CH_4/TJ of charcoal produced was used. Since there are no available official activity data about charcoal production in the Czech Republic, the un-official data from FAOSTAT statistics were used. The missing data were extrapolated. The default net calorific value 30 MJ/kg (Table 1-13 in Revised 1996 Guidelines) was used to convert activity data to the energy units. Resulting CH_4 emissions please see in the Tab. 3-65. 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. 3-65 CH_4 emissions from charcoal production

	1.B.1.b Solid Fuel Transformation		
	Production [kt/year]	Production [TJ/year]	CH_4 emissions [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
2016	6.00	180.00	0.18

Fugitive CO_2 emissions are not estimated or are negligible and no known method is available for their determination in this category (notation key NE). Fugitive N_2O emissions are not estimated because, according to the current state of knowledge, these emissions cannot occur (notation key NA) and also IPCC 2006 Guidelines (IPCC 2006) do not provide default emission factor.

3.3.1.1.3 Other (CRF 1.B.1.c)

No other subcategory of fugitive methane emissions is known in the Czech Republic.

3.3.1.2 Methodological issues

Underground Mines (CRF 1.B.1.a.1)

Underground Mining Activities (1.B.1.a.1.i)

Country specific emission factors were determined for calculation of fugitive methane emissions in underground mines in the second half of the 1990's: the ratio between mining and the volume of methane emissions is given in Tab. 3-66, see (Takla and Nováček, 1997).

Tab. 3-66 Coal mining and CH_4 emissions in the Ostrava - Karvina coal-mining area

	Coal mining [mil. t/year]	CH_4 emissions [mil. m^3/year]	Emission factors [m^3/t]
1960	20.90	348.9	16.7
1970	23.80	589.5	24.7
1975	24.11	523.8	21.7
1980	24.69	505.3	20.5
1985	22.95	479.9	20.9
1990	20.60	381.1	19.0
1995	15.60	270.7	17.4
1996	15.10	276.0	18.3
Total	**167.31**	**3375.3**	**20.2**
1990 till 1996	50.76	927.8	18.3

Only the values for 1990, 1995 and 1996 were used from this table to determine the emission factors.

The average value of the emission factor of 18.3 m^3/t was recalculated to 12.261 kg/t using a density of methane of 0.67 m^3/kg. This emission factor is used for coal mined in the Ostrava-Karviná coalmining area for years 1990 - 1999. The emission factor set by estimation at 50% of this value was used for the remaining Hard Coal from underground mines in other areas. This is valid for coal with minimum coal gas capacity (coal from the Kladno area to 2002 and coal from the Žacléř area from 1998).

For the period after 2000 were determined new, revised emission factors CH_4/t mined coal.

The management of OKD, a.s. (Ostrava-Karviná mines, joint share company) was contacted since this company monitors in very detail the issues about methane production. In response to a request from the reporting team, the company provided a document in which the total amount of gas released by OKD mines was determined, together with the amount of methane withdrawn by degassing, the amounts of methane used for industrial purposes, venting of methane from degassing and the total amount of methane released into the atmosphere. A summary of the information provided is given in Tab. 3-67.

Tab. 3-67 Methane production from gas absorption of mines and its use

Year	Total amount of gas	Pumped out by gas absorption	Industrial use	Venting from gas absorption into the atmosphere	Released into the atmosphere - total
	mil.m^3 CH_4 * $year^{-1}$				
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. 3-68 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. 3-68 Calculation of emission factors from OKD mines for period 2000 onwards

Year	OKD mining [kt/year]	CH_4 emissions [t/year]	EF [t CH_4/kt]
2000	11 514	106 396	9.24
2001	11 844	94 336	7.96
2002	12 049	87 301	7.25
2003	11 301	85 626	7.58
2004	10 901	80 869	7.42
2005	10 822	92 058	8.51
2006	11 656	97 150	8.33
2007	10 153	82 879	8.16
2008	10 030	87 770	8.75
2000 - 2008	100 270	814 385	8.12

For years 2000 – 2008 were used emission factors given in Tab. 3-68 for calculation of emission factors from OKD mines. For years onwards 2008 is used average emission factors from the period 2000-2008; 8.12 t/kt of mined hard coal, for period before 1999 the value is same as in previous submission 12.3 t/kt of mined coal (Takla and Nováček, 1997).

This emission factor can be considered as emissions factor on the level Tier II – it is country-specific emission factor, which is applicable for Ostrava-Karviná area.

For other mines in the Czech Republic where hard coal was also mined, the value of 6.7 t/kt was used – the same as in previous submissions. However it is necessary to remind that underground mining in the mines of other areas than OKD is really minor and at the end of the first decade of 21st century was completely stopped.

Country specific emission factors were determined for calculation of fugitive carbon dioxide emissions. An extra study was performed to determine the CO_2 emission factor for underground hard coal mining. Monthly data on the concentrations and amounts of CO_2 were processed for all the exhaust air shafts in the OKD area for 2009, 2010 and for part of 2011. These data yielded an average value of the emission factor, which is related to the volume of mining. The emission factor is equal to 22.75 t CO_2/kt of mined coal and this emission factor is country specific – Tier II level. This value is valid for the OKD area. The author of the study recommended that the determined emission factor for 1990 – 2009 be used. He determined an emission factor 22.68 t CO_2/kt of mined coal for 2010 and it was recommended that this value also be used for the subsequent years. These emission factors were used to extend the data for CO_2 emissions for underground hard coal mining; the values are given in the Tab. 3-69.

Tab. 3-69 Emission factors and emissions from underground mining of hard coal

Year	Production OKD [kt/year]	Emission factor [t CO_2/kt]	Emissions of CO_2 [kt CO_2/year]
1990	20 059	22.75	456.3
1991	17 371	22.75	395.1
1992	17 271	22.75	392.9
1993	16 419	22.75	373.5
1994	15 942	22.75	362.6
1995	15 661	22.75	356.2
1996	15 109	22.75	343.7
1997	14 851	22.75	337.8
1998	14 620	22.75	332.6
1999	13 468	22.75	306.4
2000	13 855	22.75	315.2
2001	14 246	22.75	324.1
2002	14 200	22.75	323.0
2003	13 614	22.75	309.7
2004	13 272	22.75	301.9
2005	13 227	22.75	300.9
2006	14 280	22.75	324.8
2007	12 886	22.75	293.1
2008	12 622	22.75	287.1
2009	11 001	22.75	250.2
2010	11 435	22.68	259.3
2011	11 265	22.68	255.4
2012	11 440	22.68	259.4
2013	8 594	22.68	194.9
2014	8 680	22.68	196.8
2015	8 314	22.68	188.5
2016	6 900	22.68	156.5

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 1.68 kg CH_4/t coal; the activity data are employed at the same level as in subcategory 1.B.1.a.1.i Mining Activities.

Tab. 3-70 contains of fugitive methane emissions from post-mining operations with Hard Coal from Underground mines.

Tab. 3-70 Used emissions factors and calculation of CH_4 emissions from underground coal mining – post mines operations in period 1990 - 2016

Year	Production OKD [kt/year]	Emission factor [t CH_4/kt]	Emissions of CO_2 [kt CH_4/year]
1990	22 371	1.675	37.47
1991	19 461	1.675	32.60
1992	18 481	1.675	30.96
1993	18 297	1.675	30.65
1994	17 376	1.675	29.10

Year	Production OKD [kt/year]	Emission factor [t CH_4/kt]	Emissions of CO_2 [kt CH_4/year]
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
2016	6 900	1.675	11.56

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 (IPCC, 2006, 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. 3-71.

Tab. 3-71 Emission of CH_4 on abandoned mines

Year	CH_4 emissions in period [kt/year]				Calculated emissions	Use of CH_4 [%]	Total emissions
	1926 - 1950	1951 - 1975	1976 - 2000	2001 - 2013			
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

Year	CH₄ emissions in period [kt/year]				Calculated emissions	Use of CH₄ [%]	Total emissions
	1926 - 1950	1951 - 1975	1976 - 2000	2001 - 2013			
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	0.00	11.63		11.63
2002	0.41	1.99	8.86	0.00	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
2016	0.37	1.71	10.31	1.75	14.13	70.0	4.24

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. 3-72.

Tab. 3-72 Used activity data, emissions factors and calculation of CH_4 emissions from surface coal mining and post mines operations in period 1990 - 2016

year	Brown Coal production [kt/year]	Emission factors for activities mines [t CH₄/kt]	post-mines [t CH₄/kt]	Emissions of CH₄ [kt CH₄/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

year	Brown Coal production [kt/year]	Emission factors for activities mines [t CH_4/kt]	post-mines [t CH_4/kt]	Emissions of CH_4 [kt CH_4/year]
2016	38 528	1.34	0.067	54.21

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, 2017), was employed to determine activity data on extraction of Brown Coal and Lignite. The mining yearbooks and other data sources continue to be used only for control purposes.

During surface mining, escaping methane is not related to specific flow of air and thus it is far more difficult to monitor the amount of methane escaping into the air. Consequently, default IPCC emission factors are employed to calculate methane emissions from surface mining and from post-mining treatment (IPCC 2006).

3.3.1.2.1 Solid Fuel Transformation (CRF 1.B.1.b)

Emission calculation was performed for the production of wood charcoal at Tier I, using default emission factors - see chapter 3.3.1.1.2.

CH_4 emissions from charcoal production were estimated by using EF provided by the Revised 1996 Guidelines (IPCC, 1997); the value of 1000 kg CH_4/TJ of charcoal produced was used. Since there are no available official activity data about charcoal production in the Czech Republic, the un-official data from FAOSTAT statistics were used. The missing data were extrapolated. The default net calorific value 30 MJ/kg (Table 1-13 in Revised 1996 Guidelines) was used to convert activity data to the energy units. Unfortunately IPCC 2006 Guidelines (IPCC 2006) don't provide default emissions factors for fugitive emissions from charcoal production. From this reason the emission factor provided in Revised 1996 Guidelines (IPCC, 1997) is still used. Since these emissions are very low the team consider this approach to be relevant in this case.

3.3.1.3 Uncertainties and time-series consistency

The inventory methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2016. The uncertainties in the activity rate result primarily from inaccuracies in weighing of extracted coal. Extensive research concerning new evaluation of uncertainties was performed last year. Uncertainties in determining the activity data were estimated at 4%.

Uncertainties in calculating methane emissions further follow from the emission factors employed. The emission factors for determining emissions from underground mining of hard coal are based on measurement of the methane concentrations in the air ventilated from underground mines in the second half of the 1990's. The uncertainty in the emission factors is considered to be at the level of 12.9%.

The uncertainty in the CO_2 emission factor is considered to be at the level of 25%.

Summary of uncertainty estimates provides Tab. 3-73.

Tab. 3-73 Uncertainty estimates for fugitive emissions from Solid Fuels

Gas	Source category	AD uncertainty [%]	EF uncertainty [%]	Origin of actual level of uncertainty
CO_2	1.B.1.a Coal Mining and Handling	4	25	V. Neuzil, P. Fott, AD unc. in line with 2006 Guidelines, EF unc. expert judgement
CH_4	1.B.1.a Coal Mining and Handling	4	13	V. Neuzil, P. Fott, AD unc. in line with 2006 Guidelines, EF unc. expert judgement

3.3.1.4 Category-specific QA/QC and verification

General quality control and source-specific quality control (Tier 1 and Tier 2), in conformance with the requirements of the QSE handbook and its associated applicable documents, have been performed to the full extent.

QC activities at the level of Tier 1 were performed according to the QA/QC plan by the sector compiler. Routine control was performed in the framework of the following activities:

- activity data employed,
- emission factors employed,
- calculation procedures employed,
- transfer of numerical data from the working set to the CRF Reporter.

During control of the activity data, the CzSO data were compared with the data from the Mining Yearbook. Good agreement was found.

In control of the emission factors employed, the emission factors used in the Czech Republic methodology were compared with the emission factors of Slovakia, Poland and Germany in the context with the default emission factors. It was found that the emission factors employed for calculation of emissions in the Czech Republic methodology correspond, in their range, to the emission factors employed in the other countries.

Furthermore, the correct usage of the methodology at Tier I level for the calculation of CH_4 emissions from abandoned mines and the performance of own calculations were checked. The calculation procedure was consulted with an independent expert from the VSB-Technical University of Ostrava. It was concluded that the input data and the method of calculation are in line with the methodology.

Control that the transfer of numerical data from the working set to the CRF Reporter does not reveal any differences. The final working set in EXCEL format is locked to prevent intentional rewriting of values and archived at the coordination workplace. The protocols on the performed QA/QC procedures are stored too.

3.3.1.5 Category-specific recalculations

No recalculations performed in this submission.

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. (IPCC 2006), 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 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. (IPCC 2006) 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, 2016									
Structure of sector		**Activity data [PJ]**	**CH_4 EF [t CH_4/PJ]**	**CH_4 Emissions [kt]**	**CO_2 EF [t CO_2/PJ]**	**CO_2 Emissions [kt]**	**N_2O EF [kg N_2O/PJ]**	**N_2O Emissions [kt]**
1.B.2.a.1	Exploration	NE						
1.B.2.a.2	Production and Upgr.	4.96	4.746	0.024	7.576	0.041	NA	-
1.B.2.a.3	Transport	230	0.146	0.034	0.013	0.003	NA	-
1.B.2.a.4	Refining	230	0.134	0.179	NA	-	NA	-
1.B.2.a.5	Distrib. of Oil Prod.	230	NA	-	NA	-	NA	-
1.B.2.a.6	Other	NO						
1.B.2.b.1	Exploration	NO						
1.B.2.b.2	Production	7.42	38.65	0.287	+)	0.0001	NA	-
1.B.2.b.3	Processing	NO						
1.B.2.b.4	Transmission and	1 157	4.74	5.484	+)	0.022	NA	-
	Storage	186	4.38	0.812	+)	0.003	NA	-
1.B.2.b.5	Distribution	136	119.89	16.27	+)	0.065	NA	-
1.B.2.b.6	Other	I.E.						
1.B.2.c.1	Venting - Oil	4.96	235.3	1.168	48.7	0.242	NA	-
1.B.2.c.2	Flaring - Oil	4.96	0.568	0.003	919.9	4.564	0.015	0.0001
Total year 2016				**24.261**		**4.940**		**0.0001**
Total year 2015				24.321		5.392		0.0001
Index 2016/2015				1.00		0.92		1.00
Total year 1990				43.196		2.202		0.00003
Index 2016/1990				0.56		2.24		3.33

+) As emission factor is used the average annual CO_2 content in natural gas

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

2016								
Structure of sector		**Source of Activity data**	**Emission factors CH_4**	**Emission factors CO_2**	**Emission factors N_2O**	**Method used CH_4**	**Method used CO_2**	**Method used N_2O**
1.B.2.a.1	Exploration	NE						
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.

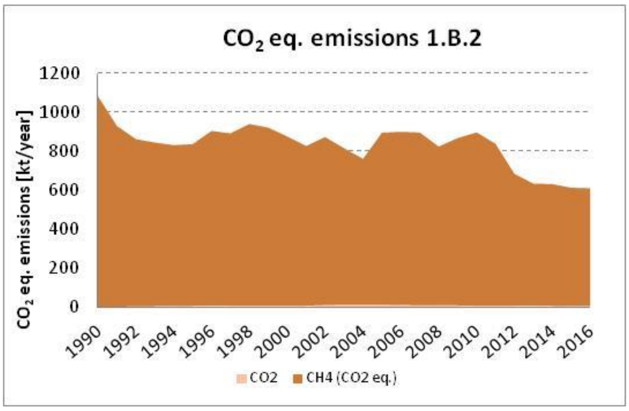

Fig. 3-45 The trend of GHG emissions and the relationship between CO_2 and CH_4 emissions (1.B.2)

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 (IPCC 2006).

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. 3-45 gives an overview of the trend in emissions in this category in the time series since 1990.

The graph on Fig. 3-45 shows that the proportion of total CO_2 emissions from the total GHG emissions is negligible (approximately 0.1%).

The contribution of the individual subsectors (Oil and Natural Gas) to the total CH_4 emissions throughout the period in the category 1.B.2 is shown on Fig. 3-46.

As shown on Fig. 3-46 for the amount of CH_4 emissions in sector 1.B.2. Oil and Natural Gas are therefore crucial the emissions, produced in the gas industry.

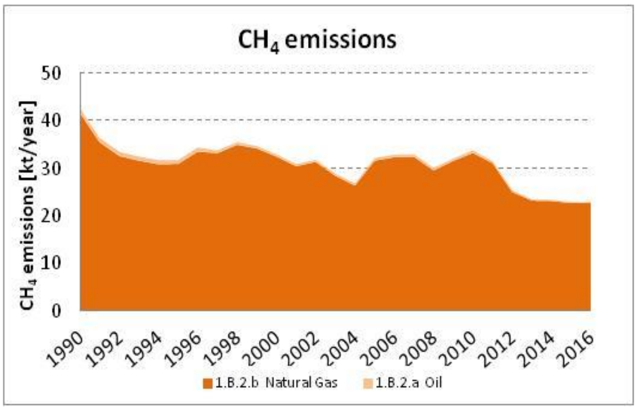

Fig. 3-46 The ratio of methane emissions from subsector Oil (1.B.2.a) and Natural Gas (1.B.2.b)

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

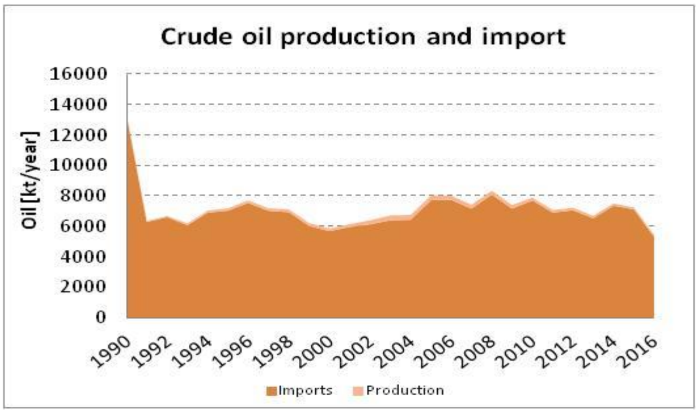

Fig. 3-47 Crude Oil production and import in the CR in 1990 – 2016

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. 3-47.

GHG emissions from Crude Oil transport and refining and from Crude Oil production, which is performed in the Czech Republic in combination with mining of Natural Gas, are reported in this category. CO_2 emissions from the refinery resulting from combustion processes (including flaring) are included in 1.A.1.b Crude Oil Refining.

Exploration (1.B.2.a.iii.1)

Emissions from this subcategory are not estimated because the activity data are not available. Exploration is not regularly performed in the Czech Republic. The statement of MND a.s. (only company with licence for exploration in Czechia) is that they did not perform exploration last several years.

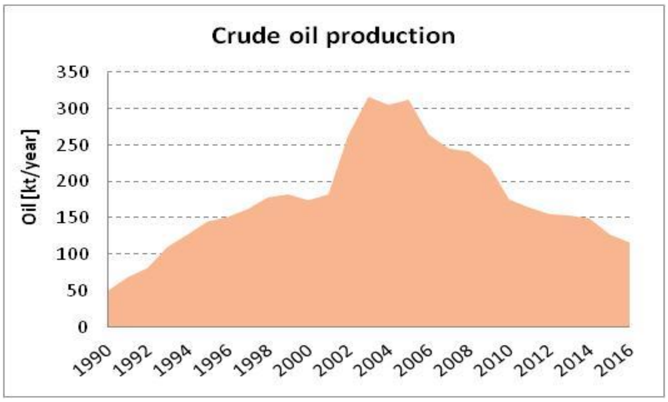

Fig. 3-48 Crude Oil production in the CR in 1990 – 2016

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. 3-48 is visible that the maximum extraction was in the period from 2003 to 2006. It is expected that the decline in production until 2014 will continue.

Transport (1.B.2.a.iii.3)

Transport of Crude Oil in the territory of the Czech Republic is performed only in closed systems (pipeline transport – Oil pipeline Družba from Russia and Ingolstat from Germany). Default emission factors were used to calculate fugitive CH_4 and CO_2 emissions in this subsector.

Refining (1.B.2.a.iii.4)

Crude Oil is processed in the territory of the Czech Republic in two main refinery facilities. The total volume of Crude Oil processed in the Czech Republic is presented in Fig. 3-41.

Distribution of Oil Products (1.B.2.a.iii.5)

The final products after processing Crude Oil no longer contain dissolved methane or carbon dioxide and thus fugitive emissions are not considered in this subcategory. For completeness, activity data corresponding to the volume of processed Crude Oil in the individual years were recorded in CRF.

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

No other operations are considered.

3.3.2.1.2 Natural Gas (CRF 1.B.2.b)

In the subcategory Natural Gas are reported GHG emissions from domestic natural gas production and emissions related to the operation of individual parts of the gas system (import, transit, storage and distribution to end users). The share of the domestic natural gas production is very small - about 1.3% (from 0.7 to 2.1%). The time profile of domestic production and import of

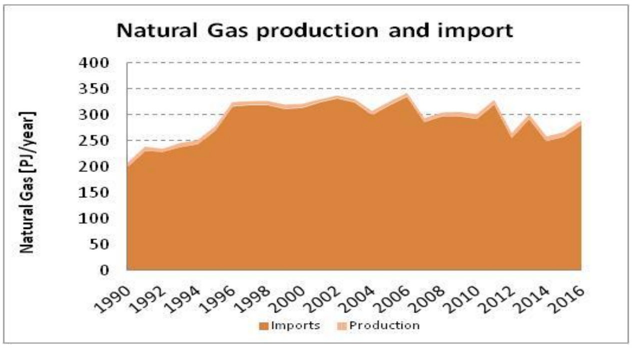

Fig. 3-49 Natural Gas production end import in the CR in 1990 – 2016

natural gas in the Czech Republic is shown on Fig. 3-49.

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. 3-50 gives the amount of production Natural Gas in the territory of the Czech Republic.

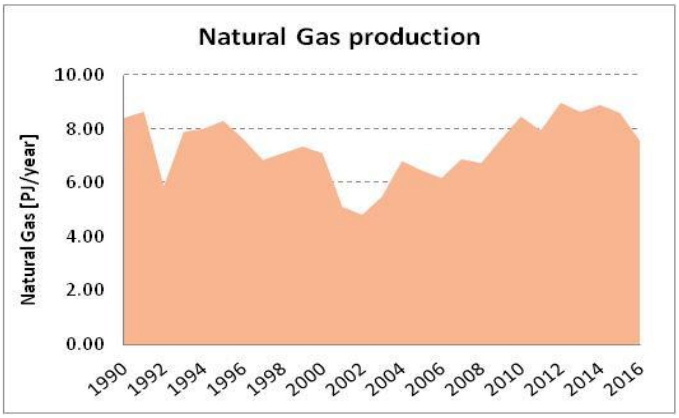

Fig. 3-50 Natural Gas production in the area of CR in 1990 – 2016

The development of domestic extraction is relatively stable over time. Fluctuations in individual years are due to technical and geological conditions of mining and market demand.

Processing (1.B.2.b.iii.3)

Gas treatments, except for drying, are not performed in the Czech Republic. The drying process is not a source of GHG emissions.

Transmission and Storage (1.B.2.b.iii.4)

The calculation of GHG emissions in this subcategory is carried out in two steps: independently in the first step is carried out an estimation of the emissions for the transit system and high-pressure gas pipelines, and in the second step emissions from underground gas storage facilities are estimated. For each part of the gas system is used a different methodological approach.

A transit gas pipeline runs through the territory of the Czech Republic, transporting Natural Gas from Russia to the countries of Western Europe, with a length of 3,821 km. In addition to this central gas pipeline, a system of high-pressure gas pipelines is in operation in the territory of the Czech Republic, providing supplies of Natural Gas from the transit gas pipeline and underground gas storage areas to centres of consumption. In 2016, the high-pressure gas pipelines had an overall length of 12,878 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 5,441 mil. m^3 in 2016.

Distribution (1.B.2.b.iii.5)

Emissions from distribution gas pipelines, with an overall length in 2016 of 65165 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. 3-73 gives the CH_4 and CO_2 emissions from Venting for domestic production (mining) of Crude Oil; N_2O emissions are not included in this subcategory since no emission factor is available for their calculation. Tab. 3-74 further contains values of emissions CH_4, CO_2 and N_2O from Flaring in domestic production of Crude Oil. From the table it is clear that this is a minor proportion from the total emissions in whole subcategory Oil and Gas (1.B.2.a).

Tab. 3-74 Emissions of CH_4, CO_2 and N_2O from Venting and Flaring in 1990 – 2016

	Venting - emissions [t/year]		Flaring - emissions [t/year]		
	CH_4	CO_2	CH_4	CO_2	N_2O
1990	0.49	0.10	0.001	1.92	0.00003
1991	0.68	0.14	0.002	2.64	0.00004
1992	0.80	0.17	0.002	3.14	0.00005
1993	1.09	0.23	0.003	4.25	0.00007
1994	1.25	0.26	0.003	4.90	0.00008
1995	1.43	0.30	0.003	5.59	0.00009
1996	1.49	0.31	0.004	5.82	0.00009
1997	1.60	0.33	0.004	6.24	0.00010
1998	1.75	0.36	0.004	6.85	0.00011
1999	1.81	0.37	0.004	7.06	0.00011
2000	1.73	0.36	0.004	6.76	0.00011
2001	1.81	0.37	0.004	7.06	0.00011
2002	2.62	0.54	0.006	10.24	0.00016
2003	3.13	0.65	0.008	12.23	0.00019
2004	3.02	0.62	0.007	11.78	0.00019
2005	3.08	0.64	0.007	12.05	0.00019
2006	2.62	0.54	0.006	10.23	0.00016
2007	2.44	0.50	0.006	9.52	0.00015
2008	2.39	0.50	0.006	9.35	0.00015
2009	2.19	0.45	0.005	8.58	0.00014
2010	1.76	0.36	0.004	6.86	0.00011
2011	1.65	0.34	0.004	6.44	0.00010
2012	1.56	0.32	0.004	6.08	0.00010
2013	1.54	0.32	0.004	6.01	0.00010
2014	1.50	0.31	0.004	5.85	0.00009
2015	1.28	0.26	0.003	4.99	0.00008
2016	1.17	0.24	0.003	4.56	0.00007

3.3.2.2 Methodological issues

During the 1990's, Czech refineries have undergone a quite extensive process of innovation and reconstruction, to decrease technical losses of raw materials and final products. Comprehensive verification has been carried out of the seals of the individual fittings, pumps and all the technical equipment. This entire process, which was carried out mainly for economic reasons, also led to a decrease in overall emissions, especially of NMVOCs. Consequently, the emission factors taken from the IPCC methodology (IPCC 2006) can be considered to correspond to the current technical condition of refineries in this country. In this connection, it should be pointed out that fugitive emissions from refinery technology couldn't be determined by direct measurements, as they are not connected with specific air outlets or chimneys. Thus, they can be determined only on the basis of professional estimates from balance losses or using emission factors. The resultant emissions of the individual substances were compared with the data in the national emission database and are of the same order of magnitude.

In general, it can be stated that fugitive greenhouse gas emissions occur in this subcategory only in operations in which Crude Oil saturated in carbon dioxide and methane is in contact with the atmosphere. All operations involving Crude Oil in the Czech Republic are hermetically sealed. Thus, fugitive emissions are formed only through leaks in the technical equipment. Following thermal treatment of Crude Oil, the resultant products no longer contain any dissolved gases and no fugitive emissions need be considered in subsequent operations.

3.3.2.2.1 Oil (CRF 1.B.2.a)

CH_4 emissions from Crude Oil transport and refining and from Crude Oil mining, which is performed in the Czech Republic in combination with mining of Natural Gas, are reported in this category. CO_2 emissions from the refinery resulting from combustion processes (including flaring) are included in 1.A.1.b Crude Oil Refining.

Exploration (1.B.2.a.iii.1)

Exploration is not systematically performed in the Czech Republic. For this reason, there are no known procedures for the determination of emissions in this subsector.

Activity data: number of mined boreholes – notation key NO, default emission factors have not been published for CO_2 and CH_4 – notation key NO. N_2O emissions: notation key NA: N_2O emissions are practically not formed in exploratory work.

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

Activity data for determining CH_4 and CO_2 emissions are taken from the CzSO – IEA questionnaires and controlled using data from the Mining Yearbook.

CH_4 emissions are determined as the product of annual Crude Oil mining and the emission factor. The emission factor has a value of 4.746 kg/PJ and was determined on the basis of published data in (Zanat et al.,1997). The emission factor was determined as the sum of the individual emission factors from pumping of raw Crude Oil and from storage of raw Crude Oil. These data were obtained by direct measurement. The resultant emission factor was increased by an estimate of fugitive emissions at mining boreholes (probes).

CO_2 emissions are estimated based on the default emission factor (IPCC, 2006, Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52).

EF CO_2: 2.8E-04 Gg per 10^3 m^3 total oil production = 7 576 kg/PJ

For the estimation of N_2O emissions, no emission factor was available.

Transport (1.B.2.a.iii.3)

In this case, the activity data correspond to the total amount of petroleum transported through the territory of the Czech Republic by the pipeline system in the individual years. This amount corresponds to the Total Crude Oil input to refineries. The default emission factors from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52 are employed to calculate the CH_4 and CO_2 emissions.

EF CH_4: 5.4E-06 Gg per 10^3 m^3 oil transported by pipeline = 146 kg/PJ

EF CO_2: 4.9E-07 Gg per 10^3 m^3 oil transported by pipeline = 13 kg/PJ

These emission factors were used to calculate fugitive emissions for the years since 1990.

For the estimation of N_2O emissions, no emission factor was available.

Refining (1.B.2.a.iii.4)

Methane emissions from refining are calculated using IPCC Tier 1 methodology (Table 4.2.4 in IPCC 2006). Emissions are calculated by multiplying the amount of Crude Oil input to refinery by the emission factor. The emission factor value used was 585 kg/PJ.

This emission factor is based on the data from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52

EF CH_4: 2.6×10^{-6} to 41.0×10^{-6} Gg per 10^3 m^3 oil refined = 585 kg/PJ (average)

The IPCC method does not give any EF for CO_2 or N_2O. Consequently, the notation key NA is used in CRF.

Distribution of Oil Products (1.B.2.a.iii.5)

The available IPCC methodology does not provide any EF for CO_2, CH_4 or N_2O – notation key – NA. The products which originate during oil processing cannot contain CO_2 or CH_4. There isn't known process by which could arise fugitive CO_2 or CH_4 emissions during the distribution of oil products.

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

Activity data: notation key: NO; CH_4, CO_2 and N_2O emissions – notation key NO.

3.3.2.2.2 Natural Gas (CRF 1.B.2.b)

Leakages in the distribution network and household distribution pipes can be considered to constitute the most serious source of emissions. In the 1990's, the distribution network was newly constructed almost entirely from welded plastics and the old pipeline was reconstructed to a major degree in the same manner. Household distribution pipes are subject to strict standards and any poor seals can be identified by the characteristic smell. In addition to safety aspects, all leakages also have an economic impact both for the distribution company and for the end user, so this aspect is carefully monitored and, as soon as possible, immediately remedied. As a whole, the gas distribution in the CR is at a high technical level and it can be stated that all leakages are carefully sought out and eliminated.

As a method was developed in the last few years for determining methane emissions in the gas industry using specific emission factors, this sophisticated method of calculation continues to be used, although, from the standpoint of ref. (IPCC 2006), calculation using default values would probably suffice. Qualified estimation of methane emissions is thus carried out using specific emission factors for the individual parts of the gas industry system (Table 4.2.8. Classification of Gas losses as low, medium or high at selected types of Natural gas facilities, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 4.71)

The total emission value given corresponds to about 0.3% of the total consumption of Natural Gas in the Czech Republic. The detailed calculation given corresponds to Tier 2.

In general, it can be stated that the determined methane emissions in category 1.B.2 Gas are basically formed in several ways:

- through poor seals in the flanges and joints, fittings, probes in mining and storage fields and other parts of the pipeline system,
- through pipeline perforation,
- through technical discharge of gas into the air,
- through accidents.

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

Exploration is not performed in the Czech Republic and thus the notation key NO is used in the CRF Report for the emissions and activity data.

Production (1.B.2.b.iii.2)

Transmission and Storage (1.B.2.b.iii.4)

Distribution (1.B.2.b.iii.5)

Fugitive methane emissions are calculated in these subcategories using an internal calculation model based on the methodology proposed in 1997 in IGU (Alfeld, 1998). Calculations of emissions are supplemented by data from the national Integrated Pollution Register (IPR) and investigations at individual distribution companies on registered units of Natural Gas.

Tab. 3-75 Model calculation of CH_4 emissions in the Natural Gas sector (2016)

	EF		Activity data		Losses of NG
	value	**units**	**value**	**units**	**mil.m^3/year**
production	0.2	% vol.	218	mil. m^3	0.49
high pressure pipelines	600	m^3/km.year	12 878	km	7.59
transmission pipelines *)					0.37
compressors **)					0.23
storage ***)					1.21
regulation stations	1 000	m^3/station	4 500	pcs	4.42
distribution network	300	m^3/km.year	48 465	km	14.28
final comsumption	2	m^3/consumer	2 832 032	pcs	5.58
Total					**34.10**
Emissions in Gg (0.67 kg/m3)					**22.85**

*) *data from IRZ (Integrated Pollution Register of Czech Republic – Czech version of E-PRTR) - company NET4GAS*
**) *data from operating records of leakage Natural Gas - company RWE*
***) *data from operating records of leakage Natural Gas - company RWE Gas Storage*

Emissions calculated in this model are then transformed to the structure of the sectors and subsectors according to the IPCC methodology.

3.3.2.2.3 Venting and Flaring (CRF 1.B.2.c)

The estimations of CO_2, CH_4 and N_2O emissions from venting and flaring in the course of oil production were obtained by using the default EFs provided by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (see table 4.2.4, pages 4.48 – 4.54). In this case the following EFs were taken:

Venting (Default Weighted Total)

CH_4: 8.7E-03 Gg per 10^3 m^3 total oil production

CO_2: 1.8E-03 Gg per 10^3 m^3 total oil production

N_2O: NA

Flaring (Default Weighted Total)

CH_4: 2.1E-05 Gg per 10^3 m^3 total oil production

CO_2: 3.4E-02 Gg per 10^3 m^3 total oil production

N_2O: 5.4E-07 Gg per 10^3 m^3 total oil production

Owing to the fact that activity data are required in kg/PJ, the value was converted to kg/PJ by using the typical value of density for crude oil of 880 kg/t and value NCV was taken from CzSO questionnaires IAE as a simple average for domestic oil (42 MJ/kg):

Venting

CH_4: 235 390 kg/PJ

CO_2: 48 701 kg/PJ

Flaring

CH_4: 568.2 kg/PJ

CO_2: 919 913 kg/PJ

N_2O: 14.61 kg/PJ

3.3.2.3 Uncertainties and time-series consistency

The inventory methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2009. Uncertainties in determining the activity data are estimated at 7%. This estimate is based on the precision of measurement of the volumes of Crude Oil, Crude Oil products and Natural Gas.

The emission factors for determining emissions in extraction of Natural Gas and Crude Oil are based on specific measurements, accompanied by an error of approx. 10%. Emission factors used to determine emissions in transport and distribution of Natural Gas are based on isolated measurements and estimates by experts in the gas industry. The uncertainty in these emission factors is considered to be at the level of 25%. Determination of gas leaks in technical operations, starting-up of compressors and accidents, as appropriate, are evaluated on the basis of calculations with knowledge of the necessary technical parameters, such as the gas pressure, pipeline volume, etc. The uncertainties then correspond to knowledge of these technical parameters – 10%. The other emission factors were taken from the IPCC methodology as default values, considered to have an uncertainty of 80% in this methodology. Overall, the uncertainty in the emission factors in category 1.B.2 Oil and Natural Gas is estimated to equal 75%.

Summary of uncertainty values provides Tab. 3-76.

Tab. 3-76 Uncertainty estimates for fugitive emissions from Oil and Natural Gas

Gas	Source category	AD uncertainty [%]	EF uncertainty [%]	Origin of actual level of uncertainty
CO_2	1.B.2 Oil and Natural Gas	7	75	V. Neuzil, P. Fott, AD and EF unc. in line with 2006 Guidelines
CH_4	1.B.2 Oil and Natural Gas	7	75	V. Neuzil, P. Fott, AD unc. in line with 2006 Guidelines, EF unc. expert judgement

3.3.2.4 Category-specific QA/QC and verification

General quality control and source-specific quality control (Tier 1 and Tier 2), in conformance with the requirements of the QSE handbook and its associated applicable documents, have been performed to the full extent.

QC activities at the level of Tier 1 were performed according to the QA/QC plan by the sector compiler. Routine control was performed in the framework of the following activities:

- activity data employed,
- emission factors employed,
- calculation procedures employed,
- transfer of numerical data from the working set to the CRF Reporter.

In control of the activity data, the CzSO data were compared with the data from the Mining Yearbook (Mining Yearbook, 2017) 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

It is planned that activity data will be obtained for subcategory 1.B.2.a.iii.1., Exploration.

3.4 CO_2 transport and storage (CRF 1.C)

Not performed in the Czech Republic.

4 Industrial processes and product use (CRF Sector 2)

The sector of industrial processes of GHG emission inventory includes emissions from technological processes and not from fuel combustion used to supply energy for carrying out these processes. Consistent emphasis is put on the distinction between the emissions from fuel combustion in the Energy sector and the emissions from technological processes and production.

For example, in the production of cement, consideration is given only to emissions derived from the thermal decomposition of mineral raw materials (specifically CO_2 emissions from the decomposition of limestone) and not from fuel used to heat the rotary kiln (considered in category 1.A.2.f). However, the situation in iron and steel production is more complicated. Evaluation of the CO_2 emissions is based on consumption of metallurgical coke in blast furnaces, where coke is used dominantly as a reducing agent (iron is reduced from iron ores), even though the resulting blast furnace gas is also used for energy production, mainly in metallurgical plants.

In 2016, the total aggregate GHG emissions from industrial processes were 15,221.74 kt of CO_2 equivalents, which represent increase of 1.52% compared to the previous year. Emissions decreased by 11.05% compared to the reference year 1990.

4.1 Overview of sector

4.1.1 General description and key categories identification

The major share of CO_2 emissions in this sector comes from sub-source categories 2.C.1 Iron and Steel Production, 2.F.1 Refrigeration and Air Conditioning and 2.A Mineral Industry. N_2O emissions coming from 2.B Chemical Industry are less significant. Iron and Steel, Cement Production, F-gases Use in Refrigeration and Air Conditioning, Lime Production and Nitric Acid 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 2016 and lists type of key category analysis for key categories.

Tab. 4-1 Overview of key categories in sector Industrial Processes (2016)

Category	Gas	KC A1	KC A2	KC A1[1]	KC A1[2]	KC A2[1]	KC A2[2]	% of total GHG[1]	% of total GHG[2]
2.C.1 Iron and Steel Production	CO_2	LA, TA	LA, TA	yes	yes	yes	yes	5.84	5.60
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	LA	LA, TA	yes	yes	yes	yes	2.47	2.37
2.A.1 Cement Production	CO_2	LA, TA	LA	yes	yes	yes	yes	1.36	1.30
2.B.1 Ammonia Production	CO_2	LA, TA		yes	yes			0.55	0.53
2.A.2 Lime Production	CO_2	LA, TA		yes	yes			0.51	0.49
2.B.8 Petrochemical and Carbon Black Production	CO_2	TA			yes			0.24	0.23

KC: key category
[1] including LULUCF
[2] excluding LULUCF

4.1.2 Emissions trends

This chapter describes the emissions of greenhouse gases in more disaggregated way than chapter 2: Trends in Greenhouse Gas emissions.

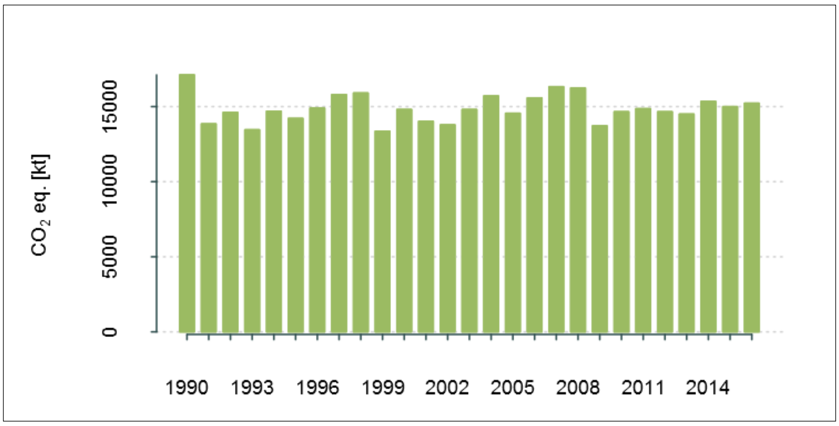

Fig. 4-1 Trend of emissions from IPPU [kt CO_2 eq.]

GHG emissions in this category are driven mainly by economic development, supply and demand of products, where abatement technology is used only in specific cases (e.g. nitric acid production) or the driving force is different (e.g. ozone depleting substances). GHG emission trends from Industrial Processes and Product Use from base year 1990 to 2016 are depicted in Fig. 4-1. CO_2 eq. emissions have shown stable trend since 2010 with minor fluctuation.

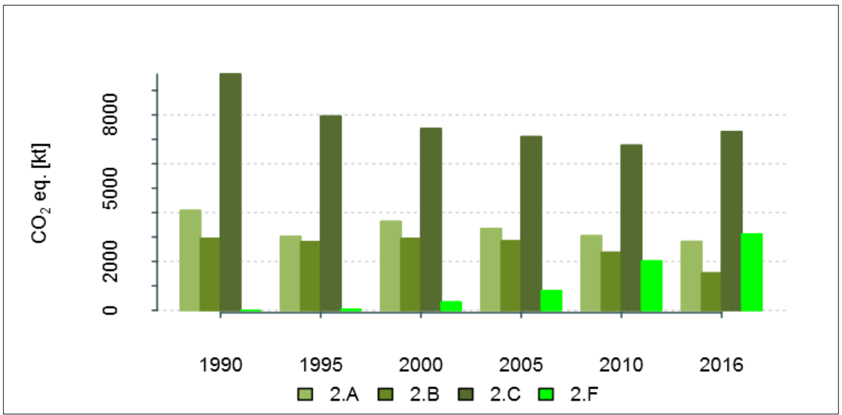

Fig. 4-2 Emissions from principal subcategories of IPPU [kt CO_2 eq.]

GHG emission trends for the principal categories of IPPU are depicted on Fig. 4-2 for years 1990, 1995, 2000, 2005, 2010 and 2016. 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.B are decreasing. Slight increase of emissions was observed for categories 2.A and 2.C for year 2016. A brief description of the relevant category trends is provided for all the categories in the following chapters.

Category 2.A Mineral Products includes practically only emissions of CO_2 as well as category 2.C Metal Production. CO_2 emissions from the 2.B Chemical Industry comes from 2.B.1 Ammonia Production, while N_2O emissions originate from 2.B.2 Nitric Acid Production. Industrial CH_4 emissions are insignificant.

4.2 Mineral Industry (CRF 2.A)

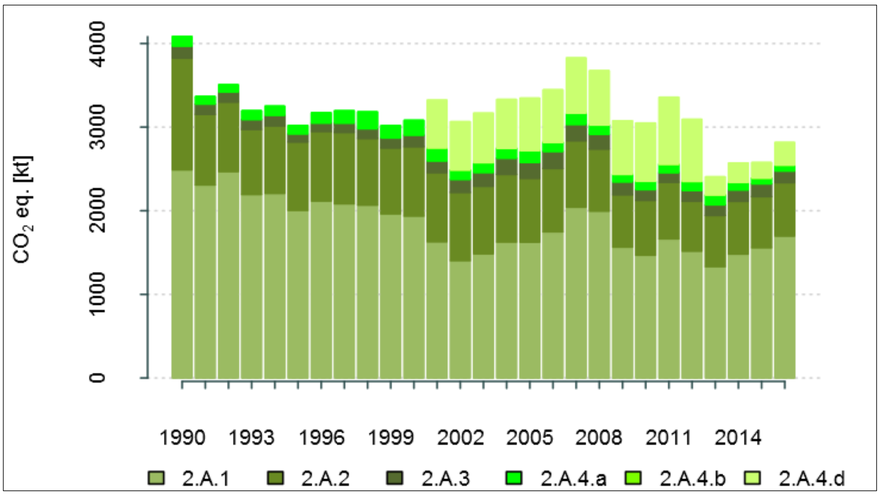

Fig. 4-3 Trend of emissions from 2.A Mineral Industry and share of specific subcategories [kt CO_2]

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 60.28% belongs to 2.A.1 Cement Production, 22.72% belongs to 2.A.2 Lime Production, 4.90% belongs to 2.A.3 Glass Production and 12.09% to 2.A.4 Other Process Uses of Carbonates.

Tab. 4-2 lists the CO_2 emissions in the individual subcategories in 2.A Mineral Products in 2016.

Tab. 4-2 CO_2 emissions in individual subcategories in 2.A Mineral Products category in 1990 – 2016

	Category 2.A - CO_2 emissions [kt]					
	2.A.1 Cement Production	2.A.2 Lime Production	2.A.3 Glass Production	2.A.4.a Ceramics	2.A.4.b Other use of Soda Ash	2.A.4.d Other
1990	2489.18	1336.65	142.75	113.86	NO	NE,NO
1991	2308.92	844.66	122.40	89.98	NO	NE,NO
1992	2468.42	831.46	120.77	85.36	NO	NE,NO
1993	2194.55	778.67	117.14	105.49	NO	NE,NO
1994	2208.38	806.53	126.65	108.31	NO	NE,NO
1995	2005.01	817.53	96.05	100.49	NO	NE,NO
1996	2116.49	830.73	101.01	123.10	NO	76.00
1997	2083.36	852.73	111.98	146.87	NO	240.63
1998	2067.65	797.00	116.83	200.61	NO	417.31
1999	1962.91	787.47	120.29	145.88	NO	536.94
2000	1936.86	828.53	138.18	177.02	NO	552.77
2001	1628.84	827.06	138.88	156.33	0.10	571.20
2002	1403.48	815.33	155.73	113.01	0.21	576.40
2003	1484.85	808.00	163.47	119.83	0.33	589.07
2004	1626.76	808.73	191.86	118.51	0.44	584.10
2005	1624.53	762.82	190.94	141.15	0.47	625.84
2006	1748.45	758.02	202.02	109.05	0.35	627.62
2007	2043.08	794.07	194.87	135.06	0.50	659.02
2008	1996.15	742.01	175.38	112.43	0.56	648.19
2009	1566.08	625.43	153.46	90.78	0.41	639.40
2010	1469.00	655.77	127.78	100.43	0.86	694.57
2011	1664.53	676.44	113.84	100.31	1.06	800.61
2012	1517.15	597.44	128.09	108.31	1.09	740.32
2013	1331.79	612.99	126.25	116.73	1.03	215.91
2014	1482.73	630.90	135.23	89.94	1.11	229.89
2015	1558.16	611.54	151.96	68.64	1.01	184.48
2016	1697.60	639.82	138.06	70.26	1.01	269.32

Tab. 4-3 gives an overview of the emission factors and methodology used for computations of emissions in category 2.A Mineral Products in 2016.

Tab. 4-3 CO_2 emission factors and methodology used for computations of 2016 emissions in category 2.A

IPCC Category	Emission factor CO_2	Unit	Source or type of EF	Methodology
2.A.1 Cement Production	0.53	t CO_2/t sinter	EU ETS	Tier 3
2.A.2 Lime Production	0.77	t CO_2/t CaO	CS	Tier 3
2.A.3 Glass Production	0.11	t CO_2/t Glass	EU ETS	Tier 3
2.A.4.a Ceramics	0.17	t CO_2/tiles thousand m^2	CS (EU ETS)	Tier 3
	0.04	t CO_2/brick unit	CS (EU ETS)	Tier 3
	C	t CO_2/roofing tiles	CS (EU ETS)	Tier 3
2.A.4.b Other Uses of Soda Ash	C	t CO_2/t soda ash	IEF	Tier 3
2.A.4.d Other (Flue-gas desulfurisation)	C	t CO_2/t desulfurated flue-gas	CS (EU ETS)	Tier 3
(Mineral wool production)	0.25	t CO_2/t mineral wool	Default (IPCC 2006)	Tier 1

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

4.2.1 Cement Production (CRF 2.A.1)

CO_2 emissions from cement production have decreased since 1990 by 31.80%. Total CO_2 emissions equal to 1698 kt in 2016. The decrease in the emissions during 1990's was caused by the transition from planned economy to market economy. This led to decline in industrial production and consequently to decrease in emissions. Since 2003, the cement production began to recover and production has increased. Decrease in emissions since 2008 was caused by the economic crisis and related construction constraints. Cement production was identified as a key category in this year's submission.

4.2.1.1 Source category description

Cement production is one of the traditional anthropogenic sources of carbon dioxide included in inventories; however, its importance is incomparably smaller than the total combustion of fossil fuels. Approx. 60% of the CO_2 is emitted during transformation of raw materials (mainly decarbonisation of limestone). Process-related CO_2 is emitted during the production of clinker (calcination process) when calcium carbonate ($CaCO_3$) is heated in a cement kiln up to temperatures of about 1 500 °C. During this process, calcium carbonate is converted into lime (CaO - calcium oxide) and carbon dioxide. CO_2 emissions from combustion processes taking place in the cement industry (especially heating of rotary kilns) have been reported in IPCC category 1.A.2.f Limestone (and dolomite). This category contains also small amount of magnesium carbonate ($MgCO_3$) and fossil carbon (C), which will also calcinate or oxidize in the process causing CO_2 emissions.

4.2.1.2 Methodological issues

CO_2 emissions from 2.A.1 Cement Production are calculated according to the Tier 3 methodology described in IPCC 2006 Guidelines (IPCC 2006). This methodology describes an approach based on direct data from individual operators of cement kilns.

Four cement plants operate in the Czech Republic. Information submitted directly by the cement kiln operators is available for years 1990, 1996, 1998 - 2002 and 2005 - 2016. For these years, the emission factor value was derived from CCA (Czech Cement Association) data (activity data about production of clinker) and individual installation data about emissions. For years 1991-1995, 1999-2001 EFs were interpolated. Since 2010, CO_2 emissions are based on data submitted by the cement kiln operators in the

EU ETS system. EU ETS system covers all cement kiln operators in the Czech Republic. The content of calcium/magnesium oxide (CaO/MgO) and composition of the limestone and dolomite are measured and independently verified. These parameters are used for calculation of the CO_2 emissions and, therefore, substantial attention is devoted to their determination.

The methodology used for CO_2 emissions must be in accordance with national legislation (Zákon 383/ 2012 o podmínkách obchodování s povolenkami na emise skleníkových plynů/Act No. 383/2012 Coll., the Greenhouse Gas Emission Allowance Trading Act) and the EU legislation (Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council).

All operating cement plants in the Czech Republic are equipped with dust control technology and the dust is then recycled to the kiln. 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, 2017), which associates all Czech cement producers. Clinker production data together with interpolated EF was used for years without direct data from cement kiln operators (1991-1995, 1999-2001). IEF, which is calculated based on CO_2 emissions and clinker production, varies during the whole time series from 0.527 to 0.553 t CO_2/t clinker.

Tab. 4-4 introduces the activity data for clinker production, emission factor and CO_2 emissions for the whole time series.

Tab. 4-4 Activity data, CO_2 emission factor and CO_2 emissions in 2.A.1 Cement Production category in 1990 - 2016

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Clinker production	[kt]	4 726	4 368	4 653	4 122	4 134	3 740	3 934	3 829	3 758	3 547
EF CO_2	[t CO_2/t clinker]	0.527	0.529	0.531	0.532	0.534	0.536	0.538	0.544	0.550	0.553
CO_2 emissions	[kt]	2 489	2 309	2 468	2 195	2 208	2 005	2 116	2 083	2 068	1 963
	Unit	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Clinker production	[kt]	3 537	2 954	2 549	2 725	3 017	3 045	3 288	3 837	3 759	2 923
EF CO_2	[t CO_2/t clinker]	0.548	0.551	0.551	0.545	0.539	0.533	0.532	0.532	0.531	0.536
CO_2 emissions	[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**	**2016**			
Clinker production	[kt]	2 748	3 132	2 838	2 472	2 792	2919	3188			
EF CO_2	[t CO_2/t clinker]	0.535	0.531	0.535	0.539	0.529	0.531	0.532			
CO_2 emissions	[kt]	1 469	1 665	1 517	1 332	1 477	1550	1698			

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 2016.

4.2.1.4 Source-specific QA/QC and verification

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

Verification is provided by comparison of the activity data obtained from CCA, CzSO, ISPOP and EU ETS. The cement clinker production data provided by CCA, which are used as input activity data for the submission, are compared with data provided by CzSO, ISPOP and data obtained from EU ETS forms. The percentage differences between cement production data for 2016 obtained from CCA and other sources are as follows:

- Difference between the data from CCA and CzSO: -0.01%
- Difference between the data from CCA and ISPOP: -0.01%
- Difference between the data from CCA and EU ETS: -0.01%

In addition to verification of the input data, the inter-annual changes in the implied emission factors are analysed. The EU ETS reports, which have been used for emission estimates since 2010, have been substantiated by independent verifiers.

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

For 2010, 2012, 2014 and 2015, the emissions were recalculated for category 2.A.1 Cement Production as a result of revision of the EU ETS data used for the calculations. The impact of the recalculation on emissions is shown in Tab. 4-5.

Tab. 4-5 Impact of the recalculation in category 2.A.1

CO_2 emissions	Unit	2010	2012	2014	2015
Submission 2017	[kt]	1469.27	1517.03	1476.74	1549.54
Submission 2018	[kt]	1469.00	1517.15	1482.73	1558.16
Difference	[%]	0.02	-0.01	-0.40	-0.55

4.2.1.6 Source-specific planned improvements, including tracking of those identified in the review process

Since the Tier 3 method is used for emission calculations in this category, no significant improvements are planned.

4.2.2 Lime Production (CRF 2.A.2)

CO_2 emissions from lime production have decreased considerably since 1990 by 52.13%. 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. In 2016, production of lime increased to 836 kt compared to previous year. Lime production was identified as a key category in this year’s submission.

4.2.2.1 Souce category description

From a chemical point of view, lime is calcium oxide. CO_2 is released during calcination. During the production of lime, the limestone is heated up which leads to decomposition (i.e. calcination) of $CaCO_3/MgCO_3$ to the lime (CaO, CaO·MgO) and CO_2 is being released into the atmosphere.

4.2.2.2 Methodological issues

Five lime producers operate in the Czech Republic. CO_2 emissions from 2.A.2 Lime Production are calculated according to the Tier 3 methodology described in IPCC 2006 Guidelines (IPCC 2006) since 2010.

CO_2 emissions are based on data submitted by the lime producers in the EU ETS system. The ETS data are available for time period 2010 - 2016 for each process. This data are at the Tier 3 level. Data in EU ETS takes into account the actual carbonates present, impurities in the raw material and LKD (LKD is included in the data and thus emission estimates also include LKD). IEF is not constant because emissions reported in EU ETS forms are calculated with the detailed information mentioned above. IEF has varied between 0.788 and 0.766 t CO_2/t $CaCO_3$ since 2010.

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. Only CO_2 emissions generated in the process of the calcination step of lime treatment are considered in this category. CO_2 emissions from combustion processes (heating of kilns and furnaces) are reported under category 1.A.2.f.

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. The national EF, used for time period 1990-2009, reflects the production of lime and quick lime (0.7884 t CO_2/t lime) (Vácha, 2004). Furthermore, it takes into account the average purity (93%) (Vácha, 2004) of the lime produced in the Czech Republic, thus applied emission factor is 0.733 t CO_2/t lime.

In 2015, research was carried out related to the country-specific emission factor from lime production (Beck, 2015). This research clarified the very small fluctuation of the emission factor (depending on the composition of the limestone) and further successfully defended the connection between Tier 1 data for the 1990 - 2009 period and Tier 3 data for the 2010 - 2014 period. Detailed information about the research is provided in Annex 3.

For the 1990-2009 time period, the activity data are based on the data from CLA (the Czech Lime Association). These data were considered to be more accurate than the data provided by CzSO, which do not differentiate between lime and hydrated lime (the data from CLA differentiate between lime and hydrated lime). For the 2010 - 2016 time period, the activity data are based on the data from EU ETS (EU ETS, 2016), which publishes data on pure lime production. The data are published directly by lime plant operators and thus these data are considered to be on a higher level of accuracy than the data obtained from CLA. Data about the production of lime from the above sources are compared annually during the preparation of emission estimates.Tab. 4-6 lists activity data for lime production, emission factors and CO_2 emissions for the whole time series.

Tab. 4-6 Activity data, CO_2 emission factor and CO_2 emissions in 2.A.2 Lime Production category in 1990 - 2016

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Lime production	[kt]	1 823	1 152	1 134	1 062	1 100	1 115	1 133	1 163	1 087	1 074
EF CO_2	[t CO_2/t $CaCO_3$]	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
CO_2 emissions	[kt]	1 337	845	831	779	807	818	831	853	797	787
	Unit	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Lime production	[kt]	1 130	1 128	1 112	1 102	1 103	1 040	1 034	1 083	1 012	853
EF CO_2	[t CO_2/t $CaCO_3$]	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
CO_2 emissions	[kt]	829	827	815	808	809	763	758	794	742	625
	Unit	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**			
Lime production	[kt]	832	858	758	778	816	800	836			
EF CO_2	[t CO_2/t $CaCO_3$]	0.788	0.788	0.788	0.788	0.773	0.764	0.766			
CO_2 emissions	[kt]	656	676	597	613	631	612	640			

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 2010-2016, 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 2016.

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.

Verification is provided by comparison of the activity data obtained from CLA, CzSO and EU ETS. The lime production data obtained from EU ETS forms (input activity data for the submission) are compared with the data provided by CLA and CzSO. The percentage differences between the lime production data for 2016 obtained from EU ETS and other sources are as follows:

- Difference between the data from EU ETS and CLA: -7.03%
- Difference between the data from EU ETS and CzSO: -5.68%

In addition to verification of the input data, the inter-annual changes in the implied emission factors are analysed. The EU ETS reports, which have been used for emission estimates since 2010, are substantiated by independent verifiers. The emission estimates are compared with the sum of the emissions from technological processes reported by the individual kiln operators. The country-specific emission factor used for emission estimates for 1990-2009 was compared with the emission factors used for the calculation by individual operators.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

4.2.2.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

Since 2014, the activity data and emissions have been recalculated for category 2.A.2 Lime Production because of revision of EU ETS data used for calculations. The impact of the recalculation on the activity data and emissions is shown in Tab. 4-7.

Tab. 4-7 Impact of the recalculation in category 2.A.2

Activity data	Unit	2014	2015
Submission 2017	[kt]	814.47	789.67
Submission 2018	[kt]	816.17	800.22
Difference	[%]	-0.21	-1.32
CO_2 emissions	**Unit**	2014	2015
Submission 2017	[kt]	629.04	609.75
Submission 2018	[kt]	630.90	611.54
Difference	[%]	-0.29	-0.29

4.2.2.6 Source-specific planned improvements, including tracking of those identified in the review process

Since the Tier 3 method is used for emission calculations in this category, no significant improvements are planned.

4.2.3 Glass Production (CRF 2.A.3)

CO_2 emissions from glass production have decreased by 3.29% since 1990. The production of glass reached a maximum value in 2006, equalling 1750 kt. CO_2 emissions from 2.A.3 Glass production equalled 138.06 kt CO_2 in 2016.

4.2.3.1 Source category description

CO_2 emissions from Glass Production (2.A.3*)* are derived particularly from the decomposition of alkaline carbonates added to glass-making sand.

4.2.3.2 Methodological issues

CO_2 emissions from 2.A.3 Glass Production were calculated according to the Tier 3 methodology described in the IPCC 2006 Guidelines (IPCC 2006) since 2010.

Since 2010, CO_2 emissions have been based on data submitted by the glass producers in the EU ETS system. The ETS data are available for the 2010 - 2016 time period for each process. These data are at the Tier 3 level. The activity data for total glass production were obtained from CzSO.

Emissions for 1990-2009 were calculated according to Tier 1 methodology with the country specific emission factor. The country specific emission factor was calculated as the average emission factor from data submitted directly by the manufacturers in EU ETS for 2010-2016. The country specific emission factor used for emission estimates in 1990-2009 equals 0.12 t CO_2 / t glass, which indicates that the country specific emission factor is slightly higher than the default emission factor multiplied by cullet ratio 50%, which equals 0.10 t CO_2 / t glass. The activity data for the emission estimates were obtained from the Association of the Glass and Ceramic Industry for 1990-2009.

Tab. 4-8 lists activity data for glass production, emission factors and CO_2 emissions for the whole time series.

Tab. 4-8 Activity data, CO_2 emission factor and CO_2 emissions in 2.A.3 Glass Production category in 1990 – 2016

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Glass production	[kt]	1237	1060	1046	1015	1097	832	875	970	1012	1042
EF CO_2	[t CO_2/t glass]	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
CO_2 emissions	[kt]	142.75	122.40	120.77	117.14	126.65	96.05	101.01	111.98	116.83	120.29
	Unit	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Glass production	[kt]	1197	1203	1349	1416	1662	1654	1750	1688	1519	1329
EF CO_2	[t CO_2/t glass]	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
CO_2 emissions	[kt]	138.18	138.88	155.73	163.47	191.86	190.94	202.02	194.87	175.38	153.46
	Unit	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**			
Glass production	[kt]	1023	1055	1088	1158	1119	1255	1295			
EF CO_2	[t CO_2/t glass]	0.12	0.11	0.12	0.11	0.12	0.12	0.11			
CO_2 emissions	[kt]	127.78	113.84	128.09	126.25	135.23	151.96	138.06			

4.2.3.3 Uncertainties and time-series consistency

Since activity data are based on the EU ETS for time period 2010-2016, the uncertainty in the activity data was estimated at the level of 2%.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2016.

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.

Activity 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. In addition to verification of the input data, the inter-annual changes of the implied emission factors are analysed. The EU ETS reports, which are used for emission estimates since 2010 are proved by independent verifiers.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

4.2.3.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

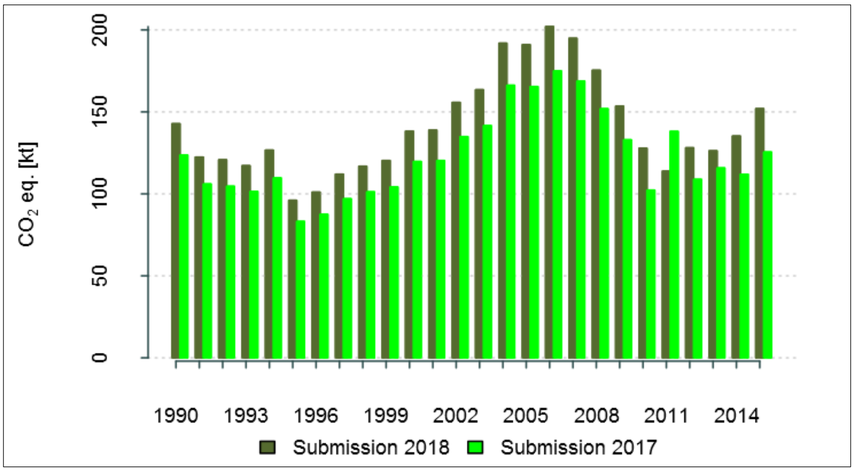

Fig. 4-4 Impact of the recalculation in category 2.A.3

Category 2.A.3 Glass production was recalculated as a result of implementation of Tier 3 methodology. Data about glass production are taken from CzSO; emission estimates are based on data submitted by the glass producers to EU ETS for 2010-2016. Emissions were also recalculated for 1990-2009 as a result of the use of the country specific emission factor for Tier 1 Methodology. The country specific emission factor was derived as the average emission factor from EU ETS for 2010-2016. The impact of the recalculation is shown in Tab. 4-9 and in Fig. 4-4.

Tab. 4-9 Impact of the recalculation in category 2.A.3

CO_2 emissions	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2017	[kt]	123.66	106.02	104.61	101.47	109.71	83.20	87.50	97.00	101.20	104.20
Submission 2018	[kt]	142.75	122.40	120.77	117.14	126.65	96.05	101.01	111.98	116.83	120.29
Difference	[%]	15.44	15.44	15.44	15.44	15.44	15.44	15.44	15.44	15.44	15.44
CO_2 emissions	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2017	[kt]	119.70	120.30	134.90	141.60	166.20	165.40	175.00	168.80	151.92	132.93
Submission 2018	[kt]	138.18	138.88	155.73	163.47	191.86	190.94	202.02	194.87	175.38	153.46
Difference	[%]	15.44	15.44	15.44	15.44	15.44	15.44	15.44	15.44	15.44	15.44
CO_2 emissions	Unit	2010	2011	2012	2013	2014	2015				
Submission 2017	[kt]	102.25	138.08	108.84	115.76	111.93	125.47				
Submission 2018	[kt]	127.78	113.84	128.09	126.25	135.23	151.96				
Difference	[%]	24.97	-17.56	17.69	9.06	20.82	21.12				

4.2.3.6 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.

4.2.4 Other Process Uses of Carbonates (CRF 2.A.4)

The 2.A.4 category Other Process Uses of Carbonates summarizes, in the Czech Republic, CO_2 emissions from 2.A.4.a Ceramics, 2.A.4.b Other uses of Soda Ash and from 2.A.4.d Other. CO_2 emissions from Other Process Uses of Carbonates have increased since 1990 by 199.12%.

CO_2 emissions from 2.A.4.a Ceramics equalled to 70.26 kt in 2016. The decrease in emissions from 2015 was caused by changes in methodology of laboratory analysis for emission estimates used by one of the ceramics manufacturers in EU ETS. CO_2 emissions from 2.A.4.b Other uses of Soda Ash amounted to 1.01 kt CO_2 in 2016. CO_2 emissions from 2.A.4.d Other amounted to 269.32 kt CO_2 in 2016.

4.2.4.1 Source category description

CO_2 emissions from 2.A.4.a Ceramics are derived particularly from the decomposition of alkaline carbonates, fossil and biogenic carbon-based substances included in the raw materials.

CO_2 emissions from 2.A.4.b Other Uses of Soda Ash category come from soda ash use for the Glass production category, soda ash is used in only one other installation. CO_2 emissions from this category are small and insignificant (varied between 0.1 and 1.1 kt CO_2) compared to the other categories.

CO_2 emissions from the 2.A.4.d Other category include emissions from mineral wool production and flue-gas desulphurisation. The CRF reporter does not allow separation of these two categories by adding new nodes under Other category 2.A.4.d. Consequently, these two categories are reported collectively.

4.2.4.2 Methodological issues

2.A.4.a Ceramics

CO_2 emissions from 2.A.4.a Ceramics have been calculated according to the Tier 3 methodology described in the IPCC 2006 Guidelines (IPCC 2006) since 2010.

The activity data and emissions are taken directly from EU ETS forms for 2010-2016. Emissions for 1990-2009 were calculated according to the Tier 1 methodology with the country specific emission factor, which was derived as the average emission factor calculated from EU ETS data for 2010-2013. The activity data for production were obtained from CzSO. The calculation is based on the total production of ceramic products (fine ceramics, tiles, roofing tiles, and bricks) and the emission factor value.

2.A.4.b. Other Uses of Soda Ash

In category 2.A.4.b Other Uses of Soda Ash is considered, that for each mole of soda ash use, one mole of CO_2 is emitted, so that the mass of CO_2 emitted from the use of soda ash can be estimated from a consideration of the consumption data and the stoichiometry of the chemical process. The data, considering the amount and purity of the soda ash used, were obtained directly from the installation operator. The activity data for soda ash use and IEF have been reported as C since 2013 because only one manufacturer uses soda ash and thus these data are confidential.

2.A.4.d Other

CO_2 emissions from the 2.A.4.d Other category include emissions from mineral wool production and flue-gas desulphurisation.

Emissions from mineral wool production are estimated according to Tier 1 methodology, using default EF. Activity data about mineral wool production are obtained by CzSO. Activity data are available for time period 2000 - 2002 and 2007 - 2016. Reported amount of CO_2 emissions for time period 2003 - 2006 were interpolated. Data before 2000 are not available but, according a representative of the mineral wool industry, a small amount of production took place before 2000. The total amount of CO_2 emissions before 2000 would be lower than the total amount of emissions in 2000. The total amount of emissions in 2000 is under the threshold of significance and thus emissions before 2000 are reported as NE.

Emissions from flue-gas desulphurization are obtained from EU ETS forms, which correspond to Tier 3 methodology with CS EF. CO_2 emissions from sulphur removal were calculated from coal consumption for electricity production, the sulphur content and the effectiveness of sulphur removal units between 1996, when the first sulphur removal units came into operation, and 2005. In 2005, these data were verified by comparison with data from the individual operators, which were collected for EU ETS preparation and cover the years 1999 - 2005. The EU ETS data form have been used since 2006. The methodology used for estimation of the CO_2 emissions must be in accordance with the national legislation (Zákon č. 383/2012 Sb. Zákon o podmínkách obchodování s povolenkami na emise skleníkových plynů /Act No. 383/2012 Coll. The Act on conditions for trading in greenhouse gas emission allowances) and the EU legislation (Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council).

These two categories (mineral wool production and flue-gas desulphurization) are reported collectively in CRF Reporter. Activity data for this category are reported as C (NK), because data from EU ETS are used, and these are confidential.

Tab. 4-10 lists the CO_2 emissions in the individual subcategories in 2.A.4 Other Process Uses of Carbonates for time period 1990 - 2016.

Tab. 4-10 CO_2 emissions in individual subcategories in 2.A.4 Other Process Uses of Carbonates category in 1990 - 2016

	Category 2.A.4 - CO_2 emissions [kt]			
	2.A.4.a Ceramics	2.A.4.b Other uses of Soda Ash	2.A.4.d Mineral wool production	2.A.4.d Flue-gas desulphurization
1990	113.86	NO	NE	NO
1991	89.98	NO	NE	NO
1992	85.36	NO	NE	NO
1993	105.49	NO	NE	NO
1994	108.31	NO	NE	NO
1995	100.49	NO	NE	NO
1996	123.10	NO	NE	76.00
1997	146.87	NO	NE	240.63
1998	200.61	NO	NE	417.31
1999	145.88	NO	NE	536.94
2000	177.02	NO	13.08	539.69
2001	156.33	0.10	19.82	551.38
2002	113.01	0.21	25.02	551.38
2003	119.83	0.33	29.03	560.04
2004	118.51	0.44	33.04	551.06
2005	141.15	0.47	37.06	588.79
2006	109.05	0.35	41.07	586.55

Category 2.A.4 - CO_2 emissions [kt]				
	2.A.4.a Ceramics	2.A.4.b Other uses of Soda Ash	2.A.4.d Mineral wool production	2.A.4.d Flue-gas desulphurization
2007	135.06	0.50	45.08	613.93
2008	112.43	0.56	41.19	607.00
2009	90.78	0.41	39.40	600.00
2010	100.43	0.86	43.57	651.00
2011	100.31	1.06	61.31	739.31
2012	108.31	1.09	41.63	698.70
2013	116.73	1.03	42.83	173.08
2014	89.94	1.11	46.89	183.00
2015	68.64	1.01	47.62	136.86
2016	70.26	1.01	46.38	222.94

4.2.4.3 Uncertainties and time-series consistency

The uncertainties for this category are in line with the IPCC 2006 Guidelines (IPCC 2006), i.e. at the level of 5% for the activity data and 10% for the CO_2 emission factor. Overall uncertainty data are given in Chapter 1.6.

For 2.A.4.a Ceramics the time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2016.

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 2001, when the use of soda started, to 2016.

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 2016 and for flue-gas desulphurization from 1996 to 2016.

4.2.4.4 Source-specific QA/QC and verification

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

Data for the emission estimates, except of category 2.A.4.d Mineral wool production, are obtained from EU ETS forms. The EU ETS forms are proved by independent verifiers. In addition to verification of the input data, the inter-annual changes of the implied emission factors are analysed.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

4.2.4.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

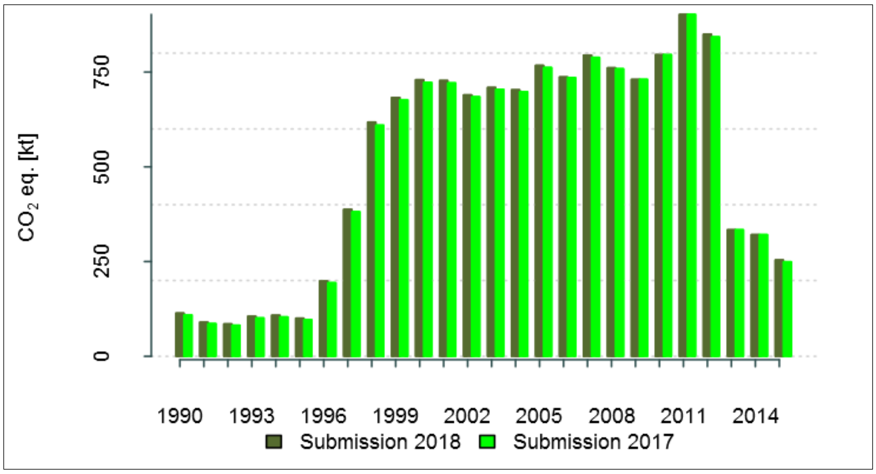

Fig. 4-5 Impact of the recalculation in 2.A.4

Subcategory 2.A.4.a Ceramics was recalculated as a result of the double counting observed between this subcategory and 2.A.4.d Other for the 2010 to 2015 period. Parts of the activity data from 2.A.4.a Ceramics were incorrectly accounted for in 2.A.4.d Other. As a result of the recalculation, the country specific emission factor used for the emission estimates for 1990-2009, which was calculated as the average emission factor for 2010-2013, was also changed and thus the emission estimates for 1990-2009 were recalculated.

The subcategory 2.A.4.d Other was recalculated as a result of double counting between 2.A.4.d Other and 2.A.4.a Ceramics.

The impact of the recalculation on the total emissions from 2.A.4 is shown in Tab. 4-11 and in Fig. 4-5.

Tab. 4-11 Impact of the recalculation in category 2.A.4

CO_2 emissions	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2017	[kt]	109.15	86.26	81.82	101.12	103.83	96.33	194.01	381.42	609.62	676.78
Submission 2018	[kt]	113.86	89.98	85.36	105.49	108.31	100.49	199.10	387.50	617.93	682.82
Difference	[%]	4.32	4.32	4.32	4.32	4.32	4.32	2.63	1.59	1.36	0.89
CO_2 emissions	**Unit**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Submission 2017	[kt]	722.47	721.17	684.94	704.27	698.14	761.84	735.21	788.55	758.58	730.66
Submission 2018	[kt]	729.79	727.64	689.62	709.23	703.05	767.46	737.01	794.57	761.18	730.60
Difference	[%]	1.01	0.90	0.68	0.70	0.70	0.74	0.25	0.76	0.34	-0.01
CO_2 emissions	**Unit**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**				
Submission 2017	[kt]	795.89	902.29	842.93	333.67	320.95	249.15				
Submission 2018	[kt]	795.86	901.99	849.72	333.67	320.94	254.13				
Difference	[%]	0.00	-0.03	0.81	0.00	0.00	2.00				

4.2.4.6 Source-specific planned improvements, including tracking of those identified in the review process

Since the Tier 3 method (except mineral wool production) is used for emission calculations in this category, no significant improvements are planned.

4.3 Chemical Industry (CRF 2.B)

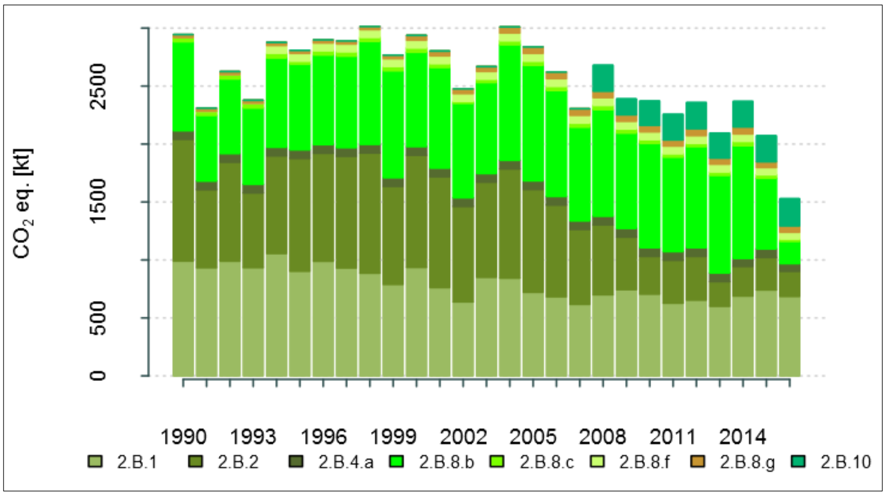

Fig. 4-6 Trend of emissions from 2.B Chemical Industry and share of specific subcategories [kt CO_2 eq.]

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 44.90% belongs to 2.B.1 Ammonia Production, 21.27% belongs to 2.B.8 Petrochemical and Carbon Black Production, 15.29% to 2.B.10 Other, 14.17% to 2.B.2 Nitric Acid Production and 4.36% belongs to 2.B.4.a Caprolactam Production.

The emission trend for the category 2.B Chemical Industry is depicted in Fig. 4-6.

Tab. 4-12 lists the exact amount of CO_2 eq. emissions from the individual subcategories in 2.B Chemical Industry for time period 1990 - 2016.

Tab. 4-12 CO_2 eq. emissions in individual subcategories in 2.B Chemical industry category in 1990–2016

	Category 2.B - CO_2 eq. emissions [kt]				
	2.B.1 Ammonia Production	2.B.2 Nitric Acid Production	2.B.4.a Caprolactam Production	2.B.8 Petrochemical and Carbon Black Production	2.B.10 Other
1990	990.80	1050.29	74.50	828.63	IE
1991	933.44	673.06	74.50	628.41	IE
1992	989.89	853.90	74.50	706.50	IE
1993	933.98	644.93	74.50	724.17	IE
1994	1055.82	842.51	74.50	903.61	IE
1995	903.19	972.95	74.50	857.57	IE
1996	989.20	932.10	74.50	902.20	IE
1997	931.15	963.55	74.50	919.89	IE
1998	886.50	1036.69	74.50	1015.73	IE
1999	788.90	846.51	74.50	1056.47	IE
2000	936.02	967.79	74.50	958.76	IE
2001	761.75	956.30	74.50	1009.21	IE
2002	638.58	823.26	74.50	939.43	IE
2003	850.60	820.74	74.50	921.55	IE
2004	843.43	942.22	74.50	1149.93	IE
2005	721.70	886.89	74.50	1154.80	IE
2006	683.27	790.51	74.50	1072.27	IE

	Category 2.B - CO_2 eq. emissions [kt]				
	2.B.1 Ammonia Production	2.B.2 Nitric Acid Production	2.B.4.a Caprolactam Production	2.B.8 Petrochemical and Carbon Black Production	2.B.10 Other
2007	617.11	646.36	74.50	965.93	IE
2008	700.21	603.31	74.50	1078.11	222.76
2009	744.18	453.58	74.50	979.92	136.47
2010	705.45	326.16	74.50	1054.79	210.17
2011	628.05	369.46	74.50	963.41	220.21
2012	653.79	377.89	74.50	1026.28	224.53
2013	601.13	212.10	74.50	991.29	214.76
2014	689.05	255.52	68.96	1134.14	219.52
2015	741.66	280.18	73.72	751.98	223.06
2016	685.72	216.44	66.59	324.91	233.58

Tab. 4-13 gives an overview of the emission factors used for computations of emissions in category 2.B Chemical Industry for year 2016.

Tab. 4-13 Emission factors used for computations of 2016 emissions in category 2.B

IPCC Category	Emission factor	Unit	Source or type of EF	Methodology
2.B.1 Ammonia Production	3.27	kt CO_2/kt NH_3	CS	Tier 1
2.B.2 Nitric Acid Production	1.29	kg N_2O / t HNO_3	IEF	Tier 1
2.B.4 Caprolactam, Glyoxal and Glyoxilic Acid Production	5.70	kg N_2O/ t caprolactam	CS	Tier 1
2.B.8 Petrochemical and Carbon Black production	1.90	t CO_2/t ethylene	Default (IPCC 2006)	Tier 1
	3.00	kg CH_4/t ethylene	Default (IPCC 2006)	Tier 1
	0.29	t CO_2/t VCM	Default (IPCC 2006)	Tier 1
	0.02	t CH_4/t VCM	Default (IPCC 2006)	Tier 1
	2.62	t CO_2/t carbon black	Default (IPCC 2006)	Tier 1
	0.06	kg CH_4/t carbon black	Default (IPCC 2006)	Tier 1
	C	t CO_2/t styrene	CS	Tier 3
	0.004	t CH_4/t styrene	Default (IPCC 2006)	Tier 1
2.B.10 Other	2.70	t CO_2/t Other	IEF	Tier 1

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

4.3.1 Ammonia Production (CRF 2.B.1)

The production of ammonia constitutes an important source of CO_2 derived from non-energy use of fuels in the chemical industry. CO_2 emissions from ammonia production in 2016 equalled to 685.72 kt of CO_2, corresponding to approx. 0.58% of total greenhouse gas emissions without LULUCF. These emissions decreased by 30.79% 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 was mainly caused by the end of urea production, which has not been produced since 2014. Ammonia production (CO_2 emissions) was identified as a key category in this year's submission.

4.3.1.1 Source category description

Industrial ammonia production is based on the catalytic reaction between nitrogen and hydrogen:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Nitrogen is obtained by cryogenic rectification of air and hydrogen is prepared using starting materials containing bonded carbon (such as, e.g., Natural Gas, Residual Oil, Heating Oil, etc.). Carbon dioxide is generated in the preparation of these starting materials. In the Czech Republic, hydrogen for ammonia production is derived from residual oil from petroleum refining, which undergoes partial oxidation in the presence of water vapour. In order to increase the hydrogen production, the second step involves conversion of carbon monoxide, which is formed by partial oxidation, in addition to carbon dioxide and hydrogen. The final products of this two-step process are hydrogen and carbon dioxide. The production technology has practically not changed since 1990.

4.3.1.2 Methodological issues

Emissions are calculated from the corresponding amount of ammonia produced, using the default emission factor provided in IPCC 2006 Gl. 3.273 kt CO_2/kt NH_3 (IPCC 2006). This emission factor was obtained from IPCC 2006 Gl. Volume 3, Chapter 3 page 3.15 table 3.1, corresponding to the total fuel requirement, which is 44.65 GJ (NCV)/tonne NH_3 (IPCC 2006).Total CO_2 emissions from ammonia production where lowered by CO_2 used in urea production and thus the emissions were calculated using the following equation

$$CO_2\ Emissions = (NH_3\, production * EF) - (CO_2\ consumed\ in\, urea\, production * stochiometric\ coefficient)$$

Urea production decreased to 1.1 kt in 2013. Since 2014, urea has not been produced in the Czech Republic and emissions are calculated without subtraction of CO_2 consumed in urea production.A potential uncertainty in the emission factor for ammonia would not influence the total sum of CO_2 emissions, because a corresponding amount of oil is not considered in the energy sector. The relevant activity data and corresponding emissions are given in Tab. 4-14. Related CO_2 emissions from ammonia production are reported in Table1.A(d) under Other Oil, which is the feedstock used, as well (please see chapter 3.2.3. for details).

Tab. 4-14 Activity data and CO_2 emissions from ammonia production in 1990 – 2016

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Residual fuel oil used for NH_3 product	[TJ]	14 997	14 534	14 985	14 012	15 644	13 812	14 865	13 623	14 044	11 963
Ammonia produced	[kt]	335.86	325.51	335.59	313.8	350.35	309.32	332.91	305.1	314.52	267.91
CO_2 from 2.B.1	[kt]	990.80	933.44	989.89	933.98	1055.82	903.19	989.20	931.15	886.50	788.9
CO_2 consumed in urea production	[kt]	108.48	131.94	108.48	93.09	90.89	109.22	100.42	67.44	142.94	87.96

	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residual fuel oil used for NH_3 product	[TJ]	13 690	11 522	10 052	13 084	12 987	11 326	10 802	10 119	11 453	11 793
Ammonia produced, [kt]	[kt]	306.59	258.04	225.12	293.03	290.84	253.65	241.91	226.62	256.49	264.10
CO_2 from 2.B.1	[kt]	936.02	761.75	638.58	850.60	843.43	721.70	683.27	617.11	700.21	744.18
CO_2 consumed in urea production	[kt]	67.44	82.83	98.22	108.48	108.48	108.48	108.48	124.61	139.27	120.21

	Unit	2010	2011	2012	2013	2014	2015	2016
Residual fuel oil used for NH_3 product	[TJ]	11 484	10 278	10 659	8 212	9 400	10 118	9 355
Ammonia produced	[kt]	257.19	230.18	238.72	183.91	210.53	226.60	209.51
CO_2 from 2.B.1	[kt]	705.45	628.05	653.79	601.13	689.05	741.66	685.72
CO_2 consumed in urea production	[kt]	136.34	125.34	127.54	0.81	NO	NO	NO

4.3.1.3 Uncertainties and time consistency

In 2014, estimates of the uncertainty parameters were verified in the study (Bernauer and Markvart, 2015) which, in addition to an expert opinion, also takes into account data given in the 2006 Guidelines (IPCC 2006). The uncertainty in the activity data remains unchanged at 5% and the uncertainty in the emission factor (CO_2 EF) was also left at a value of 7%.

Time series consistency is ensured as the above mentioned methodology are employed identically across the whole reporting period from the base year 1990 to 2016.

4.3.1.4 Source-specific QA/QC and verification

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

During verification, attention is focused on identifying gaps. Attention is also focused on checking sources from inter-sector boundaries (Energy, Industry) that they are neither omitted nor counted twice. Therefore CO_2 emissions from residual oil used for ammonia production are not taken into account in Energy sector. This part of QA/QC procedure is carried out in cooperation with KONEKO marketing, Ltd. (see Chapter 3.6).

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

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

For future submissions, it is planned that the country specific conditions will be investigated to revise the emission factor used for emission estimates in category 2.B.1.

4.3.2 Nitric Acid Production (CRF 2.B.2)

The production of nitric acid constitutes one of the most important sources of N_2O in the chemical industry. N_2O emissions from production of nitric acid in 2016 equalled to 0.73 kt N_2O, corresponding to approx. 0.18% of total greenhouse gas emissions without LULUCF. These emissions have decreased by 79.37% 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 2016, the production of nitric acid (N_2O emissions) was identified as a key category by trend assessment. In this submission 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. Nitric acid production can be described using the following stoichiometric equations:

a) Ammonia oxidation in the gas phase

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

b) NO oxidation in the gas phase

$$2NO + O_2 \leftrightarrow 2NO_2$$

c) NO_2 absorption in water

$$3NO_2 + H_2O \leftrightarrow 2HNO_3 + NO$$

The nitric acid is manufactured at three pressure levels (at atmospheric pressure, slightly elevated pressure (approx. 0.4 MPa) and at elevated pressure (0.7 - 0.8 MPa). While production processes prior to 2003 mostly progressed at atmospheric pressure and only to a lesser degree at medium elevated pressure, the process at elevated pressure had predominated since 2004.

All the nitric acid production processes in the Czech Republic are equipped with technologies for removal of nitrogen oxides, NO_X, based on selective or non-selective catalytic reduction. Non-selective catalytic reduction also makes a substantial contribution to removal of N_2O. Since 2004, the technology to reduce N_2O emissions, based on catalytic decomposition of this oxide, has been gradually introduced at units working at elevated pressure. It has been possible to substantially improve the effectiveness of this process in recent years.

4.3.2.2 Methodological issues

Nitrous oxide emissions from 2.B.2 Nitric Acid Production are generated as a by-product in the catalytic process of oxidation of ammonia. It follows from domestic studies (Markvart and Bernauer, 1999, 2000, 2003), describing conditions prior to 2004, that the resulting emission factor depends on the technology employed: higher emission factor values are usually given for processes carried out at normal pressure, while lower values are usually given for medium-pressure processes. Two types of processes were carried out in this country before 2004, at pressures of 0.1 MPa and 0.4 MPa. The amount of nitrous oxide in the exit gases is also affected by the type of process employed to remove nitrogen oxides, NO_X (i.e. NO and NO_2). In this country, the process of Selective Catalytic Reduction (SCR) is mostly used, which slightly increases the amount of N_2O, and also to a certain degree Non-Selective Catalytic Reduction (NSCR), which also removes N_2O to a considerable degree.

Studies (Markvart and Bernauer, 2000, 2003) recommend the following emission factors for various types of production technology and removal processes that are given in Tab. 4-15. The emission factors for the basic process (without $DENO_X$ technology) are in accord with the principles given in the above-cited IPCC methodology. The effect of the NO_X removal technology on the emission factor for N_2O was evaluated on the basis of the balance calculations presented in studies (Markvart and Bernauer, 2000, 2003).

Tab. 4-15 Emission factors for N_2O recommended by (Markvart and Bernauer, 2000) for 1990 - 2003

Pressure in HNO_3 production	0.1 MPa			0.4 MPa		
Technology $DENO_X$	--	SCR	NSCR	--	SCR	NSCR
Emission factors N_2O [kg N_2O/t HNO_3]	9.05	9.20	1.80	5.43	5.58	1.09

Collection of activity data for HNO_3 production is difficult, because of the present legislation, which complicates the releasing of statistical data on manufactured products where the number of producers is smaller than (or equal to) three. Therefore, it was necessary to obtain them by questioning/interviewing all three producers in the Czech Republic, see (Markvart and Bernauer, 2000, 2003, 2004).

During 2003, conditions changed substantially as a result of the installation of new technologies operating under higher pressure of 0.7 MPa. At the same time, some older units operating under atmospheric pressure of 0.1 MPa were phased out. These changes in technology were monitored in the study of Markvart and Bernauer (Markvart and Bernauer, 2005). This study presents a slightly modified table of N_2O emission factors, while those for new technologies were obtained from a set of continuous emission measurements lasting several months. Other values are based on several discrete measurements. A table of these technology-specific emission factors is given below.

Tab. 4-16 Emission factors for N_2O recommended by Markvart and Bernauer, for 2004 and thereafter

Pressure in HNO_3 production Technology $DENO_X$	0.1 MPa SCR	0.4 MPa SCR	0.4 MPa NSCR	0.7 MPa SCR
Emission factors N_2O [kg N_2O/t HNO_3]	9.05	4.9	1.09	7.8 [a)]

[a)] *EF without N_2O mitigation.*

In the last quarter of 2005, a new N_2O mitigation unit based on catalytic decomposition of N_2O was experimentally installed for 0.7 MPa technology, and became the most important such unit in the Czech Republic. As a consequence of this technology, the relevant EF decreased from 7.8 to 4.68 kg N_2O/t HNO_3 (100%). Therefore, the mean value in 2005 for the 0.7 MPa technology was equal to 7.02 kg N_2O/t HNO_3 (100%), (Markvart and Bernauer, 2006).

In 2006 - 2016, the mitigation unit described above was utilized in a more effective way. The decrease in the emission factor for 0.7 MPa technology as a result of installation of the N_2O mitigation unit and gradual improvement of the effectiveness is given in Tab. 4-17.

Two high temperature N_2O decomposition catalytic systems were used in the above-mentioned high pressure nitric acid technology (0.7 MPa) in 2009; these systems were more efficient in comparison with the catalytic systems used in previous years. The first system consisting of Raschig rings provided by Heraeus was used in the January-June 2009 period and the measured EF N_2O was 3.10 kg N_2O/ t HNO_3 (100%); in the July-November 2009 period, EF N_2O was 3.30 kg N_2O/ t HNO_3 (100%). The second system consisting of high temperature N_2O decomposition catalyst developed by YARA company, decreased EF N_2O in the November-December 2009 period to the value 0.95 kg N_2O/ t HNO_3 (100%) in a high-pressure nitric plant. The catalytic activity of the high temperature decomposition system has decreased slightly due to both increasing selectivity of the Pt-Rh ammonia oxidation catalyst towards N_2O and slow deactivation of the N_2O decomposition catalyst. Thus, the mean value of EF N_2O for this high pressure nitric acid technology in 2009 was assessed at a value of 2.85 kg N_2O/ t HNO_3 (100%) (Tab. 4-17).

The most efficient decomposition catalyst provided by YARA was used in this high pressure nitric acid technology during whole year of 2010. It is expected that, if high temperature N_2O decomposition catalyst (i.e. YARA catalyst) is employed, the EF N_2O would be approximately close to 1.3 kg N_2O/ t HNO_3 (100%).

YARA's catalyst, which was also used in 2012, exhibits excellent stability with respect to N_2O conversion and the catalyst efficiency was practically constant during the last three years in the high-pressure (0.7 MPa) nitric acid unit.

Tab. 4-17 Decrease in the emission factor for 0.7 MPa technology due to installation of the N_2O mitigation unit

	2004 a)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
EF, kg N_2O/t HNO_3 (100%)	7.8	7.02	5.94	4.37	4.82	2.85	1.29	1.30	1.45	1.65	2.51	2.72	1.78
Effectiveness of mitigation,%	-	10	23.9	43.9	38.2	63.4	83.4	83.3	81.4	78.8	67.8	65.19	77.18

[a)] *EF without N_2O mitigation.*

The emission factors used in the Czech Republic are compared with the EFs presented in the IPCC methodology (IPCC 2006) in the Tab. 4-18.

Tab. 4-18 Comparison of emission factors for N_2O from HNO_3 production

Production process	N_2O Emission factor (kg N_2O/t 100% HNO_3)	Reference
Plants with NSCR (all processes) Plants with processed integrated or tailgas N_2O destruction Atmospheric presssure plants (low pressure) Medium pressure combustion plants High pressure plants	2.00 ± 10% 2.50 ± 10% 5.00 ± 10% 7.00 ± 20% 9.00 ± 40%	(IPCC 2006)
Czech Republic Atmospheric pressure plants Medium pressure plants with SCR Medium pressure plants with NSCR High pressure plants SCR (no N_2O decomposition) High pressure plants SCR (with N_2O decomposition)	 9.05 4.90 1.09 7.80 4.82 – 1.29	(Markvart and Bernauer, 2009, 2010)

Tab. 4-19 gives the N_2O emissions from production of nitric acid, including the production values. Since 2013, activity data and emissions have been taken directly from the EU ETS form and thus Tier 3 is the methodology for emission estimates.

Tab. 4-19 Emission trends for HNO_3 production and N_2O emissions in 1990-2016

	Production of HNO_3, [kt HNO_3 (100%)]	Emissions of N_2O from HNO_3 production [kt N_2O]	Implied Emission Factor IEF [Mg N_2O/ kt HNO_3]
1990	530.00	3.52	6.65
1991	349.56	2.26	6.46
1992	439.39	2.87	6.52
1993	335.95	2.16	6.44
1994	439.79	2.83	6.43
1995	505.32	3.26	6.55
1996	484.80	3.13	6.45
1997	483.10	3.23	6.69
1998	532.50	3.48	6.53
1999	455.00	2.84	6.24
2000	505.00	3.25	6.43
2001	505.08	3.21	6.35
2002	437.14	2.76	6.32
2003	500.58	2.75	5.50
2004	533.73	3.16	5.92
2005	532.21	2.98	5.59
2006	543.11	2.65	4.88
2007	554.22	2.17	3.91
2008	506.96	2.02	3.99
2009	505.17	1.52	3.01

	Production of HNO_3, [kt HNO_3 (100%)]	Emissions of N_2O from HNO_3 production [kt N_2O]	Implied Emission Factor IEF [Mg N_2O/ kt HNO_3]
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	546.77	0.86	1.57
2015	532.15	0.94	1.77
2016	562.66	0.73	1.29

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. 4-15 and Tab. 4-16, 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. 4-17) to 2010. A further reduction in IEF in 2011 was then caused by an increasing contribution of this dominant technology (0.7 MPa) to 56% of the annual production of HNO_3.

The Institute of Physical Chemistry of the Czech Academy of Science together with the University of Chemistry and Technology (Prague) are studying the high temperature decomposition of N_2O from HNO_3 production by using a structured catalyst with focus on the possible use of the technology on an industrial scale. It follows that the development of technologies used in nitric acid production is still ongoing and possible improvements could be introduced in the future.

4.3.2.3 Uncertainties and time-series consistency

In 2014, the estimates of the uncertainty parameters were refined on the basis of in the study (Markvart and Bernauer, 2013), which takes into account the data in the 2006 Guidelines (IPCC 2006). The uncertainty in the activity data following adjustment equalled to 4% and the uncertainty in the average emission factor (N_2O EF) was reduced to 15% in relation to the increasing number of direct measurements.

Time series consistency is ensured as inventory approaches concerned are employed identically across the whole reporting period from the base year of 1990 to 2016.

4.3.2.4 Source-specific QA/QC and verification

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 EU ETS reports, which are used for emission estimates are proved by independent verifiers.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

4.3.2.5 Source-specific recalculations, including changes made in response to the review process and impact on emissions trend

Since 2013, activity data and emissions have been taken directly from EU ETS forms. As a result of harmonization of the reported data with EU ETS forms, changes in the activity data were introduced this year. The changes in the activity data and are shown in Tab. 4-20.

Tab. 4-20 Impact of the recalculation on activity data in 2.B.2

Activity data	Unit	2013	2014	2015
Submission 2017	[kt]	514.94	541.02	562.77
Submission 2018	[kt]	514.95	546.77	532.15
Difference	[%]	0.00	-1.05	5.75

4.3.2.6 Source-specific planned improvements, including tracking of those identified in the review process

No improvement is planned for the next submission.

4.3.3 Adipic Acid Production (CRF 2.B.3)

Adipic Acid production is not occurring in the Czech Republic.

4.3.4 Caprolactam, Glyoxal and Glyoxylic Acid Production (CRF 2.B.4)

4.3.4.1 Source category description

There is only one facility for production of caprolactam in the Czech Republic. Glyoxal and Glyoxylic Acid are not produced in the Czech Republic. Information provided in this chapter is related to caprolactam production.

Caprolactam is prepared by traditional technology from cyclohexanone and hydroxylamine sulphate, which is prepared by the Rasching process. Cyclohexanone reacts with hydroxylamine sulphate yielding cyclohexanonoxime, from which caprolactam is produced by the Beckmann rearrangement. Then caprolactam is isolated from the reaction mixture by neutralisation with ammonium hydroxide.

4.3.4.2 Methodological issues

There is only one facility for caprolactam production in the Czech Republic. Emission estimates for caprolactam production are based on a series of studies (Markvart and Bernauer, 2004 – 2013) and (Bernauer and Markvart, 2014 - 2016). The facility for caprolactam production provided data on the consumption of ammonia (1177 kg NH_3/hour) and the production capacity (5.4 t caprolactam/hour). Assuming that the conversion of NH_3 to N_2O is routinely 2%, the emission factor 5.7 kg N_2O/t caprolactam was established from the mass balance. The production unit in the facility works at atmospheric pressure and thus the emission factor should be compared with the emission factor for atmospheric burning of ammonia and not with high-pressure burning of ammonia. Emissions of N_2O in the amount 246 t N_2O/year were estimated by using the plant-specific emission factor and working hours per year (8000 hours/year). Due to the lack of activity data, emissions were reported consistently through the time series until 2014. Since 2014, the activity data have been obtained directly from the producer.

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

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

In relation to the relatively unimportant greenhouse gas emissions from category 2.B.4, only QC, Tier 1 procedures were used, in accordance with the QA/QC plan.

Data from the EU ETS forms cannot be used for emission estimates because the facility reports all sources of emissions together and thus it is not possible to separate the data for caprolactam. However, according the EU ETS forms of this facility, it can be stated that the emissions from caprolactam production are not greater than the estimated amount of 0.25 kt N_2O used for 1990-2013.

4.3.4.5 Category-specific recalculations, including changes made in response to the review process and impact on emission trend

The activity data were obtained directly from the manufacturer for this submission. Data have been available since 2014. The impact of the recalculation on the activity data and emissions from caprolactam production are given in Tab. 4-21.

Tab. 4-21 Impact of the recalculation in category 2.B.4

Activity data	Unit	2014	2015
Submission 2017	[kt]	43.20	43.20
Submission 2018	[kt]	40.60	43.40
Difference	[%]	6.40	-0.46
Emissions of N_2O	Unit	2014	2015
Submission 2017	[kt]	0.25	0.25
Submission 2018	[kt]	0.23	0.25
Difference	[%]	6.40	-0.46

4.3.4.6 Category-specific planned improvements, including tracking of those identified in the review process

No improvement is planned for the next submission. Emissions are estimated according a series of studies (Markvart and Bernauer, 2004 – 2013) and (Bernauer and Markvart, 2014 - 2016) and activity data are obtained directly from manufacturer. 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 (IPCC 2006) 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)

A factory for soda ash production in the Czech Republic was founded in 1905 and the first production of soda ash started in 1907. The factory constituted a monopolist manufacturer of soda in the Czech

Republic and Czechoslovakia. Soda was produced by the traditional Solvay process and the product was usually distributed to glass manufacturers. The factory was closed in 1991. Since then, soda has not been 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 427.07 kt CO_2 eq. compared to the previous year. Decrease of emissions since 2015 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. The ethylene unit is still under reconstruction. It is assumed that, after the completion of reconstruction, the production capacity will be greater than that before the accident in the refinery 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 ethylene, ethylene dichloride, carbon black and styrene. These are all less important sources (excluding emission of CO_2 from ethylene production).

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.

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). 1,2-dichloroethane is prepared by oxychlorination of ethylene and is then used as source material for vinyl chloride monomer (VCM) production.

In the Czech Republic, carbon black is produced in one facility by the furnace black process. The input materials for the production are heavy aromatic hydrocarbons.

Styrene is produced in one facility by catalytic alkylation of benzene over ethylbenzene followed by ethylbenzene dehydrogenation. The internal ethylbenzene dehydrogenation operates in a system of 2 reactors in the presence of catalysers (Fe_2O_3-Cr_2O_3-K_2O).

4.3.8.2 Methodological issues

Default emission factors from the IPCC 2006 Guidelines (IPCC 2006) are employed to determine carbon dioxide and methane emissions from the production of carbon black, ethylene, ethylene dichloride and styrene. Related CO_2 emissions from Petrochemical and Carbon Black Production are reported in Table1.A(d) under Naphtha, which is the major feedstock used, as well (please see chapter 3.2.3. for details).

CO_2 and CH_4 emissions from the production of ethylene

Reliable data for the production of ethylene are available from CzSO. The IPCC methodology provides a value of 1.73 tonnes CO_2/tonne ethylene produced (with correction factor 110% for countries of Eastern Europe) and 3 kg CH_4/tonne ethylene produced as default emission factors. In the period 1990 – 2016,

CO_2 emissions varied between 184 to 959 kt CO_2 and methane emissions varied between 0.3 and 1.5 kt CH_4, detailed values for each year are available in Tab. 4-22.

Tab. 4-22 Emission trends from CO_2 and CH_4 emissions from production of ethylene in 1990-2016

		Category 2.B.8.b	
	Ethylene Production [kt]	CO_2 Emissions [kt]	CH_4 Emissions [kt]
1990	388.02	738.40	1.16
1991	286.45	545.12	0.86
1992	325.37	619.17	0.98
1993	332.68	633.10	1.00
1994	389.53	741.28	1.17
1995	373.34	710.47	1.12
1996	390.80	743.69	1.17
1997	399.09	759.46	1.20
1998	448.94	854.34	1.35
1999	466.32	887.40	1.40
2000	411.66	783.39	1.23
2001	439.16	835.72	1.32
2002	412.12	784.26	1.24
2003	396.88	755.27	1.19
2004	503.86	958.85	1.51
2005	503.86	958.85	1.51
2006	462.14	879.46	1.39
2007	408.55	777.47	1.23
2008	464.73	884.38	1.39
2009	416.10	791.83	1.25
2010	454.97	865.80	1.36
2011	412.07	784.17	1.24
2012	441.08	839.37	1.32
2013	425.62	809.95	1.28
2014	491.50	935.32	1.47
2015	308.44	586.96	0.93
2016	96.91	184.41	0.29

CO_2 and CH_4 emissions from the production of ethylene dichloride

The data on production of PVC are obtained from CzSO. While CzSO does not publish information on the amount of VCM, it does give data on the amount of PVC produced, which are practically the same as VCM data. The IPCC 2006 Guidelines methodology provides a value of emissions of carbon dioxide 0.294 tonne CO_2/tonne VCM produced and for methane 0.0226 kg CH_4/tonne VMC produced as default emission factors. Carbon dioxide emissions varied in the period 1990 - 2016 between 16.7 kt CO_2 and 40.3 kt CO_2. Due to the low emission factors' value, the values of methane emissions varied in the period 1990 – 2016 between 0.001 and 0.003 kt CH_4, which is considered as insignificant value. In 2016, emissions of carbon dioxide equalled to 20.01 kt and methane emissions equalled to 0.0015 kt CH_4.

CO_2 and CH_4 emissions from the production of carbon black

The production of carbon black is approximately 26 kt of p.a. Exact information on activity data is available since 2013; thus, the data for other years were taken from the study (Bernauer and Markvart, 2016). Since 2013, the activity data and CO_2 emissions have been based on data from EU ETS. In the Czech Republic, only one facility is involved in carbon black production and thus the activity data and emissions are reported as confidential C (NK) in the CRF reporter. Data are available for review experts in calculation sheets upon a request. The emission factor taken from the IPCC 2006 Gl. methodology equals to 0.06 kg CH_4/tonne carbon black produced and 2.62 t CO_2 /t carbon black produced. The highest value of methane emissions over the past few years is practically insignificant (0.00153 kt).

CO_2 and CH_4 emissions from the production of styrene

Because of the growing consumption of polystyrene, the production of styrene has gradually increased since 1990. CzSO also does not publish any information on the production of styrene. Thus, the necessary activity data were estimated on the basis of production capacities:

1990 - 1998	70 kt styrene p.a.
1999	80 kt styrene p.a.
2000 - 2003	110 kt styrene p.a.
2004	140 kt styrene p.a.
2005 - 2010	150 kt styrene p.a.
from 2011	exact production from EU ETS forms

These estimates on the amount of styrene produced were based on the data given in the article (Dvořák and Novák, 2010). The emission factor taken from the IPCC methodology equals to 0.004 kt CH_4/kt styrene. The emission factor for CO_2 emissions is 0.27 kt CO_2/kt styrene (Bernauer and Markvart, 2015). Since 2011, activity data 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 - 2016, methane emissions varied between 0.3 and 0.7 kt CH_4 and carbon dioxide emissions varied between 18.9 and 45.9 kt CO_2.

4.3.8.3 Uncertainties and time-series consistency

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 40% for the CO_2 and CH_4 emission factors. Overall uncertainty data are given in Chapter 1.6.

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

The input information and calculations are archived by the sectoral expert and the coordinator of NIS.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

4.3.8.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculation performed in this submission.

4.3.8.6 Source-specific planned improvements, including tracking of those identified in the review process

No improvements are planned.

4.3.9 Fluorochemical Production (2.B.9)

Fluorinates are not produced in the Czech Republic.

4.3.10 Other (2.B.10)

CO_2 emissions from category 2.B.10, which includes other non-energy use in chemical industry and non-selective catalytic reduction equalled to 233.58 kt CO_2 in 2016.

4.3.10.1 Source category description

Subcategory 2.B.10 Other is divided into two subcategories. The first sub-category includes CO_2 emissions from non-selective catalytic reduction (NSCR) of output gases from nitric acid production; the second one includes emissions for hydrogen production by steam reforming in the petrochemical and chemical industry (excluding hydrogen used for NH_3 production, which is based on other feedstock than NG, see section 4.3.1). Emissions from NSCR are not very significant (about 15 kt of CO_2). Emissions from steam reforming of NG are somewhat more significant (about 200 kt of CO_2)).

4.3.10.2 Methodological issues

Thanks to intensive consultation with experts at CzSO and the University of Chemistry and Technology in Prague (VSCHT), it is now possible to reliably specify emissions from non-energy use and thus reallocate activity data, which are reported under 1.A.2.c in accordance with IPCC 2006 Gl. (IPCC 2006).

The production of nitric acid in installations with NSCR is obtained from EU ETS forms. Currently, two installation units with NSCR are operating in the Czech Republic. Emissions of CO_2 are calculated by simple Tier 1 methodology, where the production data are multiplied by the emission factor. The emission factor is based on a series of studies (Markvart and Bernauer, 2004 – 2013) and (Bernauer and Markvart, 2014 - 2016). Reduction of oxygen, which is the main source of CO_2 emissions in the NSCR process, can be described by the following reaction

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

The emission factor 103 kg CO_2 /1 t HNO_3 was derived for the reaction and was used for emission estimates.

Emissions for hydrogen production by steam reforming in the petrochemical and chemical industry (excluding hydrogen used for NH_3 production) are calculated using the following equation

$$Emissions = (Net\ calorific\ value\ of\ NG * EF\ for\ NG) - emissions\ of\ NSCR$$

The net calorific value of natural gas consumed for non-energy use in the chemical industry is obtained from the Energy Questionnaire - Natural Gas provided by AIE - Eurostat – UNECE. EF for natural gas is calculated on the basis of the NET4GAS Ltd. correlation (see Annex A5.1).

Tab. 4-23 gives an overview of the CO_2 emissions from category 2.B.10 Other. Related CO_2 emissions from 2.B.10 are reported in Table1.A(d) under Natural Gas as well (please see chapter 3.2.3. for details).

Tab. 4-23 Emission trends for category 2.B.10 Other in 2008-2016

		2008	2009	2010	2011	2012	2013	2014	2015	2016
Other non-energy use in chemical industry	**CO_2 emissions [kt]**	208.34	123.08	195.74	206.72	210.01	201.33	204.76	208.02	220.49
Non selective catalytic reduction	**CO_2 emissions [kt]**	14.42	13.39	14.42	13.49	14.52	13.43	14.77	15.04	13.09

4.3.10.3 Uncertainties and time consistency

The uncertainty of the activity data and emission factors used for computations of emissions from category 2.B.10 correspond to the uncertainty estimates from the Energy sector, category 1.A.2 Manufacturing industries and construction. The uncertainties are for this category are in line with IPCC 2006 Guidelines (IPCC 2006), i.e. at the level of 3% for the activity data and 2.5% for the emission factor.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from 2008 to 2016.

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.

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

Category 2.B.10 Other non-energy use in the chemical industry was recalculated by using updated natural gas consumption data and because of harmonization with calculations in the Energy sector.

Category 2.B.10 NSCR was recalculated for 2013 to 2015. The data obtained directly from EU ETS forms was used for emission estimates.

The impact of these recalculations on the overall emissions from category 2.B.10 is shown in Tab. 4-24.

Tab. 4-24 Impact of the recalculation in category 2.B.10

Emissions of CO_2	Unit	2013	2014	2015
Submission 2017	[kt]	214.76	219.52	222.81
Submission 2018	[kt]	214.76	219.52	223.06
Difference	[%]	0.00	0.00	-0.11

4.3.10.6 Source-specific planned improvements, including tracking of those identified in the review process

In further submissions it is planned to investigate the possibility of disaggregating data for non-energy and energy use of NG for the 1990-2007 period. CO_2 emissions from NG in the chemical industry were reported for this period under 1.A.2.c.

4.4 Metal Industry (CRF 2.C)

This category includes mainly CO_2 emissions from 2.C.1 Iron and Steel Production, 99.8% of CO_2 emissions arise from 2.C.1. CO_2 emissions from iron and steel are identified as a key category (by both level and trend assessments). A small amount of CH_4 is also emitted.

Ferro-alloys were manufactured in limited amounts in a small production unit in the Czech Republic; this process could constitute an unsubstantial source of CO_2 emissions. Specific data were obtained straight from the operator – there is only one producer of ferrovanadium.

For the production of Lead and Zinc data are also obtained straight from the operators, however there is only one producer of secondary lead and one producer of zinc.

Investigation revealed one smaller production plant, which reported that aluminium was used as a reducing agent; this did not lead to CO_2 emissions. In 2009 this production was stopped.

4.4.1 Iron and Steel Production (CRF 2.C.1)

4.4.1.1 Category description

Iron is produced in the Czech Republic in two large metallurgical facilities located in the cities of Ostrava and Třinec in the Moravian-Silesian Region, in the north-eastern part of the Czech Republic. Both these metallurgical works employ blast furnaces and also lines for the production of steel, coking furnaces and other supplementary technical units. Another large steel plant is located immediately next to the metallurgical works in Ostrava, taking raw iron (in the liquid state) from the nearby blast furnaces (located in the area of the Ostrava metallurgical works).

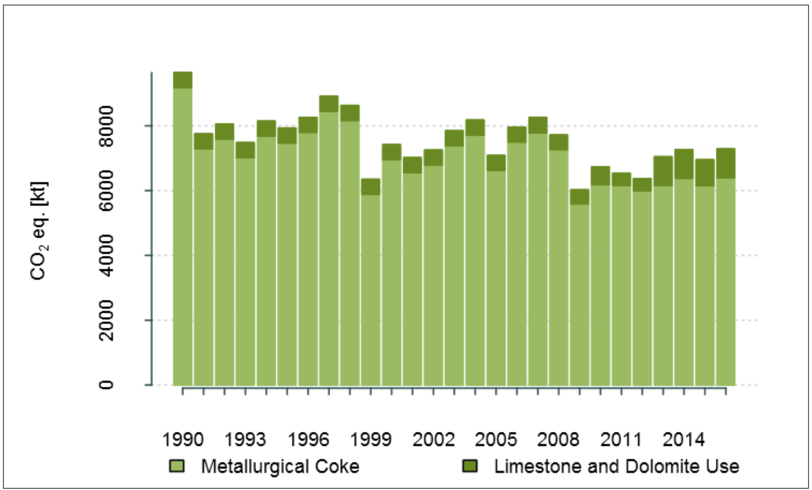

Fig. 4-7 Trend of CO2 emissions in 2.C.1, 1990 – 2016 [kt CO2]

2.C.1. was identified as key category in this submission by level and trend assessment, both by Approach 1 KC analysis and also approach 2 KC analysis.

4.4.1.2 Methodological issues

The CO_2 emissions from iron and steel production were calculated using the national approach which can be considered as Tier 2. However, Tier 2 emission estimations based in IPCC 2006 Guidelines (IPCC 2006) include recommendations to also include emissions arising from combustion of Blast Furnace and Oxygen Steel Furnace Gas in other than metallurgical complexes (for instance in Energy category 1.A.1.a). However, it is expected in the Czech Republic that all Blast Furnace and Oxygen Steel Furnace Gases are combusted directly in the metallurgical complexes. This means that the national approach to emission estimations contains a few aspects from Tier 1, as some parts of the equation are available for the computation. An important aspect of the computation is the amount of carbon in the reducing agent (i.e. in metallurgical coke) and thus also the amount of carbon in scrap and in steel. Further, small amount of Bituminous Coal in 2014, 2015 and 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. Details of the amount of reducing agents are given in Tab. 4-25. In the carbon balance the amount of carbon in coke, bituminous coal (in 2014 – 2016) and coal tar (in 2007-2013) used in blast furnaces. Further amount of carbon in sinter, pig iron and steel is part of the emission estimation. The total amount of total carbon produced in the process is following equation

$$C_{total} = \left(C_{coke} + C_{bituminous\ coal} + C_{coal\ tar} + C_{scrap} + C_{electrodes}\right) - C_{steel}$$

Coke Oven Gas is not in the official CzSO data reported in transformation processes, so it is used only for warming up, so the emissions are reported under 1.A.2.a. Blast Furnace Gas is used for warming the air for the blast furnace.

99% of produced pig iron is used immediately in the facility for steel production. Iron ore charge for blast furnaces is ensured from three quarters by sintering of sinter fines in our own Sinter Plant and the remaining portion of iron ore charge is formed by pellets, lump ores and also secondary materials. Blast furnace coke is supplied from the neighboring Coke Oven Plant, part of blast furnace coke and liquid fuel is purchased from external sources. Produced hot metal and sinter is used for internal consumption only. Steel is here homogenised, additionally alloyed to the exact chemical composition, heated to the appropriate casting temperature and desulphurized, and modification of inclusions is performed using filled profiles. After this out-of-furnace processing molten steel is sequentially cast on three continuous casters into billets, slabs or small slabs. Finishing lines represents two section-rolling mills and a wire-rod mill, which provide a wide assortment of profiles and wire rod.

The calculation in IPCC 2006 Gl. (IPCC 2006) also includes CO_2 emissions from limestone and dolomite used in iron and steel metallurgy. Since the 2015 submission, these emissions have been reported under 2.C.1. Data reported under EU ETS were used for these emissions, i.e. Tier 3.

The computational approach as well as the parameters used were consulted in general with a representative of The Steel Federation, Inc. Related CO_2 emissions from 2.C.1 are reported in Table1.A(d) under Coke Oven Coke (1990-2016), Other bituminous coal (2014-2016) and Coal Tar as well (2007-2013) as well(please see chapter 3.2.3. for details).

Tab. 4-25 The amounts of metallurgical coke consumed and CO_2 emissions in 1990 – 2016

	Coke consumed in blast furnaces	Other Bituminous Coal	Coal Tar	Use of limestone and dolomite	CO_2 from 2.C.1 [kt]
1990	3211	NO	NO	891.04	9642.54
1991	2559	NO	NO	891.03	7750.98
1992	2624	NO	NO	891.03	8049.44
1993	2426	NO	NO	891.04	7479.70
1994	2663	NO	NO	891.03	8143.88
1995	2587	NO	NO	891.04	7930.90
1996	2701	NO	NO	891.05	8257.45
1997	2846	NO	NO	891.01	8907.86
1998	2750	NO	NO	891.05	8625.62
1999	1941	NO	NO	891.08	6346.94
2000	2327	NO	NO	890.88	7418.03
2001	2175	NO	NO	891.20	7016.95
2002	2252	NO	NO	891.16	7251.30
2003	2459	NO	NO	890.29	7846.70
2004	2628	NO	NO	892.15	8176.00
2005	2260	NO	NO	891.06	7084.34
2006	2480	NO	NO	887.65	7952.48
2007	2570	NO	35	897.73	8258.72
2008	2366	NO	59	887.78	7715.56
2009	1801	NO	56	877.45	6022.92
2010	2082	NO	33	927.97	6733.78
2011	2086	NO	26	857.92	6536.30
2012	2007	NO	23	846.47	6368.95
2013	2057	NO	7	1079.53	7041.88
2014	1886	276	NO	1051.93	7263.48
2015	1780	300	NO	947.59	6952.69
2016	1842	319	NO	1039.28	7286.67

The amounts of blast furnace coke consumed and corresponding emissions are given in Tab. 4-25.

Estimation of CH_4 from metal production is based on the IPCC 2006 Guidelines Tier 1 methodology. Default emission factors 0.1 g CH_4 per tonne of coke produced and 0.07 kg CH_4 per tonne of sinter produced were used. In this case, the relevant activity data correspond to the amount of coke produced from the Energy Balances of the CR are given in CRF Tables and official statics data of sinter produced.

Emission estimates of precursors for the relevant subcategories have been transferred from NFR to CRF, as described in previous chapters and in Chapter 9.

4.4.1.3 Uncertainties and time consistency

The uncertainty estimates have so far been based on expert judgment. Their improvement is ongoing and some uncertainty estimates for Iron and steel production have been revised in previous submissions (CHMI, 2012b). The new estimate of EF (CO_2) is now 10%, which is in accordance with the 2006 Guidelines (IPCC 2006) and is slightly higher than the former value (5%). The estimate for AD (7%) remained unchanged, because this value is in good agreement with the recommendation in the Regulation of Commission (EU) No. 601/2012 (EU, 2012). Further improvement of uncertainty estimates is planned for the next submission.

Consistency of the time series is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year of 1990 to 2016.

4.4.1.4 Source-specific QA/QC and verification

The sector-specific QA/QC plan follows from the overall plan described in Chapter 1. The greatest attention was focused on identifying gaps and imperfections using the new reporting software (CRF Reporter), specifically by observing trends in figures and by checking IEFs. Attention was also focused on checking sources from inter-sector boundaries (Energy, Industry) that they are neither omitted nor counted twice. CO_2 emissions from coke used in blast furnaces are not considered in Energy sector (see Chapter 3.2).

Activity data available in the official CzSO materials in relation to QA/QC were independently determined by experts from CHMI and KONEKO and were mutually compared. Experts at CHMI additionally checked most of the calculations carried out by experts at KONEKO and vice versa. For another QA, especially QA of computational approach, is also used former coordinator of National Inventory System.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

4.4.1.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

A small change in data for bituminous coal was provided for 2014 and 2015. The change yelds in increase of emissions by 1% in both affected years.

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 and 2017, however the issue need further detailed activity data, which will be discussed with relevant representatives.

4.4.2 Ferroalloys Production (CRF 2.C.2)

4.4.2.1 Source category description

Ferroalloys Production is production of concentrated alloys of iron and or more metals such as silicon, manganese, chromium, molybdenum, vanadium and tungsten. In the Czech Republic is only one producer of ferrovanadium. Therefore, activity data are reported as confidential.

4.4.2.2 Methodological issues

The activity data were obtained straight from the operator, where ferrovanadium is produced. IPCC 2006 Guidelines (IPCC 2006) does not provide emission factors of this type of ferroalloy. However, IPCC 2006 Guidelines provides emission factors based on specific share of Si in the ferroalloy. Chemical composition of the ferrovanadium produced in the Czech republic is known. Using the simple proportion rule, emission factors were calculated for CO_2, as well as for CH_4. This can be considered as conservative approach.

The emissions are under the threshold of significance and can be considered negligible.

Tab. 4-26 Evaluation of emission factors used for 2.C.2 emission estimates

Composition of ferrovanadium		IPCC 2006 Gls. EF		EF CO_2 (1.5% od Si)	EF CH_4 (1.5% od Si)
Vanadium	75-85%	FeSi 45% Si	2.5	0.083333*)	
Aluminum	1.5% max	FeSli 65% Si	3.6	0.083077	0.023077*)
Silicon	1.5% max	FeSi 75%Si	4	0.08	0.02
Carbon	0.25% max.	FeSi90%Si	4.8	0.08	0.018333
Phosphorus	0.08% max.				
Sulfur	0.08% max.				

**)emission factors used for computation*

4.4.2.3 Uncertainties and time 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

No recalculation was performed in this category in current submission.

4.4.2.6 Source-specific planned improvements, including tracking of those identified in the review process

Since the emissions are negligible, no improvement is planned.

4.4.3 Aluminium Production (2.C.3)

Investigation revealed one smaller production plant, which reported that aluminium was used as a reducing agent; this did not lead to CO_2 emissions. In 2009 this production was stopped. Recently, there is only secondary production of aluminium in the Czech Republic. From this reason no greenhouse gases are reported in this category. There is recycling of aluminium. In order to avoid using of F-gases is used cover salts method. The recommendation from FCCC/ARR/2016/CZE, I.13 is not in line with IPCC 2006 Guidelines and further not comparable to the reporting of other Annex I Parties. The recommendation is requesting to report CO_2 and PFC emissions from secondary aluminium production in the correct category (2.C.7 Other). There is no guidance for this kind of processes for reporting under 2.C.7. Further, no Annex I Party is reporting such emissions. The inventory team believes, that no greenhouse gases are arising from the processes mentioned.

4.4.4 Lead Production (2.C.5)

4.4.4.1 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.

4.4.4.2 Methodological issues

Research was performed on potential Lead producers in the Czech Republic. The data were obtained straight from the operator; the data has to be displayed as confidential. The CO_2 emissions were estimated at the level of Tier 1 methodology based on the IPCC 2006 Guidelines (IPCC 2006) using the default CO_2 emission factor 0.2 t CO_2/t of lead. CO_2 emissions in 2016 equalled 9.2 kt.

The emissions are under the threshold of significance.

4.4.4.3 Uncertainties and time 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. The activity data and composition of ferroalloys were discussed with representative of The Steel Federation, Inc.

4.4.4.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculation was performed in this category in current submission.

4.4.4.6 Source-specific planned improvements, including tracking of those identified in the review process

Since the emissions are negligible, no improvement is planned.

4.4.5 Zinc Production (2.C.6)

4.4.5.1 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. Updated activity data from other producer, which was operating during 1990 – 1999 were obtained in this submission. No GHG emissions are arising from the secondary zinc production.

4.4.5.2 Methodological issues

The research of potential Zinc producers in the Czech Republic was performed. Detailed data were obtained straight from the operator, the data has to be displayed as confidential. The CO_2 emissions were estimated on the level Tier 1 methodology based on IPCC 2006 Guidelines (IPCC 2006) using default CO_2 emission factor 1.72 t CO_2/t of zinc. CO_2 emissions in 2016 equalled 0.6 kt, which presents negligible share in the whole inventory.

4.4.5.3 Uncertainties and time 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.

4.4.5.4 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.

4.4.5.5 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 1990 - 1999. The transparency of reporting was increased due to this recalculation. The updated emissions are by 0.5% higher in comparison to the reporting of last submission.

4.4.5.6 Source-specific planned improvements, including tracking of those identified in the review process

Since the emissions are negligible, no improvement is planned.

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

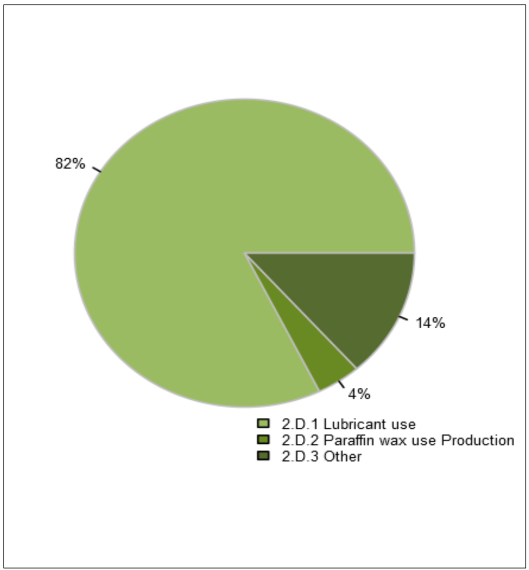

Fig. 4-8 The share of individual subcategories for CO2 emissions in 2.D in 2016 [kt CO2]

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.

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. 4-8 shows the share of individual subcategories in 2.D. 82% of 2.D CO_2 emissions are produced from Lubricant Use, followed by Urea used as catalysts (14%) and the use of Paraffin Wax (4%).

4.5.1 Lubricant Use (2.D.1)

4.5.1.1 Source category description

Lubricants are produced from refining of crude oil in petrochemical installations. There can be distinguished between engine oils and industrial oil or grease.

4.5.1.2 Methodological issues

The activity data are provided by CzSO in the official Energy balance of the Czech Republic. The non-energy use of fuels is also included. The amount of lubricants used for other than energy production is included in this category as activity data.

Tier 1 methodology from the IPCC 2006 Guidelines was used for CO_2 emission estimations. The default emission factor 20 kg C/GJ was used; the Oxidised During Use (ODU) factor was used as a default value equal to 0.2. CO_2 emissions from this category in 2016 were equal to 115 kt CO_2. Related CO_2 emissions from 2.D.1 are reported in Table1.A(d) under Lubricants as well (please see chapter 3.2.3. for details).

4.5.1.3 Uncertainties and time consistency

Since the activity data used are from official statics, the suggested 5% uncertainty (IPCC 2006) was applied for this category. Since default ODU factor was used, suggested 50% uncertainty from IPCC 2006 Gl. was applied for emission factor uncertainty.

4.5.1.4 Source-specific QA/QC and verification

Standard QA/QC procedures were applied for this subcategory. Special attention was paid to cross-sectoral issues (Energy x IPPU), so no emissions are omitted, nor counted twice.

4.5.1.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculation performed in this submission.

4.5.1.6 Source-specific planned improvements, including tracking of those identified in the review process

No improvements are planned in this subcategory.

4.5.2 Paraffin Wax Use (2.D.2)

4.5.2.1 Source category description

This category includes use of products separated from fossil fuels called paraffins, waxes or vaseline. From chemical point of view they are mixtures of solid paraffinated hydrocarbons obtained from crude oils. Different types are characterised by point of solidification and amount of oil contained.

4.5.2.2 Methodological issues

Activity data reported in official Energy balance of CzSO as non-energy use are used for emission estimation in this category. Tier 1 methodology from IPCC 2006 Guidelines (IPCC 2006) was used for CO_2 emission estimation. Default emission factor 20 kg C/GJ was used, Oxidised During Use (ODU) factor was used default equal to 0.2. CO_2 emissions in 2016 from this category were equal to 5.9 kt CO_2.

4.5.2.3 Uncertainties and time consistency

Since the activity data used are from official statics, the suggested 5% uncertainty (IPCC 2006) was applied for this category. Since default ODU factor was used, suggested 50% uncertainty from IPCC 2006 Gl. (IPCC 2006) was applied for emission factor uncertainty.

4.5.2.4 Source-specific QA/QC and verification

Standard QA/QC procedures were applied for this subcategory. Special attention was paid to cross-sectoral issues (Energy x IPPU), so no emissions are omitted, nor counted twice.

4.5.2.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No recalculation performed in this submission.

4.5.2.6 Source-specific planned improvements, including tracking of those identified in the review process

No improvements are planned in this subcategory.

4.5.3 Other (2.D.3)

4.5.3.1 Source category description

Solvent Use

This category includes particularly emissions of NMVOC (ozone precursor) from the use of solvents, which based in IPCC 2006 Guidelines (IPCC 2006) are not considered to be a source of direct CO_2 emissions.

Road Paving With Asphalt

This category includes particularly emissions of ozone precursors in 1990 – 2005 time - series. Based on the IPCC 2006 Gl. (IPCC 2006) only NMVOC emission should be reported. Data in reporting for the UNECE/CLRTAP inventory in NFR are used. Emissions from Road Paving with Asphalt are not considered to be a source of CO_2 emissions (IPCC 2006).

Urea used as catalyst

IPCC 2006 Gl. (IPCC 2006) incorporate this category as source of CO_2 emissions. However, based on methodology temissions from this process should be included in Energy sector, 1.A.3. Since the emissions does not arise from fuel combustion, the emissions are covered under IPPU sector.

4.5.3.2 Methodological issues

Solvent Use

The IPCC methodology (IPCC 2006) uses the CORINAIR methodology (EMEP/CORINAIR Guidelines, 1999) for processing NMVOC emissions in this category. This manual also gives the following conversions for the relevant activities, which can be used in conversion of data from the CORINAIR (i.e. SNAP) structure to the IPCC classification.

Inventory of NMVOC emissions for 2016 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 and Association of Industrial Distilleries,
- information from the Customs Administration,
- regular monitoring of economic activities and economic developments in the CR, knowledge and monitoring of important operations in the sphere of surface treatments, especially in the area of application of coatings, degreasing and cleaning,
- regular monitoring of investment activities is performed in the CR for technical branches affecting the consumption of solvents and for overall developmental technical trends of all branches of industry,
- monitoring of implementation of BAT in the individual technical branches,
- technical analysis of consumption of solvents in households; NMVOC emissions from households are entirely fugitive and, according to qualified estimates, contribute approximately 16.5% to total NMVOC emissions.

The activity data for Solvent Use were extracted from the official Energy balance. Form the whole amount of non-energy use of Other oil products were extracted the Oil needed for NH_3 production. Sum of the rest of Other Oil and non-energy use of White spirit was considered as the best available data for Solvent Use. This approach was approved with relevant experts from CzSO.

Road Paving With Asphalt

The activity data from last submission were used. Emissions are used from UNECE/CLRTAP inventories.

Urea used as catalyst

Since no detailed data about urea used as catalyst is available, the default approach was used, i.e. the activity level is 1% to 3% of diesel consumption by the vehicle. For the Czech Republic conservative estimate of 2% was used. 2% of the amount of diesel used in road transport was used as activity data. This approach was used for the emission estimates for 1998 – 2016 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. (IPCC 2006) was applied to estimate CO_2 emissions. This approach is clearly conservative approach, since it is taking into account total consumption of diesel. However, exact amount of vehicles using this technology is not known. The data are under investigation. Even using this conservative approach the emissions are under the threshold of significance.

CO_2 emissions in 2016 from this category were equal to 18.9 kt CO_2.

4.5.3.3 Uncertainties and time 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 2016.

Road Paving With Asphalt

Since no CO_2, CH_4 or N_2O emission were estimated in this category, no uncertainties were considered in this category.

Urea used as catalyst

Suggested default range for uncertainty was applied for 2.D.3 category, i.e. 5% for activity data and 5% for emission factor uncertainty. However even though the emission are reported under 2.D.3, the range was applied based on IPCC 2006 Gl. Vol. 2 Energy (IPCC 2006), 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

No recalculations performed in this submission.

4.5.3.6 Source-specific planned improvements, including tracking of those identified in the review process

Solvent Use

No improvements are planned in this category.

Road Paving With Asphalt

No improvements are planned in this category.

Urea used as catalyst

Further investigation of activity data is planned for the future submissions.

4.6 Electronics Industry (CRF 2.E)

Of the categories of sources classified under the Electronics Industry (2.E), only the Integrated Circuit or Semiconductor (2.E.1) category is relevant for the Czech Republic. This category includes the gases HFC-23, CF_4, C_2F_6, SF_6 and NF_3.

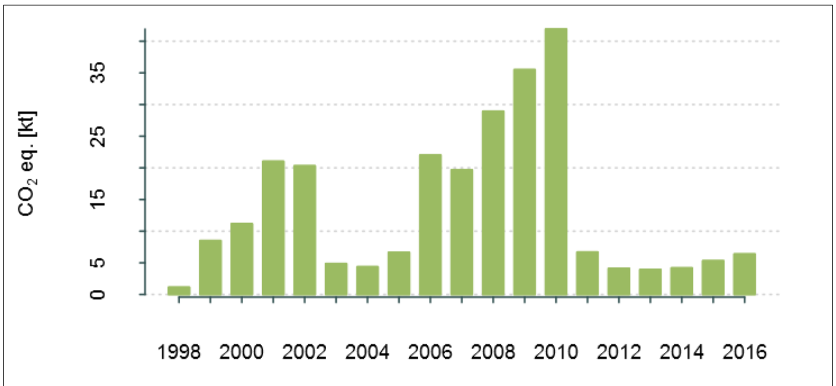

Fig. 4-9 Trend of emissions from 2.E Electronics Industry [kt CO_2 eq.]

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. 4-9 from year 1997, when the use of CF_4 began to 2016.

Emissions of F-gases equalled to 6.39 kt CO_2 eq. in 2016. Total emissions of F-gases from 2.E increased in 2016 by 1.07 kt CO_2 eq. compared to previous year.

Tab. 4-27 lists the exact amount of CO_2 eq. emissions from category 2.E.

Tab. 4-27 Emissions from category 2.E. Electronics Industry in time period 1997-2016

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Emissions [kt CO_2 eq.]	1.14	1.14	8.51	11.17	21.03	20.30	4.87	4.36	6.64	22.03
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Emissions [kt CO_2 eq.]	19.68	28.94	35.50	41.93	6.58	4.29	4.40	4.19	5.32	6.39

Tab. 4-28 gives an overview of the emission factors and methodology used for computations of emissions in category 2.E. Electronics Industry in 2016.

Tab. 4-28 Type of CO_2 emissions factors used for computations of 2016 emissions in category 2.E Electronics Industry

	F-gas reported	Source or type EF	Methodology
2.E.1 Integrated Circuit or Semiconductor	HFC-23, CF_4, C_2F_6, SF_6, NF_3	Default (IPCC 2006)	Tier 2a

4.6.1 Integrated Circuit or Semiconductor (CRF 2.E.1)

4.6.1.1 Source category description

This category includes the gases C_2F_6, CF_4, SF_6, CHF_3 (HFC-23) and NF_3 used by semiconductor manufacturers. These gases are used in the plasma chemical thin layer etching process. The process is based on the reaction between atomic fluorine and the material of the layer. Atomic fluorine is derived from the fluorinated gases mentioned above in the presence of capacity-induced plasma.

Gases SF_6 and NF_3 are currently used for semiconductor manufacturing in the Czech Republic. Consumption of NF_3 has increased since 2010, when the first use of NF_3 for semiconductor manufacturing was recorded. According to the main manufacturer, the fluctuating trend in emissions is linked with the fluctuating consumption of gases for semiconductor manufacturing. The consumption of gases in the current year depends on the planned capacity of production, type of manufactured products and types of etching processes.

4.6.2 Methodological issues

Because of the lack of detailed information, the data about gases C_2F_6, CF_4, SF_6, CHF_3 (HFC-23) and NF_3 are reported for category 2.E.1 Integrated Circuit or Semiconductor. Activity data about consumption of F-gases are available since 1997.

Emissions from this category are calculated using Tier 2a methodology described in IPCC 2006 Gl. (IPCC 2006), equation 6.2 without using fractions a_i and d_i, which are considered by expert judgement to be negligible and further using equation 6.3 for estimation of by-product emissions of CF_4. By-product emissions of CF_4 are reported together with regular CF_4 emissions.

The manufacturers of electrical equipment maintain very eco-friendly policies (involving treatment, training of staff, certificate etc.). Operational leakages are not measured (legislation does not force operators to do so) but can be estimated based on stock change. After a consultation with the main operator in the country the leakages are virtually non-existent and depend solely on accidents. Leakages represent less than 100 kg/yr in total. Such a low amount of SF_6 is not required to be reported from the operator into national database "Integrated system of reporting obligations" (*Integrovaný systém plnění ohlašovacích povinností* - ISPOP).

The emission factors employed are summarized in Tab. 4-29. The default emission factors for the gases HFC-23, CF_4, C_2F_6, SF_6 and NF_3 were chosen from IPCC, 2006, volume 3, part 2 Electronic Industry emissions, Table 6.3 (IPCC 2006).

Tab. 4-29 Emissions factors used for computations of 2016 emissions from 2.E.1 Integrated Circuit or Semiconductor

F-gas	2006 Guidelines (IPCC)			
	(1-Ui)	B_{CF4}	B_{C2F6}	B_{C3F8}
HFC-23 (CHF_3)	0.4	0.07	NA	NA
CF_4	0.9	NA	NA	NA
C_2F_6	0.6	0.2	NA	NA
SF_6	0.2	NA	NA	NA
NF_3	0.2	0.09	NA	NA

4.6.3 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006 Volume 1 Chapter 3 Uncertainties). Improvement of uncertainty estimation is in progress.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from 1997 when the use of CF_4 began to 2016.

4.6.4 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 directly from manufacturer with data obtained from Custom Office of the Czech Republic, ISPOP and Ministry of the Environment.

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

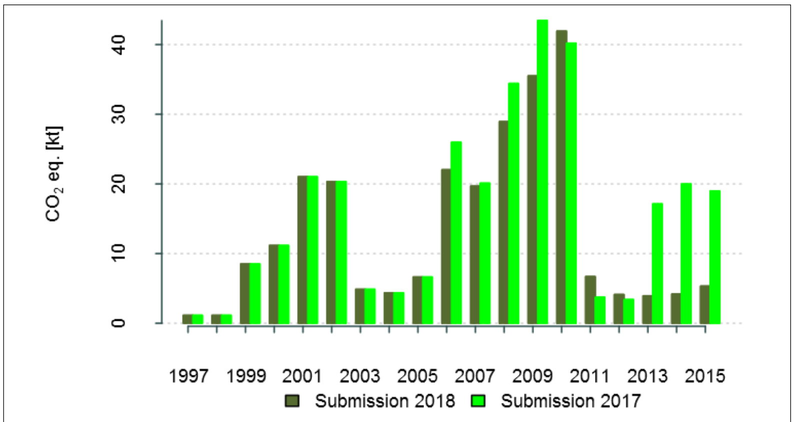

Fig. 4-10 Impact of the recalculation for category 2.E

For this submission, direct data were obtained from the manufacturer about the consumption of SF_6 and NF_3 for 2007-2016; these data were used for the emission estimates. The consumption of gases for 2006 was linearly interpolated. The impact of the recalculation on emissions from category 2.E.1 is shown in Fig. 4-10 and in Tab. 4-30

Tab. 4-30 Impact of the recalculation for category 2.E

CO_2 emission	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Submission 2017	[kt]	25.97	20.10	34.41	43.45	40.20	3.74	3.40	17.13	20.01	18.97
Submission 2018	[kt]	22.03	19.68	28.94	35.50	41.93	6.58	4.29	4.40	4.19	5.32
Difference	[%]	-15.18	-2.07	-15.89	-18.29	4.29	76.14	26.29	-74.31	-79.05	-71.95

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. Improvement of uncertainty estimation is in progress.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (ODS) (CRF 2.F)

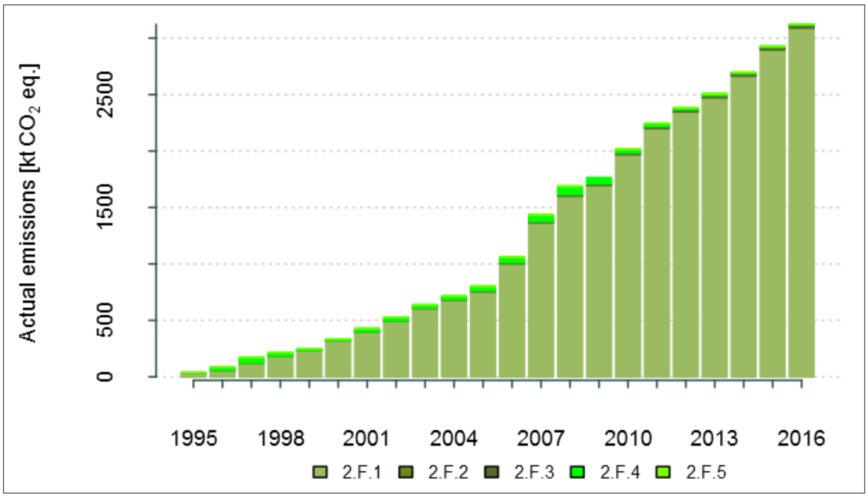

Fig. 4-11 Trend of emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances and share of specific subcategories [kt CO_2 eq.]

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.

The emission trend for category 2.F is depicted in Fig. 4-11. The major share of 98.87% in the range of actual emissions for year 2016 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 35.99 kt CO_2 eq. in 1995 to 3087.09 kt CO_2 eq. in 2016. This significant leap forward by orders of magnitude has been driven mainly by substantial increase in the use of HFCs in refrigeration.

Detailed information about actual emissions is given in Tab. 4-31 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. 4-31 Actual emissions of HFCs and PFCs in 1995 - 2016 [kt CO_2 eq.]

	Category 2.F - emissions of PFCs and HFCs [kt CO_2 eq.]		
	Emissions of PFCs and HFCs	Emissions of HFCs	Emissions of PFCs
1995	35.99	35.99	NO
1996	57.90	57.23	0.66
1997	121.58	121.00	0.58

Category 2.F - emissions of PFCs and HFCs [kt CO_2 eq.]			
	Emissions of PFCs and HFCs	Emissions of HFCs	Emissions of PFCs
1998	182.13	181.62	0.51
1999	232.18	231.32	0.86
2000	318.30	316.22	2.08
2001	396.07	392.72	3.34
2002	491.17	487.68	3.48
2003	604.36	597.67	6.70
2004	678.91	670.25	8.66
2005	752.87	743.51	9.36
2006	1000.90	991.07	9.83
2007	1364.27	1353.84	10.43
2008	1600.22	1588.52	11.71
2009	1694.34	1683.74	10.60
2010	1967.58	1959.80	7.79
2011	2199.05	2193.28	5.77
2012	2346.20	2341.46	4.73
2013	2471.18	2467.40	3.78
2014	2663.94	2661.40	2.53
2015	2894.43	2892.94	1.49
2016	3087.09	3086.10	0.99

Emissions of F-gases (HFCs, PFCs, SF_6, NF_3) 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. 4-32 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 2016.

Tab. 4-32 Type of emissions factors used for computations of 2016 emissions in category 2.F

	Reported emissions	Source or type EF	Methodology
2.F.1 Refrigeration and Air Conditioning	HFCs, PFCs	CS and Default (IPCC 2006)	Tier 2a
2.F.2 Foam Blowing Agents	HFCs	Default (IPCC 2006)	Tier 1a
2.F.3 Fire protection	HFCs, PFCs	Default (IPCC 2006)	Tier 1a
2.F.4 Aerosols	HFCs	Default (IPCC 2006)	Tier 1a
2.F.5 Solvents	HFCs	Default (IPCC 2006)	Tier 1a

Currently, the national F-gas inventory is based on the method of actual emissions, according to the IPCC 2006 Guidelines (IPCC 2006). In 2016, 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.

Data about direct import/export, use and destruction for subcategories under 2.F.are obtained from following sources:

- ISPOP ("Integrated system of reporting obligations"),
- The 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),
- The Customs Administration of the Czech Republic.

Collecting of data and preparation of input data for emission estimates are described in more detail in chapter 4.7.1.12. The description in chapter 4.7.1.12 is related to subcategory 2.F.1 but data sources and input data preparation are the same for each subcategory under 2.F.

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 and 2.F.1.f Stationary Air Conditioning.

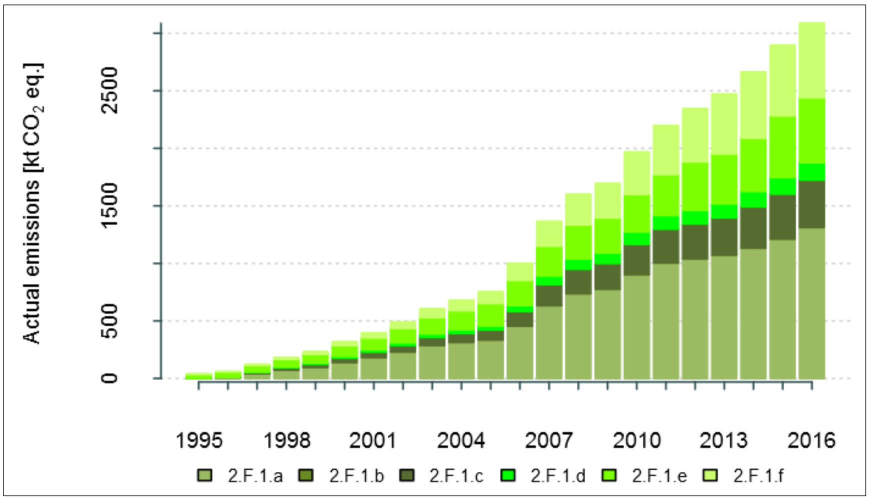

Fig. 4-12 Trend of emissions from 2.F.1 Refrigeration and Air conditioning and share of specific subcategories [kt CO_2 eq.]

The major share 42.49% in the range of actual emissions for year 2016 belongs to the subcategory 2.F.1.a, share 20.92% belongs to the subcategory 2.F.1.f, share 18.34% belongs to the subcategory 2.F.1.e, share 13.31% belongs to the 2.F.1.c., share 4.87% belongs to the 2.F.1.d and share 0.07% belongs to the 2.F.1.b. Trend of emissions from 2.F.1 is depicted on Fig. 4-12. 2.F.1 was identified as a key category in this submission.

A large number of blends are being used in refrigeration and air conditioning systems. Many blends contain HFCs and/or a limited amount of PFCs in various proportions. The main type of blend used in the Czech Republic for stationary air conditioning/refrigeration is R-410A, a mixture of HFC-32 and HFC-125 in a ratio of 50:50. Blends R-404A and R-407C are used in smaller amounts. R-404A contains HFC-125, HFC-143a and HFC-134a gases in a ratio of 44:52:4. This mixture is mainly used in commercial refrigeration. R-407C is a mixture of HFC-32, HFC-125 and HFC-134a in a ratio of 23:25:52. R-407C is used mainly in stationary air conditioning.

An overview of reported gases under specific subcategory is presented in Tab. 4-33. PFCs have not been used in the Czech Republic for many years, but emissions from previous use of PFCs still occur.

Tab. 4-33 An overview of the F-gases reported under subcategory 2.F.1

Source category	Reported F-gases
2.F.1.a Commercial Refrigeration	HFC-125, HFC-143a, HFC-23, HFC-134a, HFC-227ea, HFC-32, HFC-152a, C_6F_{14}, C_3F_8, C_2F_6
2.F.1.b Domestic Refrigeration	HFC-134a
2.F.1.c Industrial Refrigeration	HFC-32, HFC-125, HFC-134a, HFC-143a
2.F.1.d Transport Refrigeration	HFC-32, HFC-125, HFC-134a, HFC-143a
2.F.1.e Mobile Air Conditioning	HFC-134a
2.F.1.f Stationary Air Conditioning	HFC-32, HFC-125, HFC-134a, HFC-143a

In 2016 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 5.01 t of HFC-134a, 14.90 t of HFC-125, 2.61 t of HFC-143a, 2.40 t of HFC-32 and 0.23 t of SF_6. However in the next 5 years we can expect an increase in appliances disposal with a lifetime of about 20 years such as industrial refrigeration, residential and commercial air-conditioning etc. A mixture of retrieved cooling media is being incinerated in specialized facilities. In one case, the retrieved mixture of ODS is exported as a raw material for a different industrial processes than air-conditioning or refrigeration.

4.7.1.2 Methodological issues

Emissions from all subcategories under 2.F.1, except subcategory 2.F.1.e, are calculated by the Phoenix calculation model. Tier 2a methodology was used for emission estimates in all the subcategories under 2.F.1; the emission factors used for the estimation are in the default ranges proposed by IPCC 2006 (IPCC 2006).

2.F.1.a, 2.F.1.b, 2.F.1.c, 2.F.1.d, 2.F.1.f

Emissions from categories 2.F.1.a, 2.F.1.b, 2.F.1.c, 2.F.1.d, 2.F.1.f are calculated by calculation model Phoenix, which was introduced for the first time for submission 2017-2015.

The calculation model can be divided to four main parts: *input, divider, emission estimates and output*. For input, it is important to update the data on the consumption of F-gases, emission factors and legislative changes. The divider separates the input activity data into sub-applications, where division into the sub-applications is based on expert judgement. The emission estimates are fully automatic and calculate the emissions of refrigerant due to the charging process of new equipment, emissions during lifetime and emissions at the end of lifetime. The output provides information about total emissions under the sub-applications and overall emission trends for category 2.F.1.

INPUT

Input of the model consists of three parts, which are manually updated - activity data, emission factors and legislative measures. Data about direct import/export, use and destruction are obtained from following sources:

- ISPOP ("Integrated system of reporting obligations"),
- The 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),
- The Customs Administration of the Czech Republic.

ISPOP provides data about import, export, regeneration, destruction and first placing on the market of F-gases considering the EU market. The threshold for submitting data to ISPOP by importers, exporters and users is 0.1 metric tonne of F-gases. The F-gas register provides data about the imported, exported and disposed amounts of F-gases and also contains information about the average specific charge of equipment, amount of imported, exported or disposed equipment and information about specific use of the equipment. Information in the F-gas register is related to the trade between EU countries and non-

EU countries and the threshold for submitting data to the F-gas register is more than 1 metric tonne of F-gases. The threshold refers to the sum of F-gases, not each imported/exported gas separately. Customs data provides information about trading between the Czech Republic and the world market. These data provide information about imported/exported products and containers of fluorinated greenhouse gases; information is classified according to the combined nomenclature, which is regularly updated.

The worldwide market is covered in the inventory because the data sources cover trade between the Czech Republic and EU countries and also non-EU countries. In the case of ISPOP, the importers/exporters/users of F-gases also voluntarily report amounts of used F-gases below the threshold, which is 0.1 metric tonne for submitting data into ISPOP. The F-gas register contains data about imported/exported equipment with a charge of F-gases smaller than 3 kg. For example, 36 importers out of 47 reported information related to products with a charge of F-gases less than 3 kg in 2016. The remaining importers submitted data related to equipment charged with 3 kg or more of refrigerant. Data from the Customs Administration of the Czech Republic contains information related to the sum of specific gases imported/exported to/from the Czech Republic; in some cases, the amount is less than 3 kg of a specific gas. Verification of the data by each importer/exporter/user of F-gases in all the data sources is a very important step in the process of inventory preparation, because it is necessary to avoid double counting.

Addition to the stock of specific F-gas is calculated from the data mentioned above. Net consumption in the current year is calculated as import minus export and destruction. The calculation of an addition to the stock of F-gas takes into account the total amount of chemical banked in the previous year, new additions to the stock and subtraction of emissions.

Selection of emission factors should be based on the national information provided by manufacturers, service providers, disposal companies and other organizations. Collecting of such detailed information is very difficult under the current state of administration in the Czech Republic and thus the emission factors are based on the expert judgement and the emission factors are in the default ranges proposed by IPCC 2006 Gl., Table 7.9 (IPCC 2006). Emission factors used for emissions estimates are shown in Tab. 4-34.

Tab. 4-34 Parameters used for emission calculations for category 2.F.1 in 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	3.00	13.00	55.00	70.00
2.F.1.b Domestic Refrigeration	13.50	0.50	3.50	55.00	70.00
2.F.1.c Industrial Refrigeration	17.00	3.00	13.00	55.00	70.00
2.F.1.d Transport Refrigeration	8.50	0.50	20.00	55.00	30.00
2.F.1.f Stationary Air Conditioning	13.50	0.50	6.50	55.00	70.00

DIVIDER

Unfortunately, there is a lack of information about the specific use of gas obtained from the above sources and thus the calculation model must divide input data into sub-applications by a divider. The divider is shown in Tab. 4-35. The percentage share of each gas in the relevant sub-application is currently based on sectoral expert judgement, which is supported by the data obtained from Association of refrigeration and air conditioning.

The calculation model takes into account the phasing out or the phasing down of F-gases depending on the Montreal Protocol and national and regional regulation schedules, e.g. according to Regulation EU

No 517/2014, the F-gas HFC-134a cannot be longer used in domestic refrigeration since 2015, which means that the relative share of HFC-134a has been considered to be 0% since 2015.

Tab. 4-35 Distribution of HFCs and PFCs use by application area used for emission calculations in 2016

Reported F-gases	2.F.1.a Commercial Refrigeration	2.F.1.b Domestic Refrigeration	2.F.1.c Industrial Refrigeration	2.F.1.d Transport Refrigeration	2.F.1.f Stationary Air Conditioning
HFC-125	40%	x	15%	5%	40%
HFC-143a	60%	x	15%	5%	20%
HFC-23	100%	x	x	x	x
HFC-134a	60%	0%	15%	5%	20%
HFC-227ea	100%	x	x	x	x
HFC-32	40%	x	15%	5%	40%
HFC-152a	100%	x	x	x	x
C_6F_{14}	100%	x	x	x	x
C_3F_8,	100%	x	x	x	x
C_2F_6	100%	x	x	x	x

EMISSION ESTIMATES

Total emissions for individual F-gas are calculated as the sum of emissions from filling of new equipment E_{charge}, emissions during the equipment lifetime $E_{lifetime}$ and emissions at the system end of life $E_{end\ of\ life}$ in accordance with equation 7.10 described in IPCC 2006 Gl. Emissions from subcategories under 2.F.1 are calculated using Tier 2a Method (emission-factor approach) described in 2006 IPCC Gl., Vol. 3-2. The parameters used for emission estimates were established by an expert judgement and Table 7.9, 2006 in the input of the calculation model. Equations for emission calculation are in accordance with the equations described in the IPCC 2006 G. (Eq. 7.12, Eq. 7.13, and Eq. 7.14). 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.

OUTPUT

The output of the model represents an overview of F-gas emissions in sub-applications for the individual gases from 1995 to the latest year of the national inventory reporting and a total overview of emissions from category 2.F.1. Tab. 4-36 depicts emissions of F-gases for the individual sub-applications in 2016 and comparison with levels of emissions in 2015 and in the base year.

Tab. 4-36 Emissions of HFCs and PFCs from subcategories under 2.F.1 in 2016 – comparison to levels of emissions in 2015 and 1995

Source sub-application	Emissions of HFCs and PFCs 2016 [kt CO_2 eq.]	Difference 2016 and 2015 [%]	Emissions 2016/Emissions 1995 [-]	Total share in overall GHG emissions in 2016 without LULUCF [%]
2.F.1.a Commercial Refrigeration	1311.68	8.32	6568	1.06
2.F.1.b Domestic Refrigeration	2.18	-14.11	2490	0.00
2.F.1.c Industrial Refrigeration	410.86	5.56	8092	0.33
2.F.1.d Transport Refrigeration	150.46	4.39	6487	0.12
2.F.1.f Stationary Air Conditioning	645.85	5.65	20691	0.52

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 C_6F_{14}, 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. 4-37.

Tab. 4-37 Subcategories in which is used notation key NE for gases HFC-134a and HFC-32 with related year

Source category	Reported F-gas	Year
2.F.1.a Commercial Refrigeration	C_6F_{14}	2016
	HFC-134a	1996
	HFC-32	1998, 1999
2.F.1.b Domestic Refrigeration	HFC-134a	1996
2.F.1.c Industrial Refrigeration	HFC-32	1998, 1999, 2000
	HFC-134a	1996
	HFC-143a	1997
2.F.1.d Transport Refrigeration	HFC-32	1998
	HFC-134a	1996
2.F.1.f Stationary Air Conditioning	HFC-32	1998, 1999
	HFC-134a	1996

2.F.1.e

Beginning with this submission, emissions from subcategory 2.F.1.e are calculated separately from other subcategories under category 2.F.1. The main reason for this separation is the different approach to collecting activity data for the emission estimates. Emissions from filling new equipment, E_{charge}, emissions during the equipment lifetime, $E_{lifetime}$, and emissions at the end of life of the system, $E_{end\ of\ life}$, are calculated separately with different data-collecting approaches for cars, buses and trucks.

Emissions from filling new equipment

Data for emission estimates are obtained from the Automotive Industry Association. These data contain the production figures for the Czech automobile industry since 1995. Three car producers, two bus producers and one truck producer are currently operating in the Czech Republic. Approximately 60% of all new cars are produced by a single manufacturer.

Emission factors used for emission estimates for 2.F.1.e are shown in Tab. 4-38.

Tab. 4-38 Parameters used for emission calculations for subcategory 2.F.1.e

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.e Mobile air conditioning	15.00	0.50	20.00	10.00	30.00

Emissions from filling of new cars are calculated by following steps:

- Data about total production for each producer are obtained from the Automotive Industry Association.
- The initial charge of HFC-134a filled into new equipment is estimated for each producer. The initial charge is not constant through the time series because the calculation takes into account the types of cars produced in a given year. Estimation of the average initial charge for a producer in a given year is based on knowledge of the types of cars produced in the Czech Republic in the

given year and the charges for those specific types. The average initial charge decreased over the years from 780 g per unit to 480 g per unit.

- The percentage share of cars equipped with air conditioning through the time series is based on data from the main Czech car bazaar and expert judgement. The percentage share of car equipped with air conditioning is calculated for each producer separately.
- In 2016, producers started to use HFO R1234yf as a substitute for HFC-134a in accordance with the preparation of Phase 3 of Directive 2006/40/EC. HFC-134a is filled into cars which are intended for the non-EU market. The share of cars that were intended for the non-EU market was calculated on the basis of data from the producers' yearbooks and these data have been used for emission estimates since 2016.
- The amount of HFC-134a filled into new cars by the producer in a given year is calculated as: *Amount of HFC-134a $_t$ = Production $_t$ * Average initial charge $_t$ * Average percentage share of cars with AC $_t$*. Since 2016, the calculation has also taken into account transition to the use of alternative refrigerant. The total amount of HFC-134a filled into the new cars produced in the Czech Republic is calculated as the sum of the amounts used by each producer.
- The emissions are calculated according Eq. 7.12 described in IPCC 2006 Gl. The emission factors are in the default ranges proposed in Table 7.9 IPCC 2006 Gl. (IPCC 2006).

Emissions from filling of new buses and trucks are calculated by the following steps:

- Data about the total production for each producer are obtained from the Automotive Industry Association.
- The initial charge of HFC-134a filled into new equipment is considered to be 10 kg per bus and 1.2 kg per truck.
- The percentage share of new buses and trucks equipped with AC is linearly interpolated from 50% in 1995 to 100% in 2014; since 2014, it has been assumed that all buses and trucks are manufactured with air conditioning. Unfortunately, there is a lack of detailed information from producers and thus the percentage share is based on expert judgement, which is based on emission estimates in neighbouring countries and the conditions in the Czech Republic.
- The amount of HFC-134a filled into new buses and trucks in a given year is calculated separately as: *Amount of HFC-134a $_t$ = Production $_t$ * Initial charge * Percentage share of buses/trucks with AC $_t$*. The total amount of HFC-134a filled into new buses and trucks produced in the Czech Republic is calculated as the sum of the amounts used for filling new buses and trucks.
- Emissions are calculated according Eq. 7.12 described in IPCC 2006 Gl. The emission factors are in the default ranges proposed in Table 7.9 IPCC 2006 Gl. (IPCC 2006).

<u>Emissions during the equipment lifetime</u>

Emissions are calculated separately for cars, buses and trucks. Operational emissions for cars are calculated as follows:

- Data about the Czech car fleet were obtained for 1995-2009 from the Automotive Industry Association and, since 2010, from the Ministry of Transport. The data contain information about the numbers of registered cars classified according to age into 4 groups: less than 2 years, 2-5 years, 5-10 years and more than 10 years. These data are then used for emission estimates.
- The number of cars equipped with air conditioning is calculated for each age group separately. For example, in 1995 approximately 2 million of cars were more than 10 years old. The percentage share of cars with air conditioning is estimated as 0% in this age group because it is assumed that, before 1985, air conditioning was rarely used in passenger cars and HFC-134a gas wasn't introduced in the Czech Republic until the 1990's. In 2005, approximately 850,000 cars were between 5-10 years old. The number of cars with air conditioning in this group is estimated as the total number of cars in the group multiplied by the average percentage share of cars with air conditioning between 1996 and 2000. The percentage time series of cars with air conditioning is based on data from the main Czech car bazaar and expert judgement.

- The specific charge for the year is estimated as 0.7 kg per unit for 1995-2005, 0.65 kg per unit for 2006-2008 and, since 2008, 0.6 kg per unit. The lower charges are a result of transformation of the car fleet.
- The refrigerant stocks are calculated for each age group as: *HFC-134 stock*$_t$ *= Number of cars equipped with air conditioning*$_t$ ** charge*$_t$. Total stocks are calculated as the sum of stocks for all age groups.
- Emissions are calculated according Eq. 7.13 described in IPCC 2006 Gl. The emission factors are in the default ranges proposed in Table 7.9 IPCC 2006 Gl. (IPCC 2006).

Operation emissions for buses and trucks are calculated by the following steps:

- The numbers of buses and trucks have been obtained from the Automotive Industry Association since 1995.
- The percentage share of bus equipment with air conditioning is linearly interpolated from 10% in 1995 to 60% in 2016; the percentage share of trucks equipped with air conditioning is linearly interpolated from 50% in 1995 to 90% in 2016. There is a lack of detailed information for emissions from filling new buses and trucks and thus the percentage share is based on expert judgement, which is based on the emission estimates of neighbouring countries and the conditions in the Czech Republic. The specific charge of HFC-134a filled into the equipment is estimated as 10 kg per bus and 1.2 kg per truck.
- The refrigerant stocks are calculated separately for buses and trucks as: *HFC-134 stock* $_t$ *= Number of buses/trucks with air conditioning* $_t$ ** specific charge.* The total stock of HFC-134a in buses and trucks in the Czech Republic is calculated as the sum of stocks for buses and trucks.
- The emissions are calculated according Eq. 7.13 described in IPCC 2006 Gl. The emission factors are in the default ranges proposed in Table 7.9 IPCC 2006 Gl. (IPCC 2006).

Emissions at the system end of life

Emissions at the system end of life are calculated by the following steps:

- The numbers of disposed vehicles are obtained from the Car Importers Association.
- The average vehicle lifetime is estimated as 15 years. The estimation is based on information from the Car Importers Association, the Automotive Industry Association and the Ministry of Transport.
- The percentage time series of cars with air conditioning is based on data from the main Czech car bazaar and expert judgement and is the same as for the estimation of operational emissions.
- The specific charge of refrigerant is the same as for the estimation of operational emissions (0.7 kg per unit for 1995-2005, 0.65 kg per unit for 2006-2008 and 0.6 kg per unit since 2008).
- The amount of disposed refrigerant is calculated as: *HFC-134a disposed* $_t$ *= Number of disposed vehicles* $_t$ ** percentage share of cars with air conditioning* $_{t-average\ lifetime}$ ** charge* $_{t-average\ lifetime}$
- The emissions are calculated according Eq. 7.14 described in IPCC 2006 Gl. The emission factors are in the default ranges proposed in Table 7.9 IPCC 2006 Gl. (IPCC 2006).

Tab. 4-39 gives the emissions of F-gases from mobile air conditioning units in 2016 and comparison with emission levels in 2015 and in the base year.

Tab. 4-39 Emissions of HFCs and PFCs from 2.F.e in 2016 – comparison to emission levels in 2015 and 1995

Source sub-application	Emissions of HFCs and PFCs 2016 [kt CO_2 eq.]	Difference 2016 and 2015 [%]	Emissions 2016/Emissions 1995 [-]	Total share in overall GHG emissions in 2016 without LULUCF [%]
2.F.1.e Mobile air conditioning	566.05	5.56	16	0.38

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 2016.

Increased amount of emissions from category 2.F.2 in 2016 is driven by emissions from disposal of HFC-134a. Deafult product lifetime is 20 years which means that emissions from disposal started to be accounted in inventory since 2015. In 1995, small amount of HFC-134a was used in category 2.F.2 and thus emissions from disposal in 2015 were not so significant. The amount of HFC-134a used in 1996 was approximately 77 times higher than in 1995 and thus emissions from disposal in 2016 are higher comparing to 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 0.20% in 2016.

4.7.2.1 Methodological issues

Emissions from this category are calculated by default methodology and EF described in IPCC, 2006 equation 7.7 for foam blowing.

4.7.3 Fire Protection (CRF 2.F.3)

Emissions from following gases are occurring in category 2.F.3 Fire protection: HFC-227ea, HFC-236fa, C_3F_8 (only from stocks and disposal). The share of this category in the total actual emissions from 2.F was 0.76% in 2016.

4.7.3.1 Methodological issues

Emissions from this category are calculated on the basis of IPCC 2006 Gl., equation 7.17 (IPCC 2006). 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)

The use of HFC-134a in metered dose inhalers was not reported in the Czech Republic in 2016. The contribution of this category to the total actual 2.F emissions equals to 0.12% in 2016.

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 during 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 2016. HFC-245fa was relocated to the category 2.F.5 in previous submission. 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 0.05% in 2016.

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). The uncertainties for the activity data are at level 37% and 23% for the emission factors. 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 input information and calculations are archived by the sectoral experts and the coordinator of NIS.

QA/QC and verification are provided for the activity data, emission factors and emission estimates:

- The activity data for all the subcategories under 2.F, except subcategory 2.F.1.e, are obtained from ISPOP, the F-gas register and the Customs Administration of the Czech Republic. Verification of the activity data is conducted by comparison of the data received from the mentioned sources to ensure that no double counting occurs. Verification of the activity data for subcategory 2.F.1.e is ensured by comparison of the data obtained from the Automotive Industry Association and the Car Importers Association. Estimated inputs of HFC-134a used in mobile air conditioning are compared with the data obtained from the latest NIRs for neighbouring countries with similar transportation status. All inputs for emission estimates are checked by external QA/QC staff members.
- Selection of the emission factors for emission estimates is currently based on expert judgement. All the emission factors are default or in the default ranges proposed by IPPC 2006 Gl. For category 2.F.1, the emission factors are verified by comparison with the emission factors for neighbouring countries and for countries with a similar status of refrigeration and air conditioning use.

Quality control was performed by completion of the QA/QC form in Annex 5 by a responsible compiler (autocontrol) and then by QA/QC staff members.

4.7.8 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

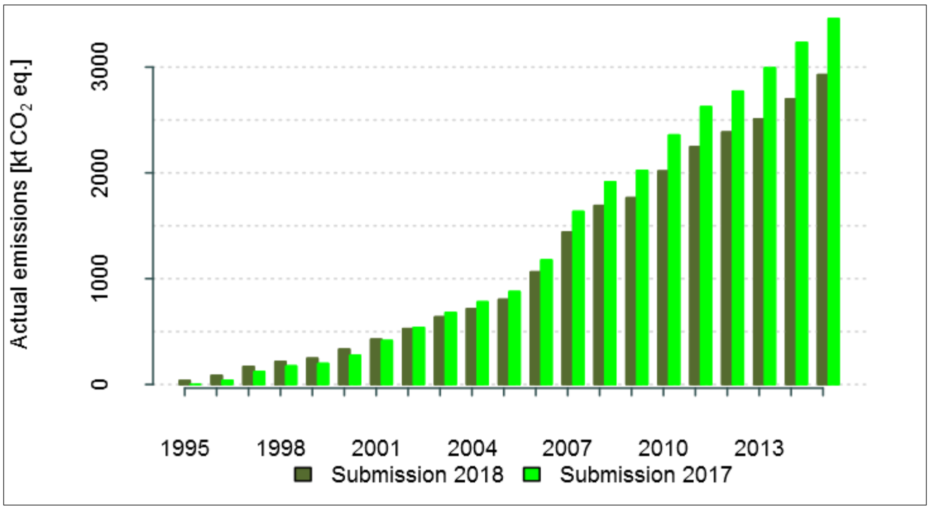

Fig. 4-13 Impact of the recalculation in category 2.F

Initial emission factors for subcategories 2.F.1.a and 2.F.1.c were revised to 3% and operation emission factors for subcategories 2.F.1.b, 2.F.1.c and 2.F.1.d were revised to 3.5%, 13% and 20%, respectively. Emission estimates were calculated using the revised emission factors.

Subcategory 2.F.1.e Mobile Air Conditioning was recalculated as a result of methodology changes in the collection of activity data. The activity data are obtained from the statistics of the Ministry of the Interior of the Czech Republic, the Ministry of Transport of the Czech Republic, the Automotive Industry Association, the Car Importers Association and data from the Czech car bazaar. Emissions from filling, from stocks and from disposal are calculated separately using calculated data from the sources mentioned above. The lifetimes of the cars were revised to 15 years using the data obtained from the Car Importers Association, the Automotive Industry Association and the Ministry of Transport. The operational emission factor was revised to 20%.

During the QC procedures, an error was discovered in the Phoenix computation model for category 2.F.1.f. The error was corrected and the emissions were recalculated.

The impact of the recalculation on the total emissions for category 2.F is shown in Tab. 4-40 and Fig. 4-13.

Tab. 4-40 Impact of the recalculation in category 2.F

F-gas emissions	Unit	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Submission 2017	[kt CO_2 eq.]	0.33	38.70	120.55	174.06	197.38	275.02	414.37	537.77	678.52	779.70	877.12
Submission 2018	[kt CO_2 eq.]	36.01	84.88	169.26	215.26	247.08	332.75	426.96	526.53	637.20	715.71	802.49
Difference	[%]	10960	119.34	40.40	23.67	25.18	20.99	3.04	-2.09	-6.09	-8.21	-8.51

F-gas emissions	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Submission 2017	[kt CO_2 eq.]	1176.33	1634.19	1913.86	2021.43	2356.78	2624.56	2770.75	2992.82	3232.09	3456.60
Submission 2018	[kt CO_2 eq.]	1062.85	1439.55	1690.49	1763.62	2016.65	2246.16	2384.93	2509.19	2698.25	2927.20
Difference	[%]	-9.65	-11.91	-11.67	-12.75	-14.43	-14.42	-13.92	-16.16	-16.52	-15.32

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 sectoral expert judgement, 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.

4.8 Other Product Manufacture and Use (CRF 2.G)

This category describes GHG emissions from the following categories: 2.G.1 Electrical Equipment, 2.G.2 SF_6 and PFCs from Other Product Use, 2.G.3 N_2O from Product Uses and Category 2.G.4 Other. Under the 2.G. category are reported SF_6 and N_2O emissions.

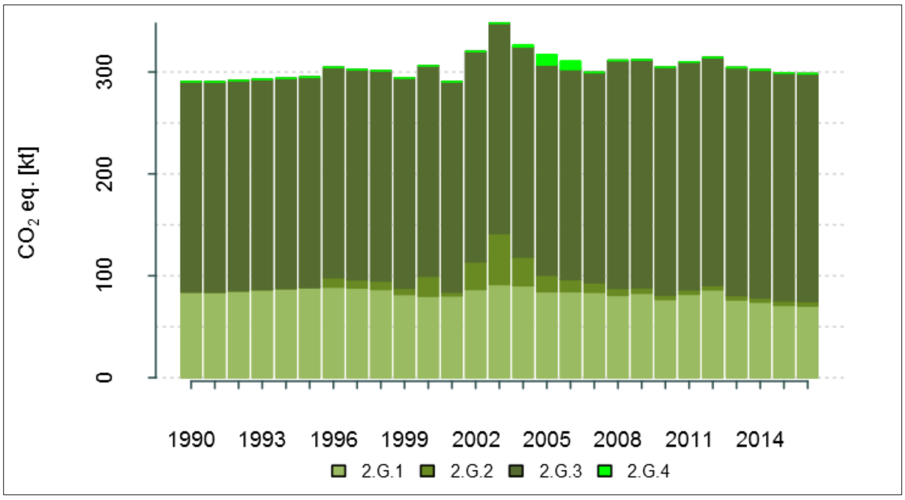

Fig. 4-14 Trend of emissions from 2.G Other Product Manufacture and Use and share of specific subcategories [kt CO_2 eq.]

The emission trend for category 2.G is depicted in Fig. 4-14. The major share of 74.92% of GHG emissions for year 2016 belongs to category 2.G.3 and the share 23.60% belongs to category 2.G.1. Total GHG emissions from 2.G were lower by 0.73 kt CO_2 eq. in 2016 compared to the previous year.

Tab. 4-41 lists the exact amount of CO_2 emissions from the individual subcategories in 2.G. Other Product Manufacture and Use for the 1990 to 2016 period.

Tab. 4-41 CO_2 eq. emissions in individual subcategories in 2.G Other Product Manufacture and Use category in 1990-2016

	Category 2.G - emissions [kt CO_2 eq.]			
	2.G.1 Electrical Equipment	2.G.2 SF_6 and PFCs from Other Product Use	2.G.3 N_2O from Product Uses	2.G.4 Other
1990	84.10	0.14	206.22	NO
1991	83.94	0.14	206.22	NO
1992	85.23	0.18	206.22	NO
1993	86.40	0.16	206.22	NO
1994	87.48	0.18	206.22	NO
1995	88.47	0.21	206.22	NO
1996	89.03	9.28	206.22	NO
1997	88.12	7.98	206.22	NO
1998	86.71	8.27	206.22	NO
1999	81.76	6.16	206.22	NO
2000	80.09	19.73	206.22	NO
2001	80.47	3.70	206.22	NO
2002	86.72	27.12	206.22	NO
2003	91.59	50.07	206.22	NO

	Category 2.G - emissions [kt CO_2 eq.]			
	2.G.1 Electrical Equipment	2.G.2 SF_6 and PFCs from Other Product Use	2.G.3 N_2O from Product Uses	2.G.4 Other
2004	90.36	28.13	206.22	1.89
2005	84.46	16.38	206.22	9.87
2006	84.58	11.77	206.22	7.98
2007	83.96	9.37	206.22	NO
2008	80.91	6.86	223.50	NO
2009	82.99	5.39	223.50	NO
2010	76.84	4.35	223.50	NO
2011	82.03	4.36	223.50	NO
2012	86.31	4.33	223.50	NO
2013	76.50	4.29	223.50	NO
2014	74.28	4.26	223.50	NO
2015	71.08	4.46	223.50	NO
2016	70.41	4.40	223.50	NO

Tab. 4-42 gives an overview of the emission factors and methodology used for computations of emissions in category 2.G for year 2016.

Tab. 4-42 Type of emissions factors used for computations of 2016 emissions in category 2.G Other Product Manufacture and Use

	Reported emissions	Source or type EF	Methodology
2.G.1 Electrical Equipment	SF_6	Default (IPCC 2006)	T1
2.G.2 SF_6 and PFCs from Other Product Use	SF_6	Default (IPCC 2006)	D
2.G.3 N_2O from Product Uses	N_2O	Default (IPCC 2006)	D

4.8.1 Electrical Equipment (2.G.1)

4.8.1.1 Source category description

This subcategory is divided into Medium Voltage (MV) Electrical equipment (< 52 kV) and High Voltage (HV) Electrical Equipment (> 52 kV) containing SF_6. The division into the two groups was based on data from two 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.

Data about consumption of SF_6 in electrical equipment are obtained from ISPOP, the F-gas register and data from the Customs Administration of the Czech Republic. SF_6 for use in electrical equipment is mainly imported as part of the equipment, which is filled below operational amount. First servicing could be then considered as "first fill". Bulk imports are mostly being transferred for the purpose of operational stock-in-trade.

4.8.1.2 Methodological issues

Emissions from this category are calculated in line with IPCC 2006 Gl., specifically Equation 8.1, which is called the Tier 1 method. Emissions for MV Electrical equipment and HV Electrical Equipment were estimated separately using default emission factors (Table 8.2, 2006 IPCC Gl., Vol. 3-2 for MV Switchgear, Table 8.3, 2006 IPCC Gl., Vol. 3-2 for HV Switchgear). The CRF reporter does not allow separation of the subcategory 2.G.1 Electrical equipment into two groups. Emissions of SF_6 from MV Electrical equipment and HV Electrical Equipment are reported collectively.

Operational leakage is not measured (legislation does not force operators to do so) but operators usually distinguish between amount of SF_6 used for servicing or filling to new equipment. According to consultations with the main operator in the country, the leakage is virtually non-existent and depends solely on accidents; leakage usually remains below 100 kg p.a. in total. Such a low amount of SF_6 does not even require the operator to report SF_6 usage in ISPOP.

SF_6 for use in electrical equipment is mainly imported as the part of the equipment which is filled below the operational amount. First servicing is then considered as "first fill". Bulk imports are mostly imported for the purpose of operational stock-in-trade.

4.8.1.3 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006 Volume 1 Chapter 3 Uncertainties). Improvement of uncertainty estimation is in progress.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2016.

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.

Verification of the activity data for subcategory 2.G.1. is performed by comparison of the data obtained from ISPOP, from the F-gas register and from the Customs Administration of the Czech Republic.

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

No recalculation was performed in this submission.

4.8.1.6 Source -specific planned improvements, including tracking of those identified in the review process

In further submissions it is planned to contact other facilities for energy transmission and distribution to verify the current division of activity data into MV and HV electrical equipment or update this division to more accurate version.

4.8.2 SF_6 and PFCs from Other Product Use (CRF 2.G.2)

4.8.2.1 Source category description

This category includes emission estimates from double-glazed sound-proof window (2.G.2.c) and from accelerators use (2.G.2.b). SF_6 was used for manufacturing sound-proof windows in the Czech Republic during 1996-2009. The use of SF_6 for sound-proof windows manufacturing reached a maximum during 2002-2004, with the highest consumption in 2003. Higher consumption of SF_6 during these years led to an increase in emissions from manufacturing. Then SF_6 started to be replaced by nitrogen and argon. The lifetime of windows filled with SF_6 is assumed to be 25 years, which means that emissions are now occurring only from stocks.

The survey of other uses of SF_6 was undertaken for this submission. Category 2.G.2.b Accelerators has been newly added to the submission. In the Czech Republic, accelerators are used in radiotherapy centres and one accelerator containing SF_6 is used in a research institute (UJV Řež, Tandetron). Data about the total number of accelerators used for radiotherapy treatment is obtained from the Institute of Health Information and Statistics of the Czech Republic. According to the data, hospitals and radiotherapy centres were equipped with 53 accelerators in 2016.

For this submission, the main shoe producers were contacted to obtain information about the amount of SF_6 used in the production of shoe soles. According the data, SF_6 is not used by shoe manufacturers in the Czech Republic.

4.8.2.2 Methodological issues

SF_6 emissions from soundproof windows

Emissions from this category (Sound-proof glazing) are calculated in line with IPCC 2006 Gl., specifically Equation 8.20, 8.21 and 8.22.

SF_6 emissions from accelerators

Data about the total number of accelerators used in radiotherapy treatment have been obtained from the Institute of Health Information and Statistics of the Czech Republic since 1990. Unfortunately, the data do not differentiate accelerators using SF_6. To avoid underestimation of emissions, we used a conservative estimate and assume that every medical accelerator uses SF_6. Emissions are calculated according to Tier 1 methodology, Eq. 8.18 with default charge factor 0.5 kg and emission factor 2 kg/kg SF_6 charge.

Tandetron is a research particle accelerator. Detailed information about SF_6 was obtained directly from the research institute. According to the research institute, leakages of SF_6 were negligible during the 12 years of operation. During the year, SF_6 can leak into the atmosphere only during regular checks of the installation and this leak is estimated at 6.17 g SF_6 per year.

Total SF_6 emissions reported in 2.G.2.b Accelerators are calculated as the sum of emissions from medical accelerators and the Tandetron research accelerator.

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 2016.

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. 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

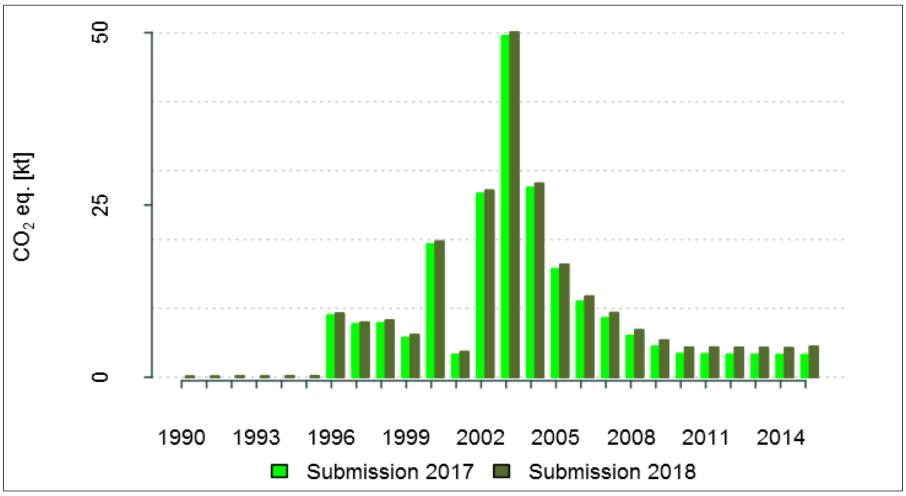

Fig. 4-15 Impact of the recalculation in category 2.G.2

A survey of other uses of SF_6 was undertaken for this submission. New source category 2.G.2.b Accelerators was added to the CRF with description in NIR. During the survey, it was confirmed that SF_6 is not used in shoe production in the Czech Republic. Impact of the recalculation on emissions from category 2.G.2 is shown on Fig. 4-15 and in Tab. 4-43.

Tab. 4-43 Impact of the recalculation in category 2.G.2

CO_2 emissions	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2017	[kt]	290.32	290.15	291.44	292.62	293.70	294.69	304.27	302.05	300.78	293.73
Submission 2018	[kt]	290.46	290.29	291.62	292.78	293.88	294.90	304.52	302.32	301.19	294.14
Difference	[%]	0.05	0.05	0.06	0.05	0.06	0.07	0.08	0.09	0.14	0.14
CO_2 emissions	**Unit**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Submission 2017	[kt]	305.63	289.98	319.58	347.38	325.99	316.27	309.77	298.76	310.42	310.94
Submission 2018	[kt]	306.04	290.39	320.06	347.88	326.61	316.93	310.54	299.55	311.27	311.88
Difference	[%]	0.13	0.14	0.15	0.14	0.19	0.21	0.25	0.27	0.27	0.30
CO_2 emissions	**Unit**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**				
Submission 2017	[kt]	303.73	308.89	313.13	303.28	301.04	297.81				
Submission 2018	[kt]	304.69	309.89	314.14	304.29	302.04	299.04				
Difference	[%]	0.32	0.32	0.32	0.33	0.33	0.41				

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

The survey of other uses of SF_6 will continue. For future submissions, it is planned to investigate the use of SF_6 in accelerators in more detail. Unfortunately, due to the current state of data confidentiality in the military sector, it is assumed that data about the consumption of SF_6 in military applications will not be provided to the sectoral expert for emission estimates but effort will be exerted in the survey.

4.8.3 N_2O from Product Uses (CRF 2.G.3)

4.8.3.1 Source category description

This category (2.G.3) includes N_2O emissions from the use of this substance in the food industry (aerosol cans) and in health care (anaesthesia).

4.8.3.2 Methodological issues

The calculation of emissions from this category, are based on IPCC, 2006, Volume 3 Chapter 8 equation 8.24. These not very significant emissions corresponding to 0.75 kt N_2O were derived from production in the Czech Republic (0.6 kt N_2O) and from import of N_2O (0.15 kt N_2O), see (Markvart and Bernauer, 2010-2013 and Bernauer and Markvart 2014-2016).

So far, in the Czech Republic, no relevant data have been available to distinguish between N_2O used in anaesthesia and for aerosol cans. Therefore, the existing split (50% for anaesthesia) was based only on a rough estimate.

4.8.3.3 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see Guidelines IPCC, 2006 Volume 1 Chapter 3 Uncertainties). Improvement of uncertainty estimation is in progress.

Uncertainties for activity data in this category at the level of 50% were estimated. No uncertainty was determined for the emission factor since we assumed that all the gas is emitted (the emission factor is equal 1 t/t N_2O). Overall uncertainty data are given in Chapter 1.7.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2016.

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.

The quality control was held by fulfilling the QA/QC form presented in Annex 5.

4.8.3.5 Source-specific recalculations, including changes made in response to the review process

In this year, no recalculations were performed in this sector.

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

In further submissions it is planned to collect activity data about the amount of N_2O imported into the Czech Republic and investigate the division of activity data according their use.

4.8.4 Other (CRF 2.G.4)

4.8.4.1 Source category description

This category includes estimated emissions from the experimental use of SF_6 under laboratory conditions. The experiment started in 2004 and lasted two years, which means that emissions occurred only in 2004-2006.

4.8.4.2 Methodological issues

The amount of SF_6 used in the experiments is investigated every year in data obtained from ISPOP, the F-gas register and from the Customs Administration of the Czech Republic. In the data set, research institutes are selected and, if the data contains information about an imported amount of SF_6, the research institutes are contacted for more detailed information.

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.

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 the Czech Ministry of Environment for providing the EU ETS data and data from the F-gas register.

The authors would like namely thank to Mr. Beck, Mr. Bernauer and Mr. Řeháček for their contribution during the inventory preparation as consultants and for final QC/QA checks.

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 land covers 54 %, arable land 30 % of the country area. The Czech agriculture is affected by communistic history of the country when the small farmers were almost eliminated by the collectivization process after World War II. Unfortunately the period with cooperative ownership and without any small family farms stretched for too long and only very few original farmers started managing their the farms again in the 90s. At this point, 90 % of agricultural land is rented and farms smaller than 50 ha occupy 8 % of agricultural land only.

Czech Republic is located in the cool climate zone (annual average temperature 7.8^{o} C). It is considered to be among the developed Western European countries.

Agricultural greenhouse gas emissions under Czech national conditions consist mainly of emissions from enteric fermentation (CH_4 emissions only), manure management (CH_4 and N_2O emissions), agricultural soils (N_2O emissions only), urea application and liming (CO_2 emissions only). The other IPCC subcategories – rice cultivation, prescribed burning of savannahs, field burning of agricultural residues and “other” – do not occur in 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 (mostly cattle in the Czech Republic). Other part of methane emissions is derived from manure 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[1].

Nitrous oxide emissions are formed mainly by nitrification and denitrification processes in the 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, sewage sludge application into the soils, nitrogen contained in parts of agricultural crops that are returned to the soil and N mineralized into the soils. In addition, emissions are also included from storage facilities and manure fertilizer management and indirect emissions derived from atmospheric deposition and from nitrogenous substances leached into water courses and reservoirs.

[1] *The reporting of ammonia emissions is coordinated and managed by CHMI under the supervision of the Ministry of the Environment. For national estimation of ammonia from animal husbandry the Tier 2 approach is used according the 3B manure management EMEP/EPA emission inventory guidebook 2013 update July 2014. Ammonia emissions from synthetic fertilizer application are estimated according to the methodology and emission factors used for the GAINS model. Emission factors for urea and other N fertilizers are based on average values provided by agricultural research.*

Carbon oxide emissions are derived from utilizing of non-organic fertilization on the agricultural soils based on the industrial produced urea and the limestone and dolomite application to the soils.

5.1.1 Key categories

There are six categories of sources evaluated by analysis described in IPCC Guidelines (IPCC 2006) as key categories in Agricultural sector. 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 (submission 2016), assessed without considering LULUCF

Category	Gas	KC A1	KC A2	KC A1[1]	KC A1[2]	KC A2[1]	KC A2[2]	% of total GHG[1]	% of total GHG [2]
3.A Enteric Fermentation	CH_4	LA, TA	LA, TA	yes	yes	yes	yes	2.37	2.27
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	LA	LA, TA	yes	yes	yes	yes	2.21	2.12
3.B Manure Management	N_2O	LA,TA	LA	yes	yes	yes	yes	0.67	0.64
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	LA	LA, TA	yes	yes	yes		0.67	0.65
3.B Manure Management	CH_4	LA		yes	yes			0.59	0.57
3.G Liming	CO_2	TA		yes				0.13	0.13

KC: key category
[1] including LULUCF
[2] excluding LULUCF

5.1.2 Quantitative overview

Agriculture is the third largest sector in the Czech Republic producing 6.82% total GHG emissions incl. LULUCF (6.54 % excl. LULUCF) in 2016 with 8519.68 kt CO_2 eq.; 42 % of emissions came from Managed Agricultural Soils, 34 % from Enteric Fermentation and 19 % from Manure Management. Carbon dioxide emissions from liming and urea application on managed soils contribute 4 % of the total agricultural emissions in 2016. The share of emissions categories on the total emissions is almost the same in 2015 and 2016. During the period 1990 - 2016, the total emissions from Agriculture decreased by about 47 %. 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 period 1990-2016 (sorted by categories)

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Managed soils (3.D)	Liming (3.G)	Urea Application (3.H)
			Unit [kt CO_2 eq.]			
1990	15 898	5 755	3 315	5 532	1 188	109
1991	13 703	5 430	3 170	4 655	316	132
1992	11 859	4 862	2 957	3 823	109	109
1993	10 466	4 211	2 694	3 364	104	93
1994	9 531	3 688	2 362	3 285	104	91
1995	9 588	3 588	2 305	3 474	111	109
1996	9 297	3 551	2 264	3 268	113	100
1997	8 889	3 319	2 170	3 239	93	67
1998	8 524	3 106	2 085	3 099	91	143
1999	8 595	3 175	2 117	3 128	88	88
2000	8 371	3 048	2 042	3 121	113	48
2001	8 493	3 071	2 003	3 236	105	77
2002	8 293	3 005	2 011	3 113	100	64

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Managed soils (3.D)	Liming (3.G)	Urea Application (3.H)
			Unit [kt CO_2 eq.]			
2003	7 866	2 972	1 997	2 757	79	61
2004	8 090	2 906	1 903	3 134	77	70
2005	7 803	2 848	1 836	2 980	65	74
2006	7 670	2 807	1 810	2 893	78	83
2007	7 843	2 837	1 813	2 992	80	122
2008	7 992	2 868	1 762	3 166	96	100
2009	7 584	2 800	1 635	2 999	65	85
2010	7 412	2 720	1 581	2 937	62	111
2011	7 586	2 726	1 531	3 137	81	111
2012	7 581	2 759	1 499	3 072	117	136
2013	7 765	2 759	1 523	3 221	137	126
2014	7 959	2 817	1 532	3 401	152	57
2015	8 158	2 896	1 554	3 357	164	187
2016	8 520	2 957	1 580	3 603	168	211

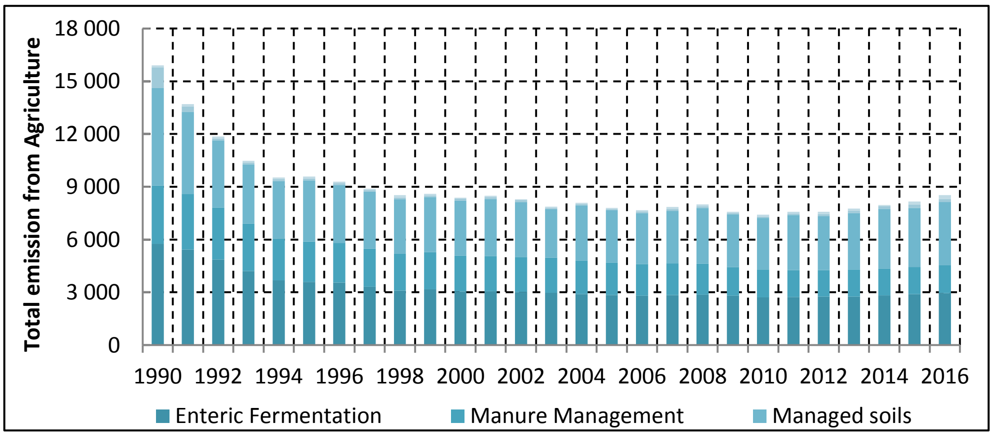

Fig. 5-1 The emission trend of agricultural sector in period 1990-2016 (in Gg CO_2 eq.)

The sum of emissions from agriculture in the Czech Republic culminated in 1990 (100 %), the lowest emissions were estimated in 2010 (47 % of the total emission in 1990). The reason of the relatively significant decrease after 1990 was the decreasing of population of livestock. The total emissions are relatively stable from 1997 till 2016 when they are fluctuating ± 10% with the lowest values being in 2010. While the Enteric fermentation and Manure management sources are relatively stable for more than 10 years, Management of agricultural soils and Application of limestone and dolomite have been increasing from 2006. In 2015 and 2016 the consumption of Urea was the highest in the history of NIR. The trend of shares within sector´s categories in relative share is shown in Tab 5-3.

Tab. 5-3 Emissions categories expressed in relative shares with respect to 1990 (year 1990 is stated as 100 %).

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Managed soils (3.D)	Liming (3.G)	Urea Application (3.H)
			Relative share [%]			
1990	100	100	100	100	100	100
1995	60	62	69	63	9	101
2000	53	53	61	56	10	44
2005	49	49	55	54	5	68
2010	47	47	47	53	5	103
2015	51	50	47	61	14	172
2016	54	51	47	65	14	194

An overview of the last recalculations is given in Chapter 10. The methodology used is in accordance with the IPCC 2006 Guidelines (IPCC 2006). According to recommendations and requests of TERT and ERT reviews several improvements were implemented in the current NIR (Submission 2018). The recalculations were performed for the entire period 1990-2016. These improvements and methodological changes have resulted in a decrease of total emissions in agricultural sector for 4 % if it compared to the previous NIR submission (Submission 2017). A detailed description of GHG emission estimation in the Czech Republic is presented in the following chapters.

5.1.3 General 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 1.2. 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. Czech University of Life Sciences, Institute of Animal Science Prague, Crop Research Institute, Research Institute for Cattle Breeding, Research Institute of Agricultural Engineering, Institute of Agricultural Economics and Information are additional institutions contributing information used in the sector of Agriculture. Slovak NIR experts responsible for agricultural sector (Slovak Hydro-meteorological Institute, SHMI) closely cooperate in the inventory methods and potential improvements.

The 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, is necessary to check (e.g. comparison of country specific and default value):

- 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 of activity data, emission factors and 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 and verified by other IFER experts. Some more specific parameters, which are 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) is 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 is transferred to the CRF Reporter, where the data is once again technically verified. The 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.

More precise information about QA/QC procedures is available in relevant subchapters.

5.2 Livestock (CRF 3.1)

The methods for estimating CH_4 and N_2O emissions from enteric fermentation and manure management of livestock require definitions of livestock sub-categories and their annual populations (see Tab. 5-4) and, for higher Tier 2 methods used for cattle, also feed intake and other zoo-technical characteristics. A coordinated livestock characterization was used to ensure consistency across the following source categories for the whole emission inventory. Czech Statistical Yearbook is the source of population data for livestock categories.

Tab. 5-4 Trends of the livestock population in the period 1990-2016 (heads)

	1990	1995	2000	2005[1)]	2010	2015	2016
Cattle	3 506 222	2 029 827	1 573 530	1 397 308	1 349 286	1 407 132	1 415 660
Swine	4 789 898	3 866 568	3 687 967	2 876 834	1 909 232	1 559 648	1 609 945
Sheep	429 714	165 345	84 108	140 197	196 913	231 694	218 493
Poultry	31 981 100	26 688 376	30 784 432	25 372 333	24 838 435	22 508 192	21 313 960
Horses	27 480	18 280	24 440	21 180	30 500	33 716	32 133
Goats	41 208	45 151	32 521	13 115	22 422	26 765	26 548

Trends of the livestock populations in the key categories (cattle, swine, and poultry) are determining for emissions trends in Agricultural sector. Cattle population in 2016 set up only a 40 % share of the population in 1990 and swine population in 2016 set up even less - only 34 % of the starting population.

5.2.1 Enteric Fermentation (CRF 3.A)

5.2.1.1 Source category description

This chapter describes estimation of CH_4 emissions from enteric fermentation. In 2016, 80 % of agricultural CH_4 emissions arose from this source category. This category includes emissions from cattle (dairy and non-dairy), swine, sheep, horses and goats. Camels, llamas, mules, asses and buffaloes are kept in several private farms and ZOOs and populations of these non-original livestock are very low (hundreds of heads). Their breeding is not very extensive therefore methane emissions are not estimated for them. Enteric fermentation emissions from poultry have not been estimated, the 2006 IPCC Gl. (IPCC 2006) does 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 by using Tier 1 (other livestock) and Tier 2 (cattle category) methodologies presented in the 2006 IPCC Gl. (IPCC 2006) that 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: 4.1 % of the total CH_4 emissions from enteric fermentation category.

Enteric Fermentation of cattle

As the most important output of the national study (Kolar, Havlikova and Fott, 2004), a system of calculation spreadsheets have been drawn up and used for all the relevant calculations of CH_4 emissions by Tier 2.

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 "gross energy intake" (GE, MJ/head/day) is taken as the main feed ration for the given type of cattle (there are 10 subcategories of cattle) and Y is methane conversion factor, which is considered to be 0.065 for cattle (Table 10.12, Volume 4, IPCC Gl. 2006). Coefficient 55.65 is the energy content of methane and has dimensions of MJ/kg CH_4 . This equation should be solved for each cattle subcategory, denoted by index i.

EF is counted for each cattle category and reported for dairy and non-dairy cattle. Value reported for non-dairy (other) cattle is weighted average of results calculated for each „non-dairy“ category separately. Total emissions are a sum of two products ($EF_{DairyCattle}$*population of dairy cattle + $EF_{NonDairyCattle}$ * population of non-dairy cattle).

There are 10 cattle subcategories in use which data are available in Czech Statistical Yearbooks (CzSO, 1990–2016):

- Calves younger than 8 months of age (male and female)
- Young bulls and heifers (8-12 months of age)
- Bulls and bullocks (1 – 2 years, over 2 years)
- Heifers (1 – 2 years, over 2 years)
- Mature cows (dairy and suckler cows)

In the calculation, it is also very important to distinguish between dairy and suckler cows, where the fraction of suckler cows (ration suckler/all cows) gradually increased in the 1990-2016 time period. The share of suckler cows in the population of mature cows increased from 2 % to 36 % during the reporting period as a result of changes in agriculture policy after 1990.

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: weight, weight gain (for growing animals), mature weight, daily milk production including the percentage of fat in milk, pregnancy (% of females that give birth in the year), feeding digestibility (% of energy in feed non extracted) and the feeding situation (stall, pasture).

The national zoo-technical inputs (noted above) were updated by expert from the Czech University of Agriculture in Prague in 2006 and 2011 and were discussed with expert from the Institute of Animal Science in 2017. Input data in use (Hons and Mudřík, 2003, Mudřík and Havránek, 2006, Kvapilík J. 2010 and 2011, Stanek, P., 2017 – pers.com.) is given below, Tab. 5-5 and Tab 5-6. The numbers of grazing days for individual cattle categories are presented in Tab. 5-7.

Tab. 5-5 Weights of individual cattle categories, 1990–2016, in kg

Categories of cattle	1990 – 94	1995 – 98	1999 – 04	2005 – 09	2010 - 15	2016
Mature cows (dairy and suckler)	520	540	580	585	590	620
Heifers > 2 years	485	490	505	510	515	541
Bulls and bullocks > 2 years	750	780	820	840	850	850
Heifers 1-2 years	380	385	395	395	390	410
Bulls 1-2 years	490	510	530	540	560	560
Heifers 8-12 months	275	280	285	285	290	299
Bulls 8-12 months	325	330	335	340	350	368
Calves female to 8 months	128	132	133	135	135	139
Calves male to 8 months	128	132	133	135	135	149

Tab. 5-6 Feeding situation, 1990–2016, in % of pasture, otherwise stall is considered

Categories of cattle	1990 – 94	1995 – 98	1999 – 04	2005 – 09	2010 – 15	2016
Dairy cows	10	20	20	22	15	15
Suckler cows	10	20	20	50	95	95
Heifers > 2 years	30	30	30	35	50	50
Bulls > 2 years.	30	40	40	40	25	25
Heifers 1-2 years	30	40	40	40	50	50
Bulls 1-2 years	30	40	40	40	25	25
Heifers 8-12 months	30	40	40	40	50	50
Bulls 8-12 months	30	40	40	40	50	50
Calves female to 8 months	0	0	0	0	0	0
Calves male to 8 months	0	0	0	0	0	0

Tab. 5-7 Grazing days for individual cattle categories for the entire period

Categories of cattle	1990 – 94	1995 – 98	1999 – 04	2005 – 09	2010 – 15	2016
Dairy cows	18	36	36	40	27	27
Suckler cows	18	36	36	90	171	171
Heifers > 2 years	54	54	54	63	90	90
Bulls > 2 years.	54	72	72	72	45	45
Heifers 1-2 years	54	72	72	72	90	90
Bulls 1-2 years	54	72	72	72	45	45
Heifers 6-12 months	54	72	72	72	90	90
Bulls 6-12 months	54	72	72	72	90	90
Calves female to 8 months	0	0	0	0	0	0
Calves male to 8 months	0	0	0	0	0	0

Percentages of pasture are related only to the summer part of the year (180 days), while only the stall type is used for the rest of year. The daily milk production statistics (Tab. 5-8), in which only milk from dairy cows is considered, increased to 22.02 l/day/head in 2016, with an average fat content of 3.91 %. A relevant daily milk production of non-dairy cows is 3.5 l/day/head. The activity data of milk production comes from the official statistics (CzSO) and these are verified in the Yearbook of cattle in 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 weighted average values for non-dairy cattle feeding situation and pregnancy % were calculated and entered to the CRF tables. The weighted feeding situation is mostly affected by time in the pasture of suckler cows (95 %), as well as in the case of pregnancy (90 % of suckler cows is pregnant, 0 % for the other cattle species).

The country-specific parameter digestibility (DE, in %) for cattle was estimated based on existing publications. Considering 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 average digestibility for cattle was estimated. The estimated average digestibility corresponds to approximately 70 % (Koukolová and Homolka 2008 and 2010, Tománková and Homolka 2010, Jančík et al. 2010, Petrikovič et al. 2000, Petrikovič and Sommer 2002, Sommer 1994, Zeman et. al. 2006, Třináctý 2010, Čermák et al. 2008). Dr. Pozdíšek (expert from the Research Institute for Cattle Breeding, Ltd., pers. com.) determined the conservative average digestibility values for 3 basic cattle sub-categories. These digestibility values were employed for the emission estimation:

- Dairy cattle DE = 67 %
- Suckler cows DE = 62 %
- Other cattle DE = 65 %

The coefficients (C_{fi}) for calculating 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. 5-9. It is obvious that 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 dropped during the 1990-2016 period to about one half of the former values due to the rapid decreases of the numbers of animals kept.

Tab. 5-8 Milk production of dairy cows and fat content (1990–2016)

Year	Dairy cows population [thousands heads]	Daily production [liters/day head]	Fat content [%]
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
2016	373	22.02	3.91

Tab. 5-9 Activity data and methane emissions from enteric fermentation, cattle (Tier 2, 1990–2016)

Year	Dairy cattle population [thous.]	Other cattle population [thous.]	EF Dairy cattle [kg CH_4/hd]	EF Other cattle [kg CH_4/hd]	Emissions, Dairy cattle [kt CH_4]	Emissions Other cattle [kt CH_4]	Total emissions in category [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

Year	Dairy cattle population [thous.]	Other cattle population [thous.]	EF Dairy cattle [kg CH_4/hd]	EF Other cattle [kg CH_4/hd]	Emissions, Dairy cattle [kt CH_4]	Emissions Other cattle [kt CH_4]	Total emissions in category [kt CH_4]
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
2016	373	1043	146.38	56.46	54.53	58.90	113.42

Enteric Fermentation of other livestock (sheep, goats, swine, horses)

Compared to cattle, the contribution of other farm animals to the whole CH_4 emissions from enteric fermentation is much smaller (4.1 % in 2016). Therefore, CH_4 emissions from enteric fermentation of other farm animals (other than cattle) are estimated using 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. 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.

The Czech Statistical Office (CzSO) publishes data on the number of goats, sheep, swine, horses and poultry annually in the Statistical Yearbooks (1990-2016). Considering the rather small numbers in these animal categories, default emission factors (Table 10.10 from 2006 IPCC Gl.) 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. IPCC Gl. (IPCC 2006) does not define or require estimates of quantities of methane from enteric fermentation of poultry population.

Overview of methane emission estimated for other livestock in period 1990-2016 is presented in Tab.5-10.

Tab. 5-10 Methane emissions from enteric fermentation, other livestock (Tier 1, 1990–2016)

Year	Sheep	Swine	Goats	Horses	Total
	CH_4 Emissions from Enteric fermentation [kt]				
1990	3.44	7.18	0.21	0.49	**11.31**
1995	1.32	5.80	0.23	0.32	**7.67**
2000	0.67	5.53	0.16	0.43	**6.80**
2005	1.12	4.32	0.07	0.38	**5.88**
2010	1.58	2.86	0.11	0.54	**5.09**
2015	1.85	2.34	0.13	0.61	**4.93**
2016	1.75	2.42	0.13	0.58	**4.88**

5.2.1.3 Uncertainty and time-series consistency

Uncertainty estimates are based on expert judgment. The uncertainty in the activity data equals to 5 %. The uncertainty in the emission factor equals to 20 %. The combined uncertainty, calculated according to IPCC Tier 1 methodology, equals 20.6 %.

There were several methodological updates during the reporting period described in the relevant NIR text. Time series consistency is preserved at all times. Recalculations due to the methodological updates were done for the whole reported period.

The current revision of cattle weight data (Submission 2018), described in chapter 5.2.1.2 and 5.2.1.4., resulted to increase of the country specific emission factors for enteric fermentation and increase of total emission by about 2 % in category enteric fermentation. Changes in emission factors are shown in Tab. 5-11. There are results of theoretical analysis what would happened with emissions factors when weight data are changed in previous submission (2017).

Tab. 5-11 Demonstration of changes in input data caused by increase of cattle weight

	Submission 2017 Old weight data		Submission 2017 New weight data	
	Dairy cattle	Other cattle	Dairy cattle	Other cattle
EF for Enteric Fermentation	142.9	55.34	145.26	56.91
EF for manure Management	21.76	9.03	22.12	9.27
VS	6.18	2.80	6.29	2.88
Nitrogen excretion	132.55	66.21	135.44	68.48

Historical overview

In the beginning, 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; however, because 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).

Then the Czech team accepted critical remarks put forth by the International Expert Review Teams (ERT) and prepared a new concept for calculation of CH_4 emissions. This concept, in accordance with the plan for implementing Good Practice, was based on the following decisions:

2) 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.
3) CH_4 emissions from enteric fermentations of other farm animals are estimated by Tier 1 approach. Because of some features of keeping livestock in the Czech Republic that are similar to the neighbouring countries of Germany and Austria, default EFs for Tier 1 approaches recommended for developed countries were employed.

Increased attention was firstly paid to enteric fermentation. It was stated that cooperation with specialized agricultural experts is crucial to obtain new consistent and comparable data of suitable quality. The relevant nationally specific data for milk production, weight, weight gain for growing animals, type of stabling, etc. was collected by our external experts (Hons and Mudrik, 2003). Moreover, statistical data for sufficiently detailed classification of cattle, which is available in the Czech Republic, was also collected at the same time. Calculation of enteric fermentation of cattle using 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 weight of individual categories of cattle, weight gains of these categories and recent feeding situation was revised in 2006. The new values were estimated in a similar way by our external experts (Mudrik and Havranek, 2006) for the next period.

The national zoo-technical inputs (mainly weight, weight gain, daily milk production including the percentage of fat and the feeding situation) were updated several times in conjunction with experts from the Institute of Animal Sciences. These changes in the activity data and input parameters obviously did not result in changes in emissions for the entire reporting period.

5.2.1.4 Source-specific QA/QC and verification

Generally QA/QC includes checking of activity data, emission factors and 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 and verified by other IFER experts. Some more specific parameters, which are 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 agricultural institutes. The appropriate values in the calculation spreadsheets are updated at IFER, replacing the older values. The verified data is transferred to the CRF Reporter, where the data is again technically verified. The completeness check of CRF tables was performed for final time-series approval.

According the actual improvement plan the zoo-technical livestock data was discussed and verified under coordination of Ministry of Agriculture (meeting on September 18, 2017, electronic communication with experts from Institute of Animal Sciences). As a result of the common activity values of body weight, mature weight and typical animal mass of dairy and non-dairy cattle categories were rectified to correspond better with data used in the national legislation No 377/2013. These changes were endorsed by the expert nominated by Ministry of Agriculture, Dr.Staněk from Institute of Animal Science Prague. Analysis of relevant data is shown in Tab. 5-12.

Tab. 5-12 Analysis of the rectification of activity data (animal weight) per individual cattle categories

Categories of cattle	Ad weight 2015 [kg]	Ad weight 2016 [kg]	Increase [%]	Expert recommendation	National legislation
Mature cows (dairy and suckler)	590	620	5	580-680	650
Heifers > 2 years	515	541	5	550+	650
Bulls and bullocks > 2 years	850	850	0	850+	600
Heifers 1-2 years	390	410	5	470+	800
Bulls 1-2 years	560	560	0	670+	470
Heifers 8-12 months	290	299	3	300+	560
Bulls 8-12 months	350	368	5	400+	NA
Calves female to 8 months	135	139	10	180+	NA
Calves male to 8 months	135	149	3	145+	NA

Estimated enteric fermentation emission factor for dairy and other cattle were compared with default enteric fermentation factors available for Western Europe region in 2006 IPCC Gl. (table 10.11). While the EF for other cattle is fully comparable with country specific one (default value= 57, country specific value= 56.46), the EF for dairy cattle is rather different: default value = 117, country specific value is 146.38.

5.2.1.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

No recalculations were done in this submission.

5.2.1.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties and update of specific zoo-technical data (feeding situation) is currently in progress.

The technical update of specific calculation spreadsheet for Cattle Enteric Fermentation is planned for 2019 submission.

5.2.2 Manure Management (CRF 3.B)

This chapter describes the estimation of CH_4 (47 %) and direct (37 %) and indirect (16 %) N_2O emissions from animal manure management. Total emissions from manure management (CH_4 and N_2O) equalled 1 580 Gg CO_2 eq. in 2016. For detailed information see Tab. 5-2.

Good agricultural practices were developed based on agricultural policies and structures that support the trends in the animal waste management system allocation after Velvet Revolution (1989) and mainly after the Czech Republic entrance to European Union (2004). These procedures include inexpensive and austerity measures, such as the incorporation of relevant proteins in livestock feed, regular cleaning of the 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 and suitable livestock housing.

5.2.2.1 Source category description

During the 1990-2016 period, the emissions from manure management decreased by 53 %. Decreasing emissions from cattle and swine predominated 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 of domestic livestock. Both nitrous oxide (N_2O) and methane (CH_4) emissions from manure management of livestock (cattle, swine, sheep, horses, goats and poultry) are reported. The animal waste management systems (AWMS) are distinguished for N_2O and CH_4 emission estimations to the same manure management systems (MMS): liquid system, daily spread, solid storage, pasture, paddock and range system (PPR) 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. Overview of total emissions from manure management is presented in Tab. 5-13.

Tab. 5-13 Overview of emissions from manure management (1990-2016)

Year	Total emissions in category [kt CO_2 eq.]	CH_4 emissions [kt CO_2 eq.]	N_2O emissions [kt CO_2 eq.]
1990	3 315.39	1 695.43	1 619.96
1995	2 304.97	1 180.18	1 124.79
2000	2 041.56	1 030.80	1 010.76
2005	1 836.06	942.65	893.42
2010	1 581.17	756.43	824.74
2015	1 554.11	727.47	826.64
2016	1 580.18	741.23	838.95

5.2.2.2 Methodological issues

5.2.2.2.1 Animal Waste Management System

There are five main manure management systems define in Czech Republic (Table 10.18 ,2006 IPCC Gl.):

1. Pasture/Range/Paddock
2. Daily spread
3. Solid Storage
4. Liquid/Slurry
5. Other one

Tab. 5-14 Overview of the Czech country specific AWMS systems for cattle category (1990-2016)

Dairy cows	Fraction of Manure Nitrogen per AWMS [%]			
	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
2010 – now	27	1	65	7
Non Dairy cattle (AVG)				
1990	45	1	42	12
1995	43	1	39	17
2000	44	1	38	17
2005	49	1	34	16
2010	43	1	32	24
2011 – now	42	1	32	25

Tab. 5-15 Overview of the Czech country specific AWMS systems for other animal categories

Livestock category	Type of AWMS				
	Liquid	Daily spread	Solid	PRP	Other
	Fraction of Manure Nitrogen per AWMS [%]				
Sheep	0	0	2	87	11
Swine	76	0	23	0	1
Poultry	13	0	1	2	84
Horses	0	0	0	96	4
Goats	0	0	0	96	4

Czech country specific AWMS system is based on the expert study Mudrik,. Z., Hons P. (2004) and was updated several times during the reporting period by the expert opinion. The last update, in 2011, is based on Kvapilik, J., Institute of Animal Science, personal communication). The history of this country specific distribution is provided in Tab. 5-14. The country specific distribution manure for other livestock category is presented in Tab. 5-15.

Manure management storage and usage is adjusted by national regulation No 377/2013 Col. This regulation is relevant to the EU regulation No 91/676/EHS from 1991. The manure storage capacity corresponds to assumed 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 on suitable places in the field. 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 match the 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 regulation No 377/2013 Coll. includes five annexes with data allowing calculating production of manure in situation when manure management system evidence on individual farm level is not available (e.g. typical mass of livestock, N content in excrement, dry mass of excrement etc.). Farmer can calculate production and control the usage of manure according number of livestock heads.

To estimate N_2O emissions from manure management, the default emission factors for the different animal waste management systems were taken from the Table 10.21 (2006 IPCC Gl.), see Tab. 5-16. Data about the usage of manure in anaerobic digesters are not available for the period 1990-2016.

Tab. 5-16 IPCC default emission factors of animal waste per different AWMS

AWMS	Emission Factor (EF_3)
	[kg N_2O-N per kg N excreted]
Daily spread	0
Liquid/Slurry	0.005
Solid Storage	0.005
Other Systems	0.01

5.2.2.2.2 Methane emissions (CRF 3.B.1)

CH_4 emissions from manure management were identified as a key source by trend and level assessments (TA, LA). The estimation of methane emissions from Manure Management for Cattle category is provided by Tier 2 method. This category of emissions was identified based on analysis of National Inventory System (NIS) as a key category by trend (see Tab. 5-1). Methane emissions of other livestock category are estimated by the Tier 1 approach.

Cattle category

The activity data, cattle population distributed by age and gender, was obtained from the Czech Statistical Office (CzSO) Yearbook. This is a consistent time series of the number of animals during entire reported period (1990-2016). Gross energy (GE) values are estimated based on the national study Kolář *et al*. (2004) and 2006 IPCC Gl. in the special spreadsheet (more in Enteric Fermentation chapter). These GE parameters are reported in CRF as a country-specific data for the entire reported period (Tab. 5-17).

Tab. 5-17 Gross Energy (GE, MJ/head/day) of cattle in reported period (1990-2016)

	1990	1995	2000	2005	2010	2015	2016
Dairy cows	226.8	237.4	264.1	294.9	309.7	335.2	343.4
Other cattle	104.3	111.6	122.2	129.6	128.9	130.0	132.4

EF is calculated for each cattle category and reported for dairy and non-dairy cattle. Value reported for non-dairy (other) cattle is weighted average of results calculated for each „non-dairy“ category separately. Total emissions are sum of two products ($EF_{DairyCattle}$*population of dairy cattle + $EF_{NonDairyCattle}$ * population of non-dairy cattle).

The current updated data of AWMS distribution were applied for emission estimation. The other specific parameters for estimation of emission factors for cattle were obtained (Bo, MCF) from Dämmgen *et al.* (2012). The specific parameters recommended for use by study in neighbouring states (Dämmgen *et al.* 2012) are the same as the default values (IPCC 2006) and correspond to the Czech climate zone. The parameters recommended in Dämmgen *et al.* (2012) were utilized for the emission estimation (Tab. 5-18). The VS parameters calculated by Dämmgen *et al.* (2012) on the basis of B_0, ASH and MCF values) and EF for estimation of methane emissions are presented in Tab. 5-19.

Tab. 5-18 List of parameters for methane emission factor estimation in manure management in the Czech conditions

Parameters (2006 IPCC Gl.)	Dairy cows	Other cattle
B_o (Table 10A-4, Table 10A-5)	0.24	0.17*
ASH (recommendation p.10.42)	8 %	
MCF values (Table 10.17):		
Liquid system	17 %	
Daily spread	0.1 %	
Solid storage	2 %	
Pasture range and paddock	1 %	

**Default value available for Eastern Region is used because of average other cattle mass is 402 kg in Czech Republic, Western Europe region calculates with average other cattle mass 420 kg, Eastern Europe region with more close value of average other cattle mass 391 kg.*

Tab. 5-19 VS Parameter (kg dry matter/head/day), EF (kg CH_4/h/yr) and methane emissions (Gg) from manure management, Cattle category (1990-2016)

	Dairy cows			Other cattle		
	VS [kg DM/head/day]	EF [kg CH_4/head/yr]	Methan Emissions [Gg]	VS [kg DM/head/day]	EF [kg CH_4/head/yr]	Methan Emissions [Gg]
1990	4.18	13.91	16.78	2.26	7.86	18.08
1991	4.03	13.39	15.61	2.26	7.89	17.31
1992	4.10	13.65	13.73	2.30	8.10	15.75
1993	4.12	13.69	12.36	2.29	8.06	12.98
1994	4.21	13.66	10.87	2.29	8.07	11.03
1995	4.38	13.61	9.97	2.39	8.08	10.49
1996	4.45	10.55	7.52	2.40	8.15	10.39
1997	4.37	8.52	5.59	2.43	8.30	10.04
1998	4.57	8.90	5.32	2.44	8.35	9.21
1999	4.77	9.42	5.49	2.57	8.87	9.53
2000	4.87	11.76	6.44	2.59	8.98	9.21
2001	4.96	12.10	6.41	2.63	9.80	10.32
2002	5.12	15.10	7.49	2.67	10.04	10.28
2003	5.23	17.99	8.82	2.68	10.12	9.95
2004	5.33	18.34	8.73	2.68	10.11	9.63
2005	5.44	18.55	8.12	2.74	10.39	9.97
2006	5.49	18.72	7.94	2.74	10.41	9.89
2007	5.56	18.96	7.78	2.76	10.22	10.03
2008	5.65	19.25	7.81	2.79	10.08	10.04
2009	5.69	19.40	7.75	2.81	9.80	9.44
2010	5.71	20.11	7.71	2.78	9.21	8.89
2011	5.82	20.48	7.66	2.80	9.19	8.92
2012	5.93	20.88	7.79	2.80	9.10	8.93
2013	5.96	20.97	7.70	2.81	9.13	9.00
2014	6.08	21.41	7.98	2.80	9.04	9.05
2015	6.18	21.76	8.19	2.81	9.04	9.32
2016	6.33	22.29	8.31	2.87	9.17	9.56

The equations for determination of emission factors and estimation of methane emissions were taken from the IPCC Gl. (IPCC 2006)):

1. The Eq. 10.22 (2006 IPCC Gl., p. 10.37) was used to estimate the methane emissions:

$$CH_{4\ emissions}\left[\frac{kt}{year}\right] = \sum\left(\frac{EF \cdot cattle\ population}{10^6}\left[\frac{kg}{kt}\right]\right)$$

2. The Eq. 10.24 (2006 IPCC Gl., 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 estimation of methane emission factors were estimated using Eq. 10.23 (2006 IPCC Gl., p. 10.41) :

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

Other livestock category

The emissions from other farm animals are estimated by the Tier 1 approach. Default EFs for developed countries were employed for similar reasons as in the previous paragraph (Tab. 5-20). In relation to the decreasing trend in the animal population (especially cattle and swine) the methane emissions from manure management rapidly declined during 1990-2003.

Tab. 5-20 Default emission factors used to estimate CH_4 emissions from manure management (Table 10.15 and 10.14 IPCC Gl. 2006)

Livestock type	EF [kg/head/yr]
Sheep	0.19
Goats	0.13
Horses	1.56
Swine	6.00
Poultry	
Broilers	0.02
Other poultry*	0.182

** Emission factor for other poultry is calculated as weighted average of two default EFs for different breeding system (13 % wet and 87 % dry systems; 0.182 = 1.2 x 0.13 + 0.03 x 0.87).*

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

N_2O emissions from manure management were identified as a key source; Tier 2 methodology is used for emission estimation for the cattle category and Tier 1 and 2 for other animals. Emissions are calculated on the basis of N excretion per animal and animal waste management system. Following the guidelines, all the emissions of N_2O that take place before the manure is applied to soils are reported under manure management. The IPCC Guidelines method for estimating N_2O emissions from manure management entails multiplying the total amount of N excretion (from all animal species/categories) in each type of manure management system by an emission factor for that type of manure management system.

Input data consists of the mass fraction Xi,j of animal excrement in animal category i (i = dairy cows, other cattle, pigs, …) for various types of excrement management (AWMS - Animal Waste Management System) j (j = liquid manure, solid manure, pasturage, daily spreading in fields, other). Here, it holds that Xi, 1 + Xi, 2 + ... + Xi, 6 = 1. For Tier 1, only the values of matrix X for typical means of management of animal excrement in Europe are given. AWMS parameters presented in the IPCC methodology (IPCC 2006) were adapted to the Czech conditions.

Special spreadsheet is used for calculation in cattle categories. There are several sources of activity data: population data, annual average excretion rates calculated from daily food intake (GE), share of protein in feed and in the milk. Example of input data is provided in Tab. 5-21. The Eq. 10.32 and 10.33 (IPCC 2006) were used for calculation of the variables for nitrogen intake and nitrogen retained (milk production and growth). The results served as an input for Eq. 10.31. The parameters for estimation of the Nex for cattle were collected from literature and from personal communications with agricultural experts. Value of protein content in milk is relevant to literature references (Poustka 2007, Ingr 2003 and Turek 2000) and protein content in feed (in dry matter) to 16.5% is relevant to available references too (Zeman - Czech feed standards 12-21 %, Central Institute for Supervising and Testing in Agriculture 18 %, Karabcová pers. commun. 16-18 %). Nex rate is estimated for each cattle category, reported for dairy, non-dairy (weighted average) and summarized for all cattle. Default emission factors (Table 10.21, 2006 IPCC Gl.) are used for different AWMS.

Tab. 5-21 Example of Input data used for calculation of Nex for dairy cattle in 2016

Input data	Country spoecific value, 2016	Source
Protein, milk, %	3.43	Annual book of cattle breeding
Protein, feed, %	16.5	Task force of reactive nitrogene, 2015
Milk production, l/head	22.02	Annual book of cattle breeding
N intake, kg N/head/yr	179.33	2006 IPCC Gl., eq 10.32
N milk, kg N/head/yr	43.21	2006 IPCC Gl., eq 10.33
N weight gain, kg N/head/yr	0	2006 IPCC Gl., eq 10.32
N excreted, kg N/head/yr	136.12	2006 IPCC Gl., eq 10.31

The overview of estimated nitrogen excretion value used for N_2O emissions from manure in cattle category is presented in Tab. 5-22.

Tab. 5-22 The Czech national Nex (nitrogen excretion) values used to estimate N_2O emissions from manure management (1990-2016)

Year	Nitrogen excretion (Nex)	
	Dairy cattle	Non-dairy cattle
	[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
2016	136.12	67.90

The Nex value for other animal category is based on the national data for Typical Animal Mass (TAM) and Eq. 10.30 and default excretion rate (Table 10.19, 2006 IPCC Gl.). Relevant input data is available in Tab 5-23. TAM of swine is slowly decreasing during the reporting period. This trend was validated by information available at the Ministry of Agriculture. Development of the TAM value of swine was confirmed as a result of changing market requirements (younger and less fat animals are required by customers) and also by decreasing of breeding swine in population (Rozkot, M., Institute of Animal Sciences).

Tab. 5-23 Input data and nitrogen excretion (Nex) for other animal categories, data 2016

Livestock type	Typical animal mass [kg/head]	Nex rate [kg/head/yr]	Nex [kg/head/yr]
Sheep	49	0.85	15.0
Swine	59	0.68	16.0
Poultry			
Broilers	2	1.10	0.8
Other poultry	2	0.95*	0.7
Horses	498	0.26	47.0
Goats	19	1.28	9.0

** * Emission factor for other poultry is calculated a weighted average of two default EFs for two animal category: hens (95%) and other poultry (5%) =(0.96*95+5*0.83)/100.*

The emissions are then summed over all the manure management systems. The manure production data for individual AWMS in 2016 is reported in Tab. 5-24.

Tab. 5-24 Manure production distributed by individual AWMS, submission 2018

AWMS	Nitrogen Production in Manure [kg N/yr]
Liquid systems	63 444 452
Daily spread	1 215 356
Solid storage	34 035 994
Pasture range and paddock	26 152 173
Other	7 415 918
Totals	166 245 831

5.2.2.2.4 Indirect Emissions from Manure Management (CRF 3.B.2.5)

Indirect emissions result from volatile nitrogen losses that occur primarily in the form of ammonia and NOx. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time and, to a lesser degree, temperature. Nitrogen losses begin at the point of excretion in buildings and other animal production areas and continue through on-site management in manure management systems.

Tier 1 calculation of N volatilization in the form of NH_3 and NO_x from manure management system (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, IPCC 2006 Gl.). In order to estimate indirect N_2O emissions from Manure Management, the fraction of nitrogen losses due to volatilization and the default indirect factor EF_4 associated with these losses were employed (Table 11.3, 2006 IPCC Gl.).

According to the methodology, the fraction of manure nitrogen that leaches from manure management systems ($Frac_{LeachMS}$) is highly uncertain and should be developed as a country-specific value applied in Tier 2 method. No values of this fraction are available in the Czech Republic (no measures or national survey) and therefore the estimation of this category cannot be included into the emission inventory. The “NO” notation key is reported in the CRF tables.

5.2.2.3 Uncertainty and time-series consistency

Uncertainty estimates are based on expert judgment. The uncertainty in the activity data equals to 5 %. The uncertainty in the emission factor for estimation of CH_4 emissions equals to 20 %, estimation of N_2O emissions equals to 30 %. The combined uncertainty for CH_4 emissions equals to 20.6 % and that for N_2O emissions equals to 30.41 %.

The time series consistency is negatively affected by unequal development of manure system distribution. The first expert judgement (Mudrík Z., Hons, P 2004) assumed important decrease of the share of liquid fraction in dairy cattle category and decrease of solid fraction in non-dairy cattle category caused by change in technology of the cattle breeding as in early 90s. This expectation has not been met and actual manure distribution became similar to the starting one (Fig.5-2).

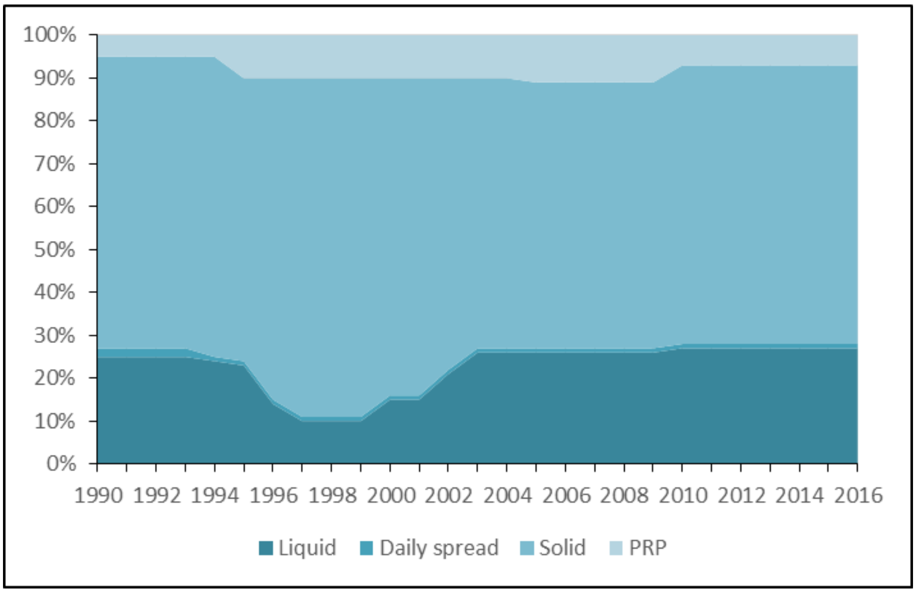

Fig. 5-2 Devepolment of Manure Managements systems share used for calculations.

5.2.2.4 Source-specific QA/QC and verification

QA/QC includes checking of activity data, emission factors and 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 and verified by other IFER experts. Some more specific parameters, which are 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) is supplied by experts from agricultural institute (see above). The appropriate values in the calculation spreadsheets are updated at IFER, replacing the older values. The verified data is transferred to the CRF Reporter, where the data is once again technically verified. The completeness check of CRF tables was performed for final time-series approval.

Special attention was paid to validation of emissions factors estimated by Tier 2 method and country specific animal waste management system.

Emission factor for methane production from manure management is calulated by Tier 2 methods for both cattle categories. Default values (Table 10.14, IPCC Gl. 2006) are lower than country specific ones:

Dairy cattle, methane emission factor for manure management default value = 21, country specific value= 22.76

Non-dairy cattle, methane emission factor for manure management default value = 6, country specific value =9.17.

Tier 2 procedures used for estimation of nitrogen excretion for cattle does not provide nitrogen excretion rate for dairy cattle and other cattle but it is possible to calculate the rates from typical animal mass data and estimated nitrogen excretion. Nitrogen excretion rate for dairy cattle and other cattle was compared with default Nex rate factors available for Western Europe region in IPCC Gl. 2006 (table 10.19). Default values for the both categories are lower than country specific ones:

Dairy cattle, Nex rate default value= 0.48, country specific value= 0.60,

Non-dairy cattle, Nex rate default value= 0.33, country specific value =0.46.

Tier 2 procedures are used for estimation of VS parameters for cattle. Country specific values were compared with default value available in 2006 IPCC Gl. (Table 10A-4 a 10A-5):

Dairy cattle, VS default value= 5.1, country specific value (2016) = 6.33

Non-dairy cattle, VS default value = 2.66, country specific value (2016) = 2.87.

The Nex excretions estimated for all livestock categories were compared with the data available in the Czech regulation 377/2103 Coll. Results are presented in Tab. 5-25. Overestimation of N_2O emissions in the Manure Management category is probable.

Tab. 5-25 Comparison of Nitrogen excretion data estimated in NIR (Submission 2018) and information available in the Czech regulation, 377/2013 Coll.

	Nitrogene excretion		
	Nex, Czech regulation kg N/livestock unit*/year	Nex, Czech regulation, livestock weight from NIR kg N/head/year	Nex , NIR Kg N/head/year
Dairy cattle (Tier 2)	84	104	136.1
Other cattle (Tier 2)	70	56	67.9
Swine (Tier 1)	100	12	14.6
Sheep (Tier 1)	75	7	15.2
Goats (Tier 1)	75	3	8.9
Horses (Tier 1)	40	40	47.2
Poultry (Tier 1)	175	0.7	0.7

** livestock unit = 500 kg*

The country specific AWMS was discussed on expert level (Klir, J., Crop Research Institute, Jelinek, L, Institute of Agriculture Economics and Information) several times during 2017 to validate the AWMS scheme in use. No changes were recommended.

The fraction of manure nitrogen that leaches from manure management systems ($Frac_{LeachMS}$) is highly uncertain and should be developed as a country-specific value applied in Tier 2 method. Research in this topic is conducted by Crop Research Institute, Dr. P. Svoboda According to his latest research results, substantial part of the nitrogen losses formed by soil nitrogen from the area after the disposal of the deposit. The nitrogen from the surrounding soil outside the deposit and the nitrogen contained in the leaked dung water constituted a minor part of the total amount.

5.2.2.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

Consistent parameters for manure management of solid manure (Chapter 5.2.2.2.) were used following recommendation from the last review process. The right use of a “dry lot” and “solid storage” animal waste system parameters were discussed with relevant expert opinions. According to Dr. Klir from the Crop Research Institute, the solid storage is the proper animal waste system currently used in Czech Republic. The recalculation of the whole time series was prepared with EF3 0.005 (Table 10.21, 2006 IPCC Gl.). This resulted in decrease of total emission in average by about 6.3 %. Decrease of N_2O emissions in manure management category as well in total emissions from Agriculture sector is presented in Tab. 5-26.

Tab. 5-26 Decrease of N_2O emissions in manure management category and total emissions from Agriculture as a result of recalculation

Year	Direct and indirect emissions from manure management [Gg N_2O]			Total emssions [kt CO_2 eq.]		
	Before recalculation	After recalculation	Decrease in %	Before recalculation	After recalculation	Decrease in %
1990	8.987	5.436	39.5	16 956	15 898	6.2
1991	8.583	5.217	39.2	14 706	13 703	6.8
1992	7.797	4.795	38.5	12 754	11 859	7.0

Year	Direct and indirect emissions from manure management [Gg N_2O]			Total emssions [kt CO_2 eq.]		
	Before recalculation	After recalculation	Decrease in %	Before recalculation	After recalculation	Decrease in %
1993	6.933	4.276	38.3	11 258	10 466	7.0
1994	6.109	3.741	38.8	10 236	9 531	6.9
1995	5.956	3.774	36.6	10 238	9 588	6.4
1996	6.109	3.783	38.1	9 990	9 297	6.9
1997	5.882	3.635	38.2	9 559	8 889	7.0
1998	5.577	3.464	37.9	9 154	8 524	6.9
1999	5.662	3.531	37.6	9 230	8 595	6.9
2000	5.347	3.392	36.6	8 954	8 371	6.5
2001	5.201	3.326	36.1	9 052	8 493	6.2
2002	5.029	3.288	34.6	8 812	8 293	5.9
2003	4.838	3.187	34.1	8 358	7 866	5.9
2004	4.671	3.070	34.3	8 567	8 090	5.6
2005	4.524	2.998	33.7	8 258	7 803	5.5
2006	4.440	2.949	33.6	8 114	7 670	5.5
2007	4.453	2.977	33.1	8 283	7 843	5.3
2008	4.428	2.987	32.5	8 421	7 992	5.1
2009	4.240	2.856	32.7	7 996	7 584	5.2
2010	4.149	2.768	33.3	7 823	7 412	5.3
2011	4.049	2.689	33.6	7 991	7 586	5.1
2012	4.028	2.669	33.8	7 986	7 581	5.1
2013	4.060	2.706	33.4	8 169	7 765	4.9
2014	4.102	2.718	33.7	8 371	7 959	4.9
2015	4.185	2.774	33.7	8 579	8 158	4.9
2016	4.260	2.815	33.9	8 950	8 520	4.8

Consistent region specific default value from 2006 IPCC Gl. in the reporting of CH_4 and N_2O emissions from manure management of swine were used for estimation following next recommendation from the last review process. According to the information from Institute of Animal Science (Dr. Rozkot), the breeding of swine in the Czech Republic is on the Western Europe level (welfare, feeding situation etc.). Therefore the new Nex rate available for Western Europe was used in recalculation of the whole time series with Nex rate 0.68 (instead of 0.74) (Table 10.19, 2006 IPCC Gl.). This resulted in decrease of direct and indirect N emissions from MM in average by about 1.8 % (Tab 5-27).

Tab. 5-27 Decrease of N_2O emissions from manure management as a result of using the suitable default value for nitrogen excretion rate of swine

Year	Direct and indirect emissions from manure management [Gg N_2O]			Total emssions [kt CO_2 eq.]		
	Before recalculation	After recalculation	Decrease in %	Before recalculation	After recalculation	Decrease in %
1990	5.54	5.44	1.8	15 950	15 898	0.3
1991	5.31	5.22	1.8	13 753	13 703	0.4
1992	4.89	4.80	2.0	11 910	11 859	0.4
1993	4.37	4.28	2.9	10 516	10 466	0.5
1994	3.83	3.74	2.2	9 575	9 531	0.5
1995	3.85	3.77	2.1	9 630	9 588	0.4
1996	3.87	3.78	2.2	9 341	9 297	0.5
1997	3.72	3.63	2.3	8 934	8 889	0.5
1998	3.55	3.46	2.4	8 568	8 524	0.5
1999	3.61	3.53	2.3	8 639	8 595	0.5
2000	3.47	3.39	2.2	8 412	8 371	0.5
2001	3.40	3.33	2.1	8 531	8 493	0.4
2002	3.36	3.29	2.1	8 331	8 293	0.5
2003	3.26	3.19	2.2	7 903	7 866	0.5
2004	3.13	3.07	2.1	8 124	8 090	0.4

Year	Direct and indirect emissions from manure management [Gg N_2O]			Total emssions [kt CO_2 eq.]		
	Before recalculation	After recalculation	Decrease in %	Before recalculation	After recalculation	Decrease in %
2005	3.06	3.00	2.0	7 835	7 803	0.4
2006	3.01	2.95	1.9	7 700	7 670	0.4
2007	3.03	2.98	1.9	7 873	7 843	0.4
2008	3.04	2.99	1.6	8 017	7 992	0.3
2009	2.90	2.86	1.4	7 604	7 584	0.3
2010	2.81	2.77	1.4	7 432	7 412	0.3
2011	2.72	2.69	1.3	7 604	7 586	0.2
2012	2.70	2.67	1.2	7 598	7 581	0.2
2013	2.74	2.71	1.2	7 782	7 765	0.2
2014	2.75	2.72	1.2	7 976	7 959	0.2
2015	2.80	2.77	1.1	8 174	8 158	0.2
2016	2.85	2.82	1.1	8 536	8 520	0.2

During the last review, the Czech Republic confirmed a mistake in estimation of nitrogen excretion in the sheep category in 2008. The erroneous data was corrected (see Fig. 5-3).

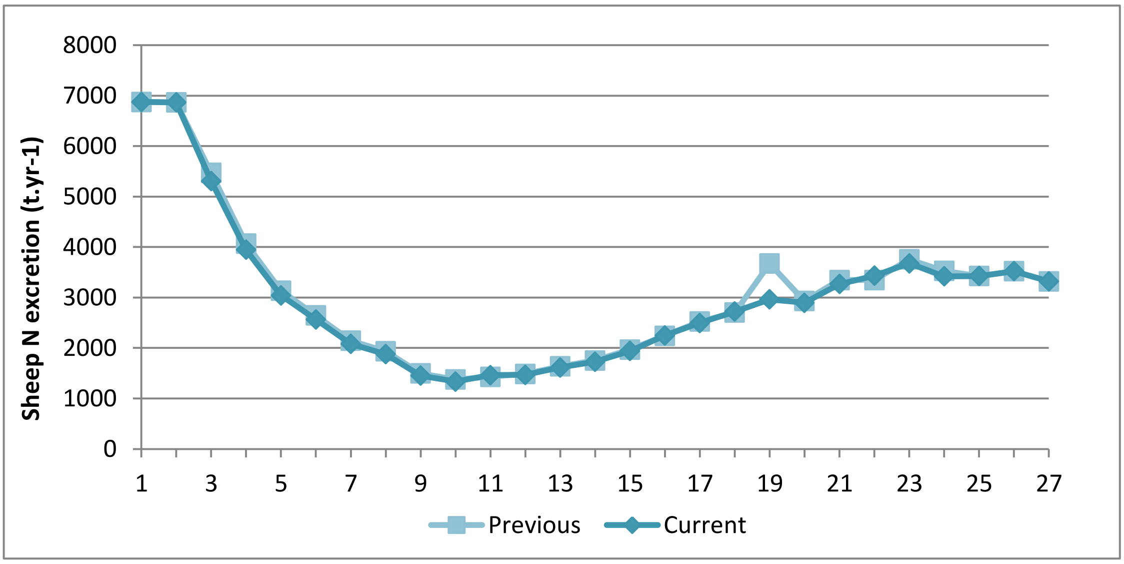

Fig. 5-3 Comparison of trends in nitrogen excretion of sheep before and after data correction

According to the last review recommendation the population data of poultry was split into two categories: broilers and other poultry. This distribution allows using specific emission factors for each category and gas. Additionally, the technical error in calculation of weighted value of methane emission factor was corrected. The complete time series since 1990 were recalculated. It resulted in decrease of total emissions from manure management of poultry category in average by about 14%. The decrease of emissions is linked to changes of ration between number of broilers and other poultry. Details of methane and nitrogen emissions from manure management of poultry are shown in Tab.5-28.

Tab. 5-28 Decrease of total emissions from manure management as a result of use the suitable default value in poultry category

Year	Emissions from manure management, poultry, before recalculation			Emissions from manure management, poultry, after recalculation				
	Methan emissions, Gg	Nitrogen emissions, Gg	Total kt CO_2 eq.	Methan emissions, Gg	Nitrogen emissions, Gg	Total kt CO_2 eq.	Decrease in %	Ratio broilers/other poultry
1990	5.53	0.28	221	4.09	0.35	206	6.80	0.5
1991	5.76	0.29	230	4.13	0.36	212	8.03	0.6

1992	5.32	0.27	213	3.88	0.34	197	7.35	0.5
1993	4.88	0.25	195	3.76	0.31	185	5.09	0.4
1994	4.32	0.22	173	3.51	0.27	168	2.83	0.3
1995	4.62	0.23	185	3.48	0.29	174	5.97	0.5
1996	4.82	0.24	193	3.40	0.31	176	8.68	0.6
1997	4.77	0.24	191	3.32	0.30	173	9.16	0.6
1998	5.02	0.25	201	3.46	0.32	182	9.55	0.6
1999	5.23	0.26	209	3.50	0.33	187	10.64	0.7
2000	5.33	0.27	213	3.39	0.34	187	12.45	0.8
2001	4.99	0.25	200	2.88	0.32	168	15.81	1.0
2002	5.18	0.26	207	2.77	0.34	170	18.10	1.2
2003	4.65	0.23	186	2.88	0.30	161	13.44	0.9
2004	4.41	0.22	177	2.35	0.29	144	18.23	1.3
2005	4.39	0.22	176	2.30	0.29	143	18.69	1.3
2006	4.45	0.22	178	2.31	0.29	144	18.97	1.3
2007	4.25	0.21	170	2.16	0.28	137	19.59	1.4
2008	4.73	0.24	189	2.35	0.31	151	20.13	1.5
2009	4.58	0.23	183	2.25	0.30	146	20.47	1.5
2010	4.30	0.22	172	2.11	0.28	137	20.48	1.5
2011	3.68	0.19	147	2.03	0.24	122	17.05	1.1
2012	3.58	0.18	143	1.85	0.23	116	19.05	1.3
2013	4.02	0.20	161	2.34	0.26	136	15.49	1.0
2014	3.71	0.19	149	2.04	0.24	123	17.22	1.2
2015	3.89	0.20	156	2.13	0.25	129	17.35	1.2

5.2.2.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is in progress.

Update of the AWMS distribution scheme including consumption of manure in anaerobic digesters should be available for submission 2020 after realization of statistical survey (Ministry of Agriculture, Institute of Agricultural Economics and Information, personal communication).

Harmonization with the reporting under the UNECE is planned to provide a consistent nitrogen balance approach in estimation of the amount of manure nitrogen dby livestock in the Czech Republic as the key input information. Informal working group for national nitrogen balance, nitrogen emission inventories and emission projections was established at Ministry of Environmental. Czech NIR team is involved in this group.

Higher tier method for estimation of methane and nitrous emissions from manure management of swine will be prepared in cooperation with relevant experts and institutions. Significant improvement is planned for submission in 2021.

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 the direct and the indirect nitrous oxide emissions from Agricultural soils. Both of these categories (direct and indirect) are key sources of N_2O soil emissions (Tab. 5-1). Nitrous oxide is produced in the 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)
- The emissions from pasture manure (PRP)
- Amount of Nitrogen mineralized in mineral soils considered for Cropland remaining Cropland
- The indirect emissions (atmospheric deposition and nitrogenous substances flushed into water courses and reservoirs -leaching).

Tab. 5-29 N_2O emissions from Agricultural Soils in period 1990-2016 in kt N_2O

Year	Total emissions	Synthtic fertilizersA	Animal manureb	Sewage sludgec	Crop residuesd	Mineralr Soil	PRP	Atmosph. deposition	Leaching
1990	18.6	6.6	3.0	0.004	3.7	0.04	0.8	1.4	3.1
1995	11.7	3.6	1.9	0.01	2.6	0.04	0.7	0.8	1.9
2000	10.5	3.4	1.7	0.02	2.2	0.05	0.6	0.8	1.7
2005	10.0	3.3	1.6	0.02	2.2	0.07	0.6	0.7	1.7
2010	9.9	3.6	1.4	0.04	1.9	0.03	0.7	0.7	1.6
2015	11.3	4.2	1.3	0.04	2.3	002	0.7	0.8	1.9
2016	12.1	4.6	1.4	0.04	2.5	0.01	0.8	0.8	2.0

In 2016, 81 % of total N_2O emissions from Agriculture originated from Agricultural Soils, while the rest originated from Manure Management (19 %). The trend in N_2O emissions from this category is decreasing during the reporting period of 1990-2010 and then slowly increasing. Tab. 5-29 presents the N_2O emissions of Agricultural soils by the individual sub-categories.

5.4.2 Methodological issues

Although agricultural soils are the key source, emissions of N_2O are estimated and analysed using Tier 1 approach of the IPCC methodology (2006 IPCC Gl.). 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 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:

- Amount of nitrogen applied to the soil in the form of industrial nitrogen fertilizers (CzSO data, Statistical Yearbooks, 1990-2016);
- Managed manure nitrogen available for application to the soil (NIR data, Eq.10.34);

- Annual yields (harvest/production area), CzSO data, Statistical Yearbooks, 1990-2016
- Annual amount of urine and dung N deposited by grazing animal on PRP (NIR data, eq.11.5)
- Amount of sewage sludge directly applied to the agricultural soils (CzSO data, Statistical Yearbooks, 1990-2016)
- Amount of N in mineral soils that is mineralised, in association with loss of soil C in Cropland remaining Cropland category (LULUCF, NIR data)

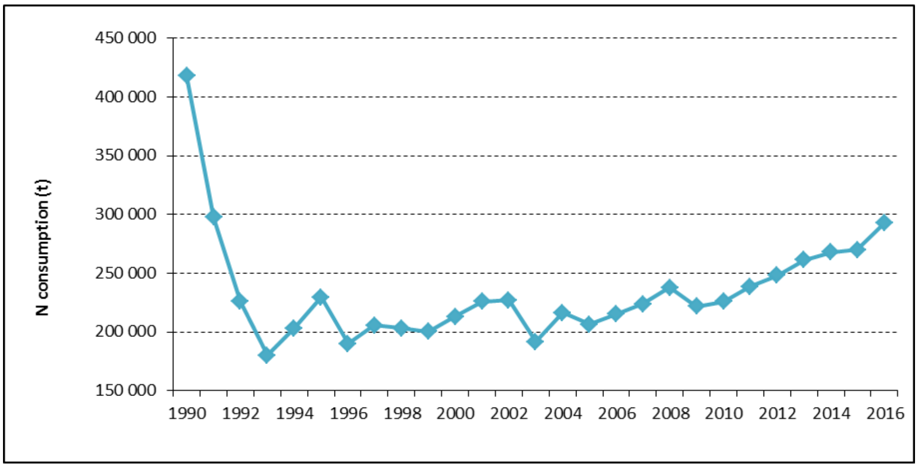

Fig. 5-4 Consumption of synthetic fertilizers during reporting period

5.4.2.2 Direct emissions from managed soils (CRF 3.D.1)

The emission factors used for calculation of direct N_2O emissions are shown in Tab. 5-30. The IPCC default fraction values are used to estimate N_2O emissions.

Tab. 5-30 The emission factors for the estimation of the direct emissions from managed soils (Table 11.1, 2006 IPCC Gl.)

Direct emissions	Synthetic fertilizer	EF_1 = 0.01 kg N_2O-N/kg N
	Animal Waste	
	Sewage Sludge	
	N-crop residues	
	Mineralized N	
Pasture, range & paddock manure	Cattle, pigs, poultry	EF_3 = 0.02 kg N_2O-N/kg N
	Sheep, others	EF_3 = 0.01 kg N_2O-N/kg N

Synthetic N fertilizers (FSN, CRF 3.D.1.1)

The application of agricultural fertilizers was formerly intensive in the Czech Republic, but decreased radically after 1990. The activity data is taken from official statistical offices (CzSO). The amount of nitrogen fertilizers applied in 1990 equalled over 418 kt, which had decreased to 180 kt in 1993. From this year, nitrogen consumption is slowly growing up to 293 kt in 2016. This trend is presented in the Fig. 5-4.

Organic N applied as fertilizer (FON incl. animal manure and sewage sludge, CRF 3.D.1.2)

The amount of managed manure nitrogen available for application to manged soil (FAM) is calculated as the product of annual average of N excretion per animal per species and fraction of manure management system and (1 –$Frac_{lossMS}$). Default value of the fraction $Frac_{lossMS}$ is provided in Table 10.23, Equation 10.34 and 11.4 (2006 IPCC Gl.).

The data on sewage sludge applied to the soil are officially available since 2002. The data of the previous period was estimated by statistical methods. 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 Gl.) were utilized to estimate the emissions from sewage sludge (FSEW).

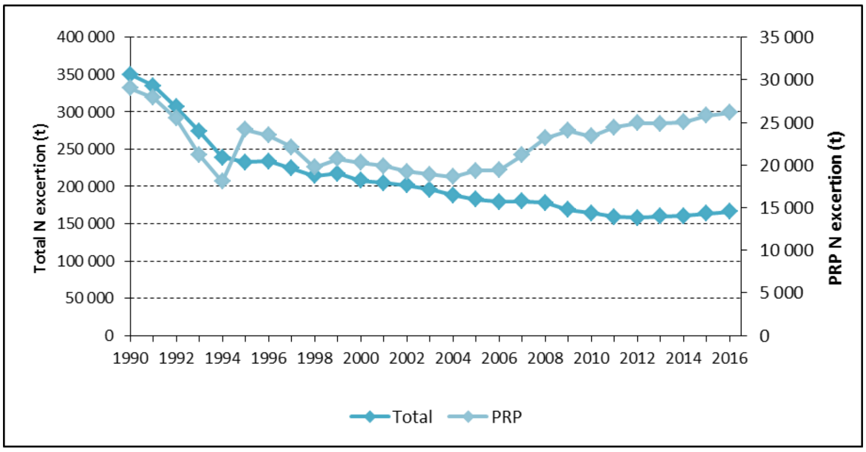

Fig. 5-5 Trend in the total amount of nitrogen excretion and nitrogen excretion from pasture during the reporting period

Total amount of organic N fertilizer applied to soil (FON) is calculated as the sum of FAM + FSEW.

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 based on 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 estimation of nitrogen content in animal waste management system, share of PRP in relevant livestock category. Two default emission factors (Tab. 5-31) are used to estimate emissions from different animal categories (Table 11.1 IPCC Gl). The fraction of livestock N excreted and deposited onto soil during grazing ($Frac_{GRAZ}$) varied from 0.083 in 1990 to 0.157 in 2016. The trend in development of the total amount of nitrogen coming from pasture is steady state for the whole reporting period, while the trend in total N excreted is rapidly decreasing because of deep changes in livestock population (Fig. 5-5).

Tab. 5-31 IPCC default emission factors of pasture, paddock, range (PRP) animal waste management system

	EF_3 [kg N_2O-N per kg N excreted]
PRP (cattle, swine, poultry)	0.02
PRP (sheep, others)	0.01

N-crop residues (FCR, CRF 3.D.1.4)

This category includes the amount of N in crop residues (above-ground and below-ground), including N-fixing crops, returned to soils annually. It also includes the N from N-fixing and non-N-fixing forages mineralised during forage or pasture renewal. This is estimated from crop yield statistics (CzSO) and default factors for above/below-ground residues: yield ratios and residual N contents (see Tab. 5-32). The zero values were applied as the parameters $Frac_{REMOVE}$ and $Frac_{BURN}$ because of the fact that no survey data of experts in country required on page 11.14 (2006 IPCC Gl.) is available. Overview of the annual yield of agriculture products is presented in Tab. 5-32. Production of grains, pulses, fodder and soya beans are almost steady state while the production of potatoes and sugar beet is growing.

Tab. 5-32 Annual yield of agricultural products (t/ha)

Year	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	5.83	2.89	22.26	59.38	5.91	1.64
2016	6.36	2.37	29.88	67.81	7.30	2.64

Tab. 5-33 Default value of input factors used in estimation of FCR, Table 11.2 (2006 IPCC Gl.)

	Grains	Pulses	Potatoes	Sugar beets	Fodder	Soya beans
Dry mater	0.88	0.91	0.22	0.22	---	0.91
R_{AG}	Calc	calc	Calc	calc	Calc	calc
AG_{DM}	Calc	calc	Calc	calc	Calc	calc
$Frac_{Remove}$	0.0	0.0	0.0	0.0	0.0	0.0
NAG	0.006	0.008	0.019	0.019	0.027	0.008
R_{BG}-BIO	0.22	0.19	0.20	0.20	0.40	0.19
N_{BG}	0.009	0.008	0.014	0.014	0.022	0.008

Note: The parameters R_{AG} and AG_{DM} are calculated by using Eq. 11.6 (2006 IPCC Gl.) and adequate parameters.

Since different crop types vary in residue, yield ratios, renewal time and nitrogen contents, separate calculations are performed for major crop types and then nitrogen values for all 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. Default values of input factors used in estimation are presented in Tab. 5-33.

Data on crop yield statistics (yields and area harvested, by crop) was 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. Only forage production activity data is presented as a dry matter in 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 are mineralised, in association with loss of soil carbon from soil organic matter (F_{SOM}), is a result of changes to land use or management in category Cropland remaining cropland in Agriculture sector. The annual amount of carbon from mineral soils from Forest land converted to Cropland (CRF Table 4.B.2.1) and Grassland converted to Cropland (CRF Table 4.B.2.2) is estimated in LULUCF sector.

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 in soil organic matter. LULUCF sector provides relevant activity data (CRF Table 4.B.1).

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. 5-35): 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 to 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. 5-34.

Tab. 5-34 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. 5-35 Emission factors (EFs) for indirect emission estimation

Indirect emissions	Atmospheric Deposition	EF_4 = 0.01 kg N_2O-per kg emitted NH_3 and NO_X
	Nitrogen Leaching	EF_5 = 0.0075 kg N_2O - per kg of leaching N

Volatilization

The N_2O emissions from atmospheric deposition of N volatilized from managed soil are estimated using Equation 11.9. The equation inputs are estimated for direct emission from managed soils. The inputs are: annual amount of synthetic fertilizer N applied to soils, annual amount of manged animal manure and sewage sludge N applied to soils, annual amount of urine and dung N deposited by grazing animal. The conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed by factor 44/28.

Leaching/Runoff

The N_2O emissions from leaching and runoff in regions, where leaching and runoff occurs, are estimated using Equation 11.10. The equation inputs are estimated for direct emission from managed soils, where FON includes also sewage sludge inputs. The inputs are: annual amount of synthetic fertilizer N applied to soils, annual amount of manged animal manure and sewage sludge N applied to soils, annual amount of urine and dung N deposited by grazing animal, amount of N in Crop residues and annual amount of N mineralised in mineral soils The conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed by factor 44/28.

5.4.3 Uncertainty and time-series consistency

In relation to the consistency of the emission series for N_2O (agricultural soils), it should be mentioned that the emission estimates have been calculated according to the default methodology of 2006 IPCC Gl.

The quantitative overview and emission trends during period 1990-2016 are shown in Fig. 5-1 and trend in N_2O emissions from agricultural soils is summarized in Tab. 5-2. During 1990-2016 the total emissions from Agricultural soils decreased by 34 % (with minimum in 2010).

Following the 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 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 histosoils on agricultural land in this country and hence also no data for this category. Organic soils mostly occur on forest land and they are reported under LULUCF sector.

Uncertainty estimates are based on expert judgment. The uncertainty in the activity data for estimation of direct and indirect emissions from agricultural soils equals to 20 %; for Pasture, Range and Paddock Manure (PRP) this value equals to 10 %. The uncertainty in the emission factor for estimation of direct and indirect emissions from agricultural soils equals to 50 %; for estimation of emissions from PRP this value equals to 100 %. The combined uncertainty for the direct and indirect emissions from agricultural soils equals to 53.85 %; this value equals to 100.5 %. for N_2O emissions from manure management system PRP.

Missing data about the amount of sewage sludge applied to the agricultural soils was added to the reported time series thanks to statistical retrospective analysis of available data about sewage sludge production (see Chapter 5.4.5. for more information).

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. Inventory in this subcategory is based on Tier 1 procedures and methods because there is a lack of relevant country specific factors.

For better understanding of how to calculate direct and indirect emissions from Managed soils, the FAO e-learning course: National GHG inventory for agriculture sectors was studied.

Several topics related to the estimation of emissions from Managed Soils were discussed with recommended EU expert in Agriculture sector. Use of the electronic and Skype communication help to exchange input data sheet and excel spreadsheets and discuss in detail relevant methodological procedures. The way how to improve coordination between the Air Quality and GHG inventories was one of the most important issues discussed with this EU expert.

5.4.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

This section (3D) of the Czech GHG inventory was revised before the 2017 submission on the recommendation of ERT 2016 and for the first time described here.

The correction in calculation of amount of nitrogen from manure applied to the managed soils was a subject of the recommendation by ERT 2016. This issue was closed only in March 2017. Therefore, it could not be reflected in the 2017 submission. The corrective action concerned the calculation of N_{MMS_Avb} (eq. 10.34), which produces input data for estimation of $F_{AM.}$. The mistake in estimation of animal manure applied to soil was corrected. The whole time series was recalculated. This resulted in decrease of N_2O emissions from managed soil by about 5%, see Tab. 5-36.

Tab. 5-36 Decrease of direct and indirect emissions from managed agricultural soils and amount of nitrogen applied to the soil before and after recalculation

Year	Direct and indirect emissions from management of agricultural soils [Gg N_2O]			Amount of nitrogene excreted (N_{MMS_avb}) [Gg N]		
	Before recalculation	After recalculation	Decrease, in %	Before recalculation	After recalculation	Difference in %
1990	21.41	18.56	13.3	193 657 589.22	320 612 525	39.6
1991	16.92	15.62	7.7	184 715 836.98	242 579 530	23.9
1992	14.06	12.83	8.7	168 373 687.59	223 202 126	24.6
1993	12.44	11.29	9.2	150 342 815.14	201 569 638	25.4
1994	12.03	11.02	8.3	131 337 514.06	176 093 740	25.4
1995	12.63	11.66	7.7	123 837 313.37	167 043 330	25.9
1996	11.90	10.97	7.8	124 487 252.55	166 124 032	25.1
1997	11.77	10.87	7.6	119 537 101.05	159 735 470	25.2
1998	11.29	10.40	7.9	114 628 945.14	154 368 199	25.7
1999	11.40	10.50	7.9	116 092 138.09	156 317 117	25.7
2000	11.36	10.47	7.8	110 930 233.25	150 517 095	26.3
2001	11.72	10.86	7.4	110 519 930.40	149 172 588	25.9
2002	11.34	10.45	7.9	108 968 990.69	149 011 265	26.9
2003	10.14	9.25	8.7	105 789 349.72	145 274 685	27.2
2004	11.36	10.52	7.4	101 815 208.66	139 351 489	26.9
2005	10.80	10.00	7.4	98 441 102.89	134 323 582	26.7
2006	10.49	9.71	7.5	96 553 693.97	131 641 426	26.7
2007	10.81	10.04	7.2	95 878 357.51	130 533 016	26.5

Year	Direct and indirect emissions from management of agricultural soils [Gg N_2O]			Amount of nitrogene excreted (N_{MMS_avb}) [Gg N]		
	Before recalculation	After recalculation	Decrease, in %	Before recalculation	After recalculation	Difference in %
2008	11.37	10.62	6.6	94 066 985.02	127 467 752	26.2
2009	10.74	10.06	6.3	88 004 772.47	118 188 386	25.5
2010	10.51	9.86	6.2	85 631 007.78	114 629 744	25.3
2011	11.13	10.53	5.4	82 202 053.23	108 965 737	24.6
2012	10.89	10.31	5.3	81 369 099.29	107 180 906	24.1
2013	11.40	10.81	5.2	82 319 332.73	108 897 837	24.4
2014	12.01	11.41	4.9	82 989 224.81	109 409 891	24.1
2015	11.86	11.26	5.0	84 526 234.66	111 130 078	23.9

3 D a 2 Organic N fertilizers

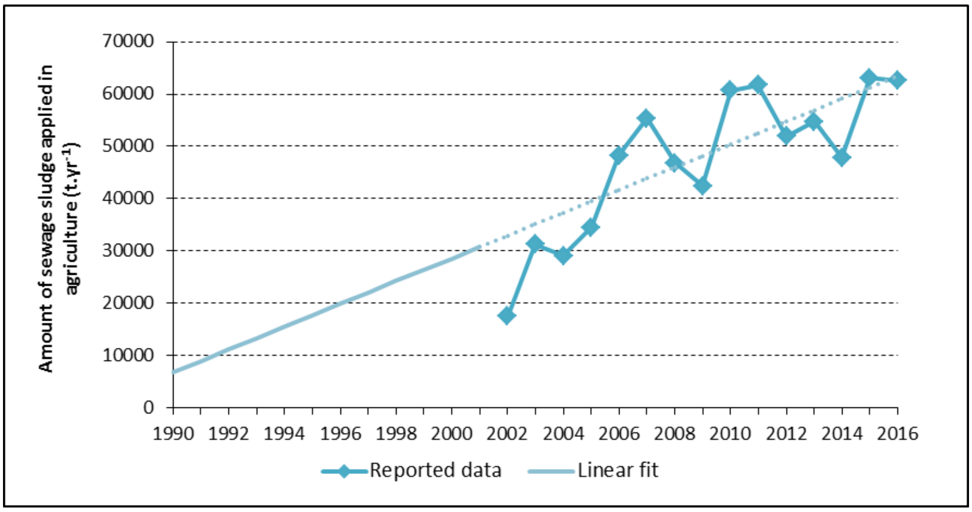

Fig. 5-6 Retrospective analysis of sewage sludge application to agriculture soil for the period 1990-2016

Activity data on N in sewage sludge applied to soil for the period 1990 -2001 was included in estimation according the recommendation of the last review process. The relevant part of the time series was recalculated. The data on sewage sludge applied to the soil are officially available since 2002. The data of the previous period were estimated by statistical methods (linear fitting). The result is presented in Fig. 5-6.

3 D a 5 Mineralization/immobilization

To avoid double counting in N_2O emissions from the mineralization of soil organic matter only N_2O emissions from mineralization of Cropland remaining Cropland is reported in Agricultural sector. The whole time series was recalculated. The recommendation of the last review process and footnote 4 of CRF table 3D were implemented in this way. Changes in emission trends caused by this recalculation are presented in Fig. 5-7.

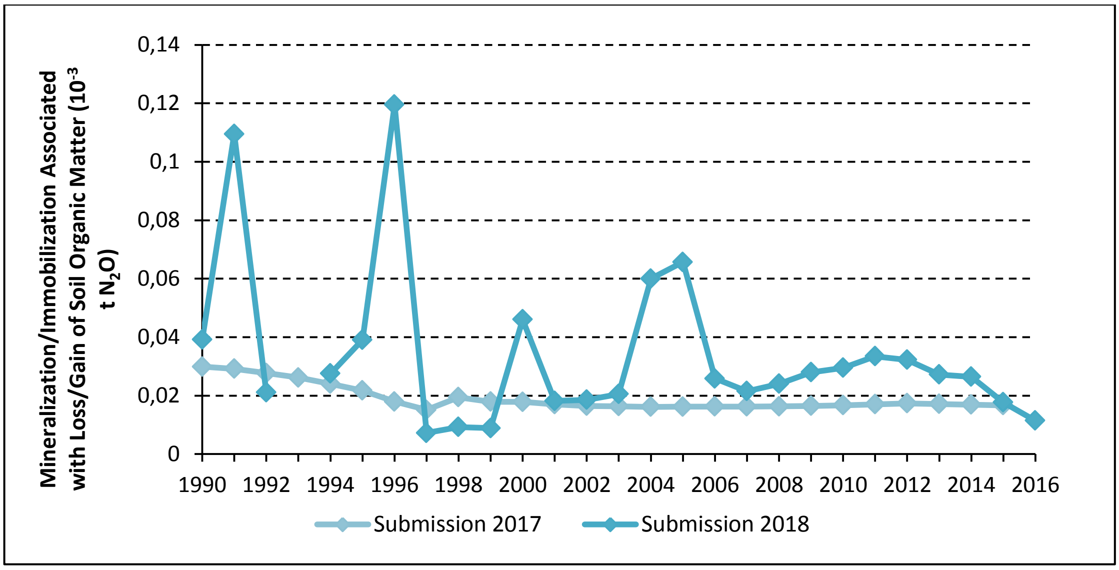

Fig. 5-7 Trend in emissions from FSOM before and after recalculation in period 1990-2016 (in Gg N_2O)

3 D b Indirect emissions from managed soils

The last review process considered overestimation indirect N_2O emissions from manure management. The recalculation of $N_{MMS\_Avb,}$ input of Fon, in the whole time series corrected erroneous reporting of activity data for estimation of N_2O emissions from management of agricultural soils. Decrease of indirect emissions from agricultural soils by about 11 % (Submission 2017) is presented in Tab.5-37.

Tab. 5-37 Decrease of indirect emissions from managed agricultural soils as a result of recalculation

Year	Indirect emissions from management of agricultural soils [Gg N_2O]		
	Before recalculation, submission 2017	After recalculation, submission 2018	Difference %
1990	5.325	4.456	16
1991	4.553	3.738	18
1992	3.860	3.089	20
1993	3.408	2.699	21
1994	3.247	2.630	19
1995	3.333	2.758	17
1996	3.143	2.581	18
1997	3.138	2.571	18
1998	3.013	2.468	18
1999	3.033	2.486	18
2000	2.993	2.486	17
2001	3.067	2.572	16
2002	2.986	2.493	17
2003	2.704	2.221	18
2004	2.926	2.475	15
2005	2.787	2.360	15
2006	2.731	2.315	15
2007	2.799	2.386	15
2008	2.903	2.506	14
2009	2.727	2.366	13
2010	2.684	2.331	13
2011	2.800	2.462	12
2012	2.763	2.431	12
2013	2.878	2.543	12
2014	3.002	2.663	11
2015	2.982	2.644	11

Body weight, mature weight and typical animal mass of dairy and non-dairy cattle were increased by about 3-10% corresponding to the data used in national legislation No 377/2013. These changes were endorsed by the expert nominated by Ministry of Agriculture, Dr.Staněk, Institute of Animal Science Prague. This revision caused the increase of country specific emission factors for N_2O emissions from Manure Management.

5.4.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is in progress.

Update of the AWMS distribution involving results of the survey funded by Ministry of Agriculture aimed to the consumption of manure in the anaerobic digesters is planned for submissions after 2020.

Harmonization with the reporting under the UNECE is planned to provide a consistent nitrogen balance approach in estimation of the amount of manure nitrogen applied to agricultural soils. Unformal working group for national nitrogen balance, nitrogen emission inventories and emission projections was established on Ministry of Environmental. Czech NIR team is involved to this group.

5.5 Prescribed burning of savanna (CRF 3.E)

This activity is prohibited by the Czech Law (Air Protection Act), thus prescribed burning of savanna does not occur in the Czech Republic**.**

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

This activity is prohibited by the Czech Law (Air Protection Act), thus field burning of agricultural residues does not occur in the Czech Republic.

5.7 Liming (CRF 3.G)

5.7.1 Source category description

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g., limestone or dolomite) leads to CO_2 emissions as the carbonate lime dissolve and release bicarbonate, which evolves into CO_2 and water. The liming on all managed soils is reported under this category, i.e. arable lands, grasslands and forest lands.

5.7.2 Methodological issues

However, the reactions associated with limestone application also lead to evolution of CO_2, which must be quantified. The activity data is derived from the official national statistics and Green Report of Forestry (see Tab. 5-38). 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).

Czech Statistical Yearbook does not provide data about consumption of limestone and dolomite separately. Based on expert experience the total amount of lime applied to the soil was reported as 90 % share of limestone and 10 % of dolomite.

The share of liming of forest lands in the 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 2016 the liming in forests equals almost 4.7 %.

Tab. 5-38 The limestone and dolomite quantity applied to managed soils (in thousand tons)

Year	Lime applied to Cropland and Grassland [kt]	Lime aplied to the Forest Land [kt]	Total amount of lime [kt]	Share of Limestone [kt]	Share of Dolomite [kt]
1990	2650	26.9	2676	2 409	267
1995	248	2.4	251	226	25
2000	209	46.7	255	230	26
2005	143	2.6	145	131	15
2010	135	5.1	140	126	14
2015	353	18.0	371	334	37
2016	366	18.0	379	341	38

The quantification followed the Tier 1 method (Eq. 11.12, 2006 IPCC Gl.), with an emission factor of 0.12 t C/t $CaCO_3$ and 0.13 t C/t CaCMgCO3. To convert CO_2–C emissions into CO_2 , factor 44/12 was used. Application of agricultural limestone was previously intensive in this country, but decreased radically during the 1990s, then from 2010 slowly increased. The activity data corresponds to the trend reported for use of fertilizers, which decreased a lot in early 1990s (Sálusová *et al.*, 2006).

Application of limestone on agricultural land (incl. forest) in 2016 reached more than 379 thousand tons, while 4.7 % of this amount was applied on the 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.

The share of dolomite use in fertilization of forest land and agricultural land was discussed with experts from Crop Research Institute.

5.7.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

According to the recommendation of the last review process the Czech Republic estimates emissions from application of dolomite and limestone separately. The amount of dolomite applied in agriculture was estimated as 10 % share of the limestone applied as a fertilizer. This was confirmed by agricultural experts from the Crop Research Institute in Prague. Specific emission factors were used for dolomite and for limestone. This recalculation resulted to increase of CO_2 emission from liming by about 1 % and increase of the share of this category on the total emission in Agriculture sector by about 0.2 % (submission 2017). Results of recalculation are presented in Tab. 5-39.

Tab. 5-39 Increase of emissions from Liming as a result of recalculation (after recalculation=submission 2018)

Year	Emissions from Liming [kt CO_2]			Total CO_2 emission [kt CO_2]		
	Before recalculation	After recalculation	Increase in %	Before recalculation	After recalculation	Difference in %
1990	1 177.8	1 187.6	0.83	1 286.3	1 296.2	0.76
1991	313.3	315.9	0.83	445.3	447.9	0.59
1992	108.3	109.2	0.83	216.8	217.7	0.42
1993	102.9	103.8	0.83	196.1	196.9	0.44
1994	103.4	104.2	0.83	194.3	195.2	0.44
1995	110.3	111.3	0.83	219.6	220.5	0.42
1996	112.4	113.4	0.83	212.9	213.8	0.44
1997	92.4	93.2	0.83	159.9	160.7	0.48
1998	90.0	90.8	0.83	233.0	233.8	0.32
1999	86.8	87.5	0.83	174.8	175.5	0.41
2000	112.3	113.2	0.83	159.9	160.8	0.59
2001	104.6	105.4	0.83	182.0	182.9	0.48
2002	98.9	99.7	0.83	162.8	163.7	0.51
2003	78.5	79.2	0.83	139.7	140.3	0.47
2004	76.1	76.7	0.83	146.2	146.8	0.43
2005	64.0	64.5	0.83	138.2	138.7	0.39
2006	77.7	78.4	0.83	160.4	161.0	0.40
2007	79.8	80.5	0.83	201.8	202.5	0.33
2008	94.8	95.6	0.83	195.0	195.7	0.41
2009	64.0	64.5	0.83	149.5	150.0	0.36
2010	61.5	62.0	0.83	172.7	173.2	0.30
2011	80.0	80.7	0.83	190.6	191.3	0.35
2012	115.6	116.5	0.83	251.5	252.4	0.38
2013	135.5	136.6	0.83	261.2	262.3	0.43
2014	150.3	151.5	0.83	207.3	208.6	0.60
2015	162.9	164.4	0.93	350.0	351.5	0.43

5.7.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is in progress.

5.8 Urea Application (CRF 3.H)

5.8.1 Source category description

Adding urea to soils during fertilization leads to a loss of CO_2 that was fixed in the industrial production process. Urea is converted into ammonium, hydroxyl ion and bicarbonate, in the presence of water and urea enzymes. This source category is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector).

5.8.2 Methodological issues

Tier 1 and Eq. 11.13 are utilized to estimate CO_2 emissions. Domestic production records for urea were used to obtain an approximate estimate of the amount of urea applied to soils on an annual basis (Tab. 5-40). The default emission factor is 0.20 for carbon emissions from urea applications, which is equivalent to the carbon content of urea on an atomic weight basis. To estimate the total CO_2-C emissions, the product of the amount of urea is multiplied by the emission factor. CO_2-C emissions are converted into CO_2 by multiplying by 44/12.

Until 2013, the values of urea application to agricultural land 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. From 2014 the new activity data is obtained and applied to the inventory estimation. The statistical production data is replaced by more precise data corresponding to the real consumption of fertilizers by the Ministry of Agriculture. These data available since 2000 until 2016 is based on farmers' fertilizer records and annual intake of nutrient from Urea. The application of urea to agricultural land in 2016 reached almost 287 kt of urea, which is the highest ever level since 1990.

Tab. 5-40 Urea applied to managed soils

Urea [kt]	1990	1991	1992	1993	1994	1995	1996
	148	180	148	127	124	149	137
Urea [kt]	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
	92	195	120	65	106	87	83
Urea [kt]	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
	96	101	113	166	137	117	152
Urea [kt]	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
	151	185	171	78	255	287	

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 section 5.1.3.

Consumption data is provided by Ministry of Agriculture and discussed with relevant experts. The increase of amount of the Urea applied to the soil is confirmed by other subjects (Institute of Agricultural Economics and Information, Crop Research Institute).

5.8.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trend

No recalculation was performed in this submission.

5.8.6 Source-specific planned improvements, including tracking of those identified in the review process

The analysis of uncertainties is in progress.

6 Land Use, Land-Use Changes and Forestry (CRF Sector 4)

6.1 Overview of sector

The emission inventory of the Land Use, Land-Use Change and Forestry (LULUCF) sector includes emissions and removals of greenhouse gases (GHG) resulting from land use, land-use change and forestry. The inventory was originally based on application of the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003, further also abbreviated as GPG for LULUCF) and the reporting format adopted by the 9th Conference of the Parties (COP) to UNFCCC. The reporting guidelines were revised at the 19th COP in 2013 by decision 24/CP.19. It demands that, starting in 2015, Parties included in Annex I to the Convention should apply the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) that are linked to the previously used methods outlined in Chapter 3 of GPG for LULUCF (IPCC 2003). In addition, decision 24/CP.19 encourages the use of the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC 2014a) in preparing the annual inventories under the Convention due in 2015 and beyond. The current LULUCF reporting is also guided by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC 2014b). This material is used, together with IPCC (2006), to prepare the assessment and reporting of annual changes in carbon stocks and associated CO_2 emissions and removals from Harvested Wood Products (HWP contribution), which have been 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 (2006, 2014a, 2014b). The current inventory of the LULUCF sector uses the recommended reporting structure, including the estimated HWP contribution. In terms of land-use representation and land-use change identification required for emission estimation for the LULUCF land-use categories, the Czech inventory employs a refined system of land-use identification at the level of the individual cadastral units. Although the Czech LULUCF inventory is still in the process of further refinement and consolidation, it represents a solid system for providing information on GHG emissions and removals in the LULUCF sector, as well as for providing additional information on the LULUCF activities required under the Kyoto protocol.

The current inventory includes CO_2 emissions and removals, and emissions of non-CO_2 gases (CH_4, N_2O, NO_X and CO) from biomass burned in forestry and disturbances associated with land-use conversion. The inventory incorporates all the 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 2016. The currently reported estimates changed in comparison with the previously reported values as a result of several refinements in the methodology, activity data and adopted emission factors affecting the emission estimates for some categories, which resulted in recalculations for the entire reporting period. The current and previously reported sectoral estimates of greenhouse-gas emissions and removals are shown in Fig. 6-1. The newly implemented improvement and changes led to somewhat different estimates for the individual years compared to the previously reported emission removals: the mean difference for comparable years 1990-2015 is -4.0%. The data shown in Fig. 6-1 include emissions and removal for all land-use categories and estimation of the HWP contribution. Detailed information on the implemented changes and performed recalculations is provided below for the individual LULUCF categories.

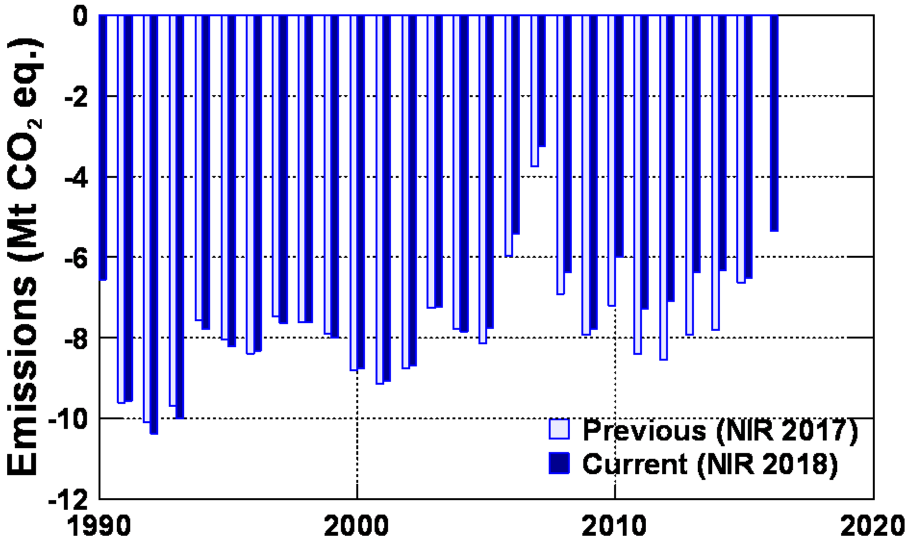

Fig. 6-1 The current and previously reported estimates of emissions for the LULUCF sector. The values are negative, corresponding to net removals of green-house gases.

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, 2016.

Tab. 6-1 GHG estimates in Sector 4 (LULUCF) and its categories in 1990 (base year) and 2016

Sector/category	Emissions 1990 [kt CO_2 eq.]	Emissions 2016 [kt CO_2 eq.]
4 Total LULUCF	-6 563	-5 337
4.A Forest Land	-5 076	-4 519
4.A.1 Forest Land remaining Forest Land	-4 736	-4 016
4.A.2 Land converted to Forest Land	-327	-503
4.B Cropland	213	124
4.B.1 Cropland remaining Cropland	94	36
4.B.2 Land converted to Cropland	123	88
4.C Grassland	-97	-662
4.C.1 Grassland remaining Grassland	48	-479
4.C.2 Land converted to Grassland	-145	-183
4.D Wetlands	21	25
4.D.1 Wetlands remaining Wetlands	(0)	(0)
4.D.2 Land converted to Wetlands	21	25
4.E Settlements	86	124
4.E.1 Settlements remaining Settlements	(0)	(0)
4.E.2 Land converted to Settlements	86	124
4.F Other Land	(0)	(0)
4.G Harvested Wood Products	-1 713	-431

Note: Emissions of non-CO_2 gases (CH_4 and N_2O) are also included.

In 2016, the net GHG flux for the LULUCF sector, estimated as the sum of emissions and removals, equalled -5 337 Gg CO_2 eq., thus representing a net removal of GHG gases. In relation to the estimated emissions in other sectors in the country for the inventory year 2016, the removals occurring within the

LULUCF sector decreased the GHG emissions generated in the other sectors by 4.1%. Correspondingly, for the base year of 1990, the total emissions and removals in the LULUCF sector equalled -6 563 Gg CO_2 eq. In relation to the emissions generated in all the other sectors, the inclusion of the LULUCF estimate reduces the total emissions by 3.3% for the base year of 1990. It is important to note that the emissions within the LULUCF sector exhibit high inter-annual variability (Fig. 6-1) and the values shown in Tab. 6-1 should not be interpreted as trends. The entire data series can be found in the corresponding CRF Tables.

6.1.2 Key categories

Tab. 6-2 Key categories of the LULUCF sector (2016)

Category	Gas	KC A1	KC A2	% of total GHG[1]
4.A.1 Forest Land remaining Forest Land	CO_2	LA, TA	LA, TA	3.26
4.G Harvested wood products	CO_2	LA, TA	TA	0.34
4.A.2 Land converted to Forest Land	CO_2	LA, TA		0.40

KC: key category
[1] *including LULUCF*

Of the main categories listed in Tab. 6-1, three were identified as key categories according to the IPCC 2006. One is 4.A.1 Forest Land remaining Forest Land with a contribution of 3.26%, which is the major LULUCF category identified by both the level and trend assessment (Tab. 6-2). The emissions in this category are mostly determined by changes in the biomass carbon stock. Second is 4.A.2 Land converted to Forest Land, the third is 4.G Harvested wood products. Its contribution reached more marginal 0.34%, which however still qualifies it among the key categories by the level assessment for 2016.

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 the 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 the reporting year of 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, the 2006 IPCC Gl. (IPCC 2006) outline the appropriate methodologies for estimation of greenhouse gas emissions.

Consistent representation of land areas and identification of land-use changes constitute key steps in the inventory of the LULUCF sector in accordance with the 2006 IPCC Gl. (IPCC 2006). The adopted system of land-use representation and land-use change identification was constructed gradually. Since the 2008 NIR submission, this has been exclusively based on the cadastral land-use information of the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz). The Czech land-use representation and the land-use change identification system use annually updated COSMC data, elaborated at the level of about 13 thousand individual cadastral units. The system was constructed in several steps, including 1) source data assembly 2) linking land-use definitions 3) identification of land-use change and 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 Gl.) imply that, for the reported period of 1990 to 2016, the required land-use information should be available for the period starting from 1969. Information on land use was obtained from the Czech Office for Surveying, Mapping and Cadastre (COSMC), which administers the database of "Aggregate areas of cadastral land categories" (AACLC). The AACLC data were compiled at the level of the individual cadastral units (1992-2016) 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 2016, the total number of cadastral units varied between 13,027 and 13,091.

Two approaches were employed to identify the administrative separation and division of cadastral units within a given year. Previous to 2004, the cadastral units were crosschecked by comparing the areas in subsequent years using the threshold of a half-hectare difference. Starting in 2004, an explicit change in land use was quantified within and for each year directly by the data provider, i.e., COSMC, at the request of the inventory team. The latter approach does not require reconciliation of individual cadastral units between the consecutive years, as it adopts the addressed land-use change information available in the COSMC database.

To obtain information on land-use and land-use changes prior to 1993, a complementary data set from COSMC at the level of 76 district units was prepared. It covered the period since 1969 and was required for application of the IPCC default transition time period of 20 years for carbon stock change in soils. The spatial coverage of cadastral and district units is also shown in Fig. 6-2.

6.2.2 Linking land-use definitions

The analysis of land use and land-use change is based on the data from the "Aggregate areas of cadastral land categories" (AACLC), centrally collected and administered by COSMC and regulated by Act No. 265/1992 Coll., on Registration of proprietary and other material rights to real estate, and Act No. 344/1992 Coll., on the real estate cadastre of the Czech Republic (the Cadastral Act), both as amended by later regulations. AACLC distinguishes ten land categories, six of them belonging to land utilized in agriculture (arable land, hop-fields, vineyards, gardens, orchards, grassland) and four under other use (forest land, water surfaces, built-up areas and courtyards, and other land). For the explicitly addressed within-year land-use change identification, two additional specific land-use subcategories were distinguished, namely other land – waterlogged soil and other land – unfertile land. The AACLC land-use categories and sub-categories of the COSMC database were linked so as to most closely match the default definitions of the six major land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land) as given by the 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2006). The country-specific definition of the content of the IPCC land-use categories is summarized in Tab. 6-3 and can also be found in Chapters 6.4 to 6.9 devoted to each of the major land-use categories.

Tab. 6-3 Linking the Czech national cadastral (COSMC) land-use categories to the IPCC land-use categories. COSMC codes in parenthesis combine type of properties and its dominant use.

IPCC land-use category	CRF coding	Czech national cadastral (COSMC) ID code and land-use category
Forest land	4.A	10. Forest land - Land with forest stad and land, where forest stands were removed to permit their regeneration, forest break and unpaved forest road, not wider than 4 m, and land, where forest stands were temporarily removed due to a decision of the state forest administration [Forestry Act 289/1995])
Cropland	4.B	2. Arable land - Land of arable soil according to the Agriculcure Act 3. Hop fields - Land of hop fields according to the Agriculcure Act 4. Vineyards - Land of vineyards according to the Agriculcure Act 5. Gardens - Land for permanent and predominant production of vegetable, flowers and other garden products or land with fruit trees and shrubs close to residential and industrial buildings 6. Fruit orchards - Land of fruit orchards according to the Agriculcure Act
Grassland	4.C	7. Permanent grassland - Land of permanent grasslands according to the Agriculcure Act
Wetlands	4.D	11. Water area - Land of watercourses and riverbeds, water reservoirs, marshes, wetlands or swamps (22). Other area – waterlogged areas - Land of Other areas that is waterlogged (marshes, wetlands or swamps)
Settlements	4.E	13. Built-up area and courtyard - Land with buildings including courtyards, common yards, 14. Other area - Land not classified under 2, 3, 4, 5, 6, 7, 10, 11 and 13, such as transport infrastructure, manipulation areas, depots, landfills, photovoltaic power stations and others (21). Other area – unfertile land - Land not suited for production and other use
Other land	4.F	NO since 2018 NIR submission, earlier including (21) Other area – unfertile land

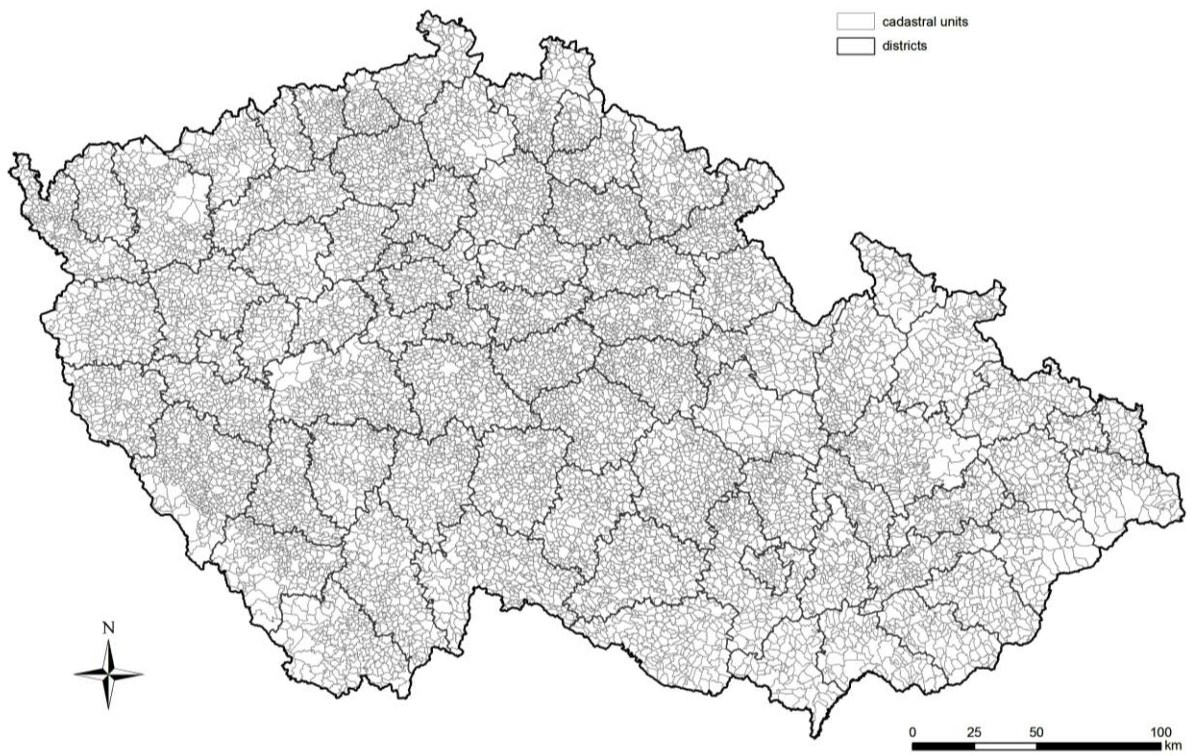

Fig. 6-2 Cadastral units (grey lines; n = 13 091 in 2016) and districts (black lines; n=79), the basis of the Czech land use representation and land use change identification system.

6.2.3 Land-use change identification

The critical aspect of any LULUCF emission inventory is the quantitative determination of land-use changes. 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 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 the 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 latter, more advanced 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 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 the identified land-use transfers estimated at the individual cadastral unit level are summarized by each type of land-use change on an annual basis to be further used for estimation of the associated emissions.

Year (date)	ID CU (Name)	Forest land	Cropland	Grassland	Wetlands	Setttlements	Other land	Total
1.1.2011	661635 (Kácov)	1992637	2627349	1186759	376350	1124451	291370	7598916
31.12.2011	661635 (Kácov)	1979724	2633115	1181825	376350	1136533	291371	7598918
Difference		-12913	5766	-4934	0	12082	1	2

Conversion type	Area (m^2)
Forest land - Cropland	977
Forest land - Settlements	11936
Cropland - Settlements	247
Grassland - Cropland	4897
Grassland - Settlements	38
Settlements - Cropland	139

Fig. 6-3 Example of land-used change identification for 2011 for cadastral unit 661635 (Kácov); all spatial units are given in m^2.

6.2.4 Complementing time-series

The above described calculation of land-use changes at the level of the individual cadastral units was performed for 1993 to 2016, because the data at that spatial resolution have been available only since 1992. For the years preceding 1993, i.e., for land-use changes attributed to 1970 to 1992, an identical approach to that described above was used, but with aggregated cadastral input data at the level of the individual districts. Due to the IPCC default time period of 20 years used for reporting the converted land, the source information contains data on land use in the Czech Republic since 1969.

6.2.5 Land use representation and land use change identification system - status and development

Development of the Czech LULUCF land-use representation and land-use change identification system as described above involved collaboration with the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz), which administers the source information on land-use used in the LULUCF emission inventory[2]. Based on internal analysis and the recommendations of COSMC, the current inventory retains exclusively use of the original data on land use without any further corrections and provides explicit information on land use for all six IPCC land-use categories. The inventory team is working in collaboration with COSMC on further consolidation of the system to provide the specific information required for KP LULUCF activities.

6.3 Land- use definitions and the classification systems used and their correspondence to the land use, land-use change and forestry categories

The IPCC land-use categories were linked to the Czech cadastral classification system, namely that of “Aggregate areas of cadastral land categories” (AACLC), centrally collected and administered by COSMC,

[2] *The work of the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) is based on digitalisation of cadastral land-use information in the Czech Republic, which is planned to be finalized in 2019. This major reconciliation of land-use information is in progress and explains the nature of the ongoing area rectifications in the official reports on areas of land and land-use categories in the country.*

as described in detail in Section 6.2 above. The specific attribution and linking of cadastral land-use categories to IPCC land-use categories is summarized in Tab. 6-3 and also provided 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 2016 period are shown in Fig. 6-4. A largest quantitative change is associated with the Cropland and Grassland land-use categories.

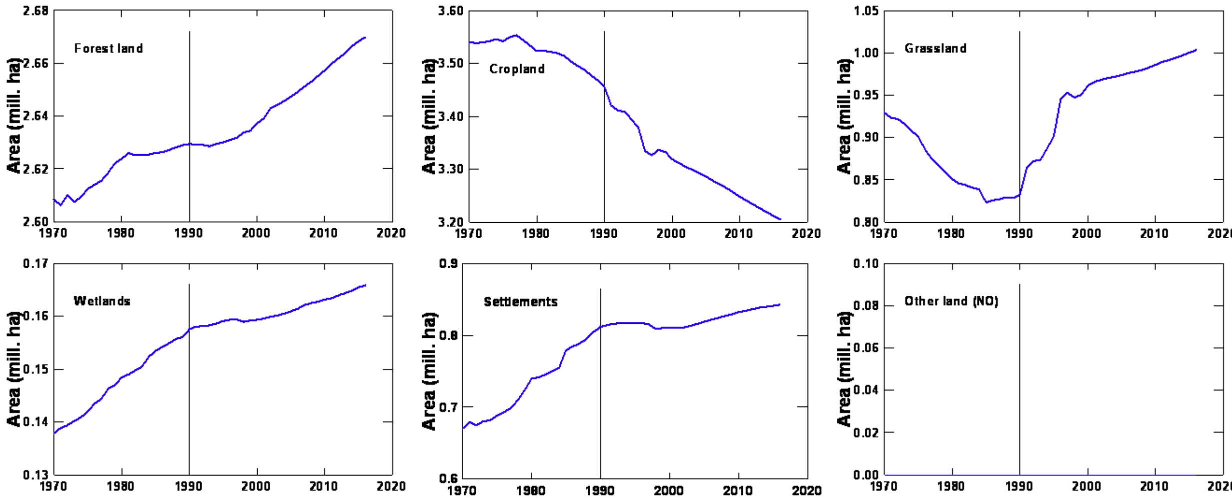

Fig. 6-4 Trends in areas of the six major land-use categories in the Czech Republic between 1970 and 2016 (based on information from the Czech Office for Surveying, Mapping and Cadastre).

Tab. 6-4 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 2016.

	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	804.1	0.0	**811.9**
	Other Land	0.0	0.0	0.0	0	0	0.0	**0.0**
	Area (kha)	2629.0	3467.9	828.5	156.1	805.0	0.0	**7886.4**

	2016	Initial (2015)						Area (kha)
	Category	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	
Final (2016)	Forest Land	2667.8	0.6	0.4	0.0	1.0	0.0	**2669.8**
	Cropland	0.1	3203.6	1.0	0.0	0.3	0.0	**3205.0**
	Grassland	0.1	4.1	998.4	0.0	0.7	0.0	**1003.4**
	Wetlands	0.0	0.3	0.2	165.2	0.2	0.0	**165.9**
	Settlements	0.3	2.7	0.6	0.2	733.1	0.0	**824.9**
	Other Land	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	Area (kha)	2668.3	3211.3	1000.6	165.5	841.2	0.0	**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. 6-4 shows products of that analysis (for the base year 1990 and 2016), 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 the 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)

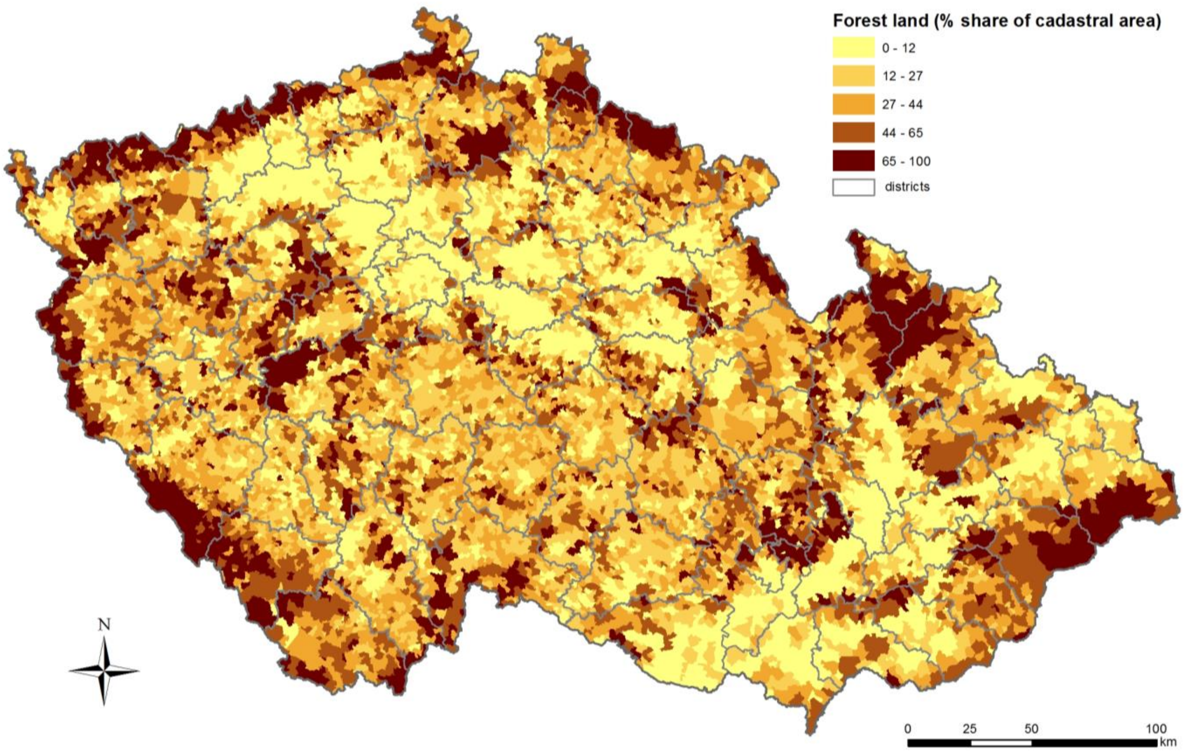

Fig. 6-5 Forest land in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2016).

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 Gl., 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 (ID 11) category of the Czech cadastral system administered by COSMC. With respect to the definition thresholds of the Marrakesh Accords, a 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[3]. As this definition of forest excludes the areas of currently (temporarily) unstocked cadastral forest land, such as forest

[3] 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

roads, forest nurseries and land under power transmission lines, these are discounted in all the emission estimates involving Forest Land using the annually updated information on the ratio of timberland to cadastral forest land. In this way, the area of cadastral forest land is also linked to the national definition of timberland (Czech Forestry Act 289/1996). These areas and the related activity data on forests on (see more below) are collected as a bottom-up process based on the mandatorily elaborated forest management plans (FMP). FMP and/or forest management outlines (for forest properties under 50 ha) serve for overall assessment of forest condition, which is mandatorily requested under the Czech Forestry Act (289/1996). In 2016 (1990), the area of Forest Land equalled 2 670 (2 629) thous. ha, whereas the stocked forest area (timberland) corresponded to 2606 (2 583) thousand ha, representing 97.6 (98.2)% of the cadastral forest land in the Czech Republic. Hence, the current temporarily unstocked area, not accounted for in forest biomass emission estimates, represents 2.4 (1.8)% of the forest land according to the Czech cadastral data.

Forests (cadastral forest land) currently occupy 33.9% of the area of the country (MAF, 2017). The tree species composition is dominated by conifers, which represent 72.1% of the timberland area. The four most important tree species in this country are spruce, pine, beech and oak, which account for 50.5, 16.4, 8.3 and 7.2% of the timberland area, respectively (MAF, 2017). Broadleaved tree species have been favoured in new afforestation since 1990. The proportion of broadleaved tree species increased from 21% in 1990 to over 27% in 2016. The total growing stock (merchantable wood volume) in forests in the country has increased during the reported period from 564 mil. m^3 in 1990 to 696 mil. m^3 (under bark) in 2017 (MAF, 2017).

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 the Forest Management Plans (further denoted as FMP), which are centrally administered 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 2011 to 2015. Its results were gradually released during 2016 and 2017. Other auxiliary statistical information on forests at a county level is provided by the Czech landscape inventory (CzechTerra; www.czechterra.cz). It is 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 been included in this emission inventory report. However, the emission inventory is still primarily 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 complementarily utilized, specifically for other carbon pools, such as deadwood and litter.

The FMP data were aggregated in accordance 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 based on 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 2016, clear-cut areas represented 1.2% of timberland areas within Forest Land.

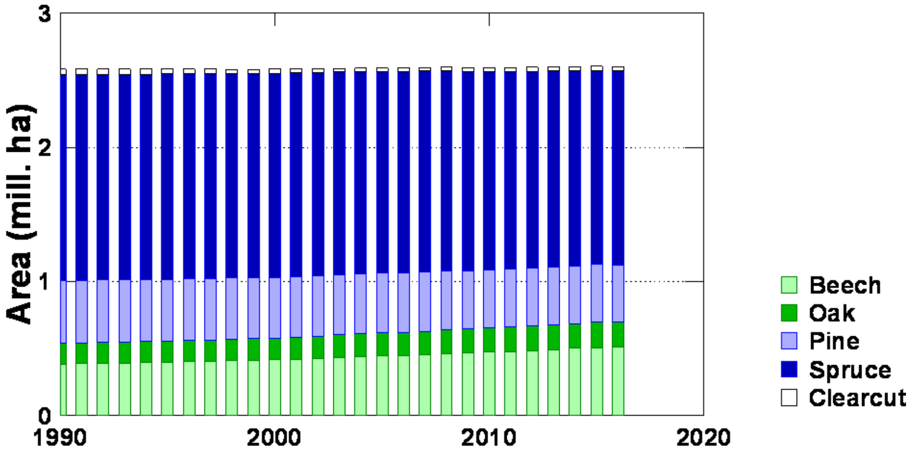

Fig. 6-6 Activity data – area for the four major groups of species and clearcut area during 1990 to 2016.

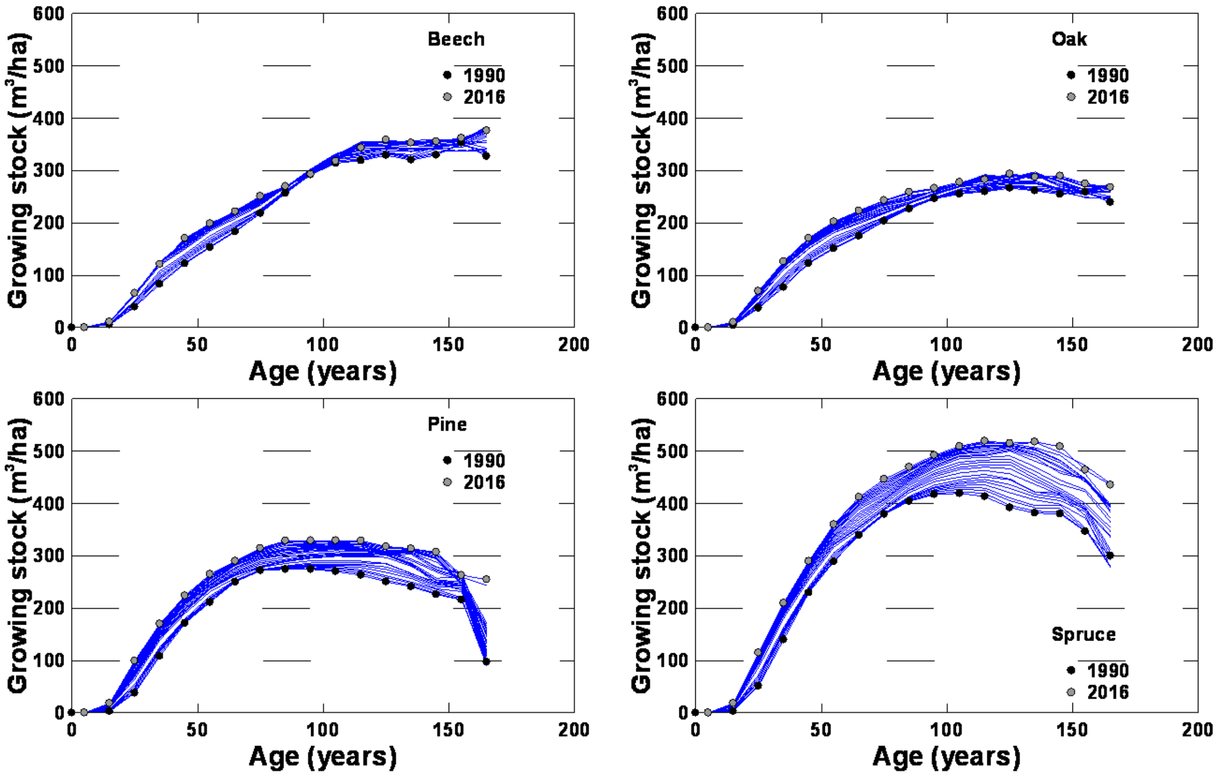

Fig. 6-7 Activity data – mean growing stock volume against stand age for the four major groups of species during 1990 to 2015; each line corresponds to an individual inventory year. The symbols identify only the situation in 1990 and 2016.

Fig. 6-7 shows the average growing stock for all tree species groups. It has increased steadily for all tree species groups since 1990 in this country.

The annual harvest volume constitutes the other key information related to forestry. This value is available from the Czech Statistical Office (CzSO). CzSO collects this information on the basis of about 600 country respondents (relevant forest companies and forest owners) and includes commercial harvest and fuel wood, with compensation for the forest areas not covered by the respondents. According to this information, the total drain of merchantable wood from forests increased from 13.3 mil. m^3 in 1990 to 17.6 mil. m^3 (under bark) in 2016, down from the all-time high of 18.5 mil. m^3 harvested in 2007 (all data refer to under-bark volumes, MAF 2017).

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 disturbances, which includes the categories of natural disasters, pollution, insects and other effects (CzSO, J. Kahuda, personal communication 2013). Therefore, the total applicable harvest is linked to the actual share of salvage logging that is annually reported by CzSO and elsewhere (MAF 2017). In 2016, the applicable volume of total annual harvest drain reached 19.5 mill. m^3, down from the maximum of nearly 21 mill. m^3 estimated for 2007. The harvest drain applicable for the emission inventory for the entire reporting period between 1990 and 2016 is shown in Fig. 6-8. The information on reported harvest, share of salvage logging, quantity of harvest by disturbance type and applicable additional harvest drain is also provided in Tab. 6-5. Tab. 6-7 also shows total harvest drain disintegrated by species groups for 1990 and 2016.

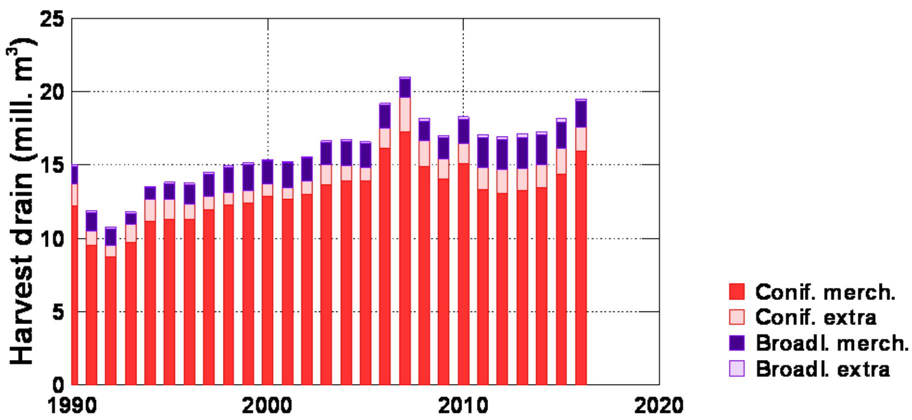

Fig. 6-8 The applicable total annual harvest drain for coniferous (Conif.) and broadleaved (Broadl.) tree species, which includes both the reported quantities of merchantable wood for the two categories (Conif. merch, Broadl. merch.) and the associated harvest loss (Conif. extra, Broadl. extra) for the entire reporting period of 1990 to 2016.

Tab. 6-5 The reported harvest, total share of salvage logging in the reported harvest, quantity of salvage logging by disturbance type (source data CzSO) and total applicable additional harvest loss (source data IFER, CzSO).

Variable	Unit	Year					
		1990	2000	2005	2010	2015	2016
Reported base harvest	Mm^{-3}	13.3	14.4	15.5	16.7	16.1	17.6
Share of salvage logging	% of reported harvest	71	14	17	39	50	53
- abiotic/natural	Mm^{-3}	NA	2.39	2.3	4.07	4.39	2.64
- pollutants	Mm^{-3}	NA	0.08	0.04	0.03	0.03	0.03
- insect outbreaks	Mm^{-3}	NA	0.32	0.98	1.79	2.31	4.42
- other	Mm^{-3}	NA	0.5	1.22	0.57	1.43	2.31
Additional loss (IFER, CzSO)	Mm^{-3}	1.62	0.92	1.04	1.48	2	1.9
Total harvest loss	Mm^{-3}	14.9	15.4	16.6	18.2	18.2	19.5

As is apparent from Tab. 6-5, the most common type of disturbance requiring salvage logging was insect outbreaks in the country in 2016. Also important is damage by abiotic factors, such as wind, snow and other climatic phenomena. On the contrary, a damage attributable to pollutants became less apparent in recent years and compared to late 1980s and early 1990s, when the region suffered from significant air pollution impacts. The residual of that period can be traced in soils, which still remain regionally acidified and apparently degraded in terms of nutrients (Hruska and Cienciala 2003). In this context, it is also important to note, that causal attribution of factors responsible to declining tree health is complex and the forest management evidence, which is the basis of the information in Tab. 6-5, does not discern the underlying factors such as unfavourable soil chemistry and sensitivity to drought, but reports on the final visible phenomena of affected trees (Cienciala et al., 2017). In this context it is important to note, the inventory team is not in position to conduct verification of the national information on disturbance type and additional harvest (Tab. 6-5) provided centrally by CzSO, as s by the latest UNFCCC in-country review.

6.4.2 Methodological issues

Category 4.A Forest Land includes emissions and sinks of CO_2 associated with forests and non-CO_2 gases generated by burning in forests. This category is composed of 4.A.1 Forest Land remaining Forest Land and 4.A.2 Land converted to Forest Land. The following text describes the major methodological aspects related to emission inventories for both forest sub-categories.

The methods of area identification described in Section 6.1.2 distinguish the areas of forest with no land-use change over the 20 years prior the reporting year. These lands are included in subcategory 4.A.1 Forest Land remaining Forest Land. The other part represents subcategory 4.A.2 Land converted to Forest Land, i.e., the forest areas “in transition” that were converted from other land-use categories over the 20 years prior to the reporting year. The areas of forest subcategories, i.e., 4.A.1 and 4.A.2, accumulated over a 20-year rolling period can be found in the corresponding CRF Tables. The annual matrices of identified land-use and land-use changes are given in Tab. 6-4 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[4] according to Eq. 2.7 of the 2006 IPCC Gl.. 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 Gl.). The key input for calculation of the carbon increment is the volume increment (I_v) data. In the Czech Republic, these values have been traditionally calculated at FMI[5] (FMP database administrator; see also Acknowledgment) and reported to 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 reporting requirements for a consistent time series.

[4] Alternative approaches of the stock-change method (Eq. 2.8; IPCC 2006) were also analysed (Cienciala et al. 2006a) for this category. However, for several reasons, the default method was finally adopted and is discussed in the cited study.
[5] 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.

No change, apart from entering the actual increment for the latest reported year, was made to the increment in the inventory submissions thereafter (Fig. 6-9).

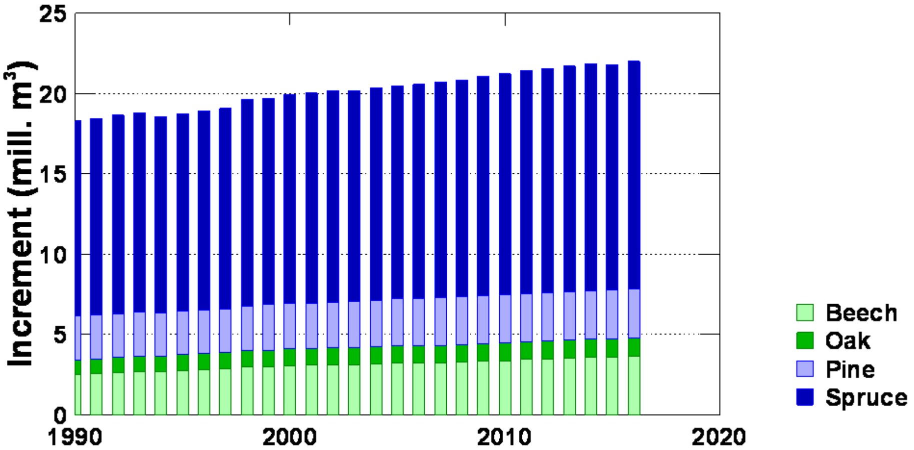

Fig. 6-9 Current annual increment (Increment, mil. m^3 under bark) by the individual tree species groups as used in the reporting period 1990 to 2016.

The merchantable volume increment (I_v) is converted to the biomass increment (G_{Total}), biomass conversion and expansion factors applicable for the increment ($BCEF_i$) using Eqs. 2.9 and 2.10 (AFOLU, 2006) as follows:

$$\Delta C_G = \sum_j (A_j \times G_{Total_j} \times CF_j) \quad (1)$$

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:

$$G_{Total} = \sum \{I_V \times BCEF_i \times (1 + R)\} \quad (2)$$

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. 6-6 lists the factors used in the calculation of the biomass carbon stock increment.

Tab. 6-6 Input data and factors used in carbon stock increment calculation (1990 and 2016 shown) for beech, oak, pine and spruce species groups, respectively

Variable or conversion factor	Unit	Year 1990	Year 2016
		Species group	
		Beech, Oak, Pine, Spruce	Beech, Oak, Pine, Spruce
Area of forest land remaining forest land (*A*)	kha	381; 156; 466; 1539	512; 188; 428; 1458
Biomass conv. & exp. factor, incr. (*$BCEF_i$*)	Mg m^{-3}	0.741; 0.862; 0.524; 0.595	0.738; 0.851; 0.526; 0.598
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*)	-	0.234; 0.235; 0.291; 0.209	0.232; 0.231; 0.229; 0.205
Volume increment (*I_v*)	m^{3}ha^{-1}	6.55; 5.96; 5.84; 7.89	7.21; 6.00; 7.12; 9.79

In Tab. 6-6, *A* represents only the areas of 4.A.1 Forest Land remaining Forest Land, updated annually. The applied biomass conversion and expansion factors applicable for the increment ($BCEF_i$) and growing stock volumes ($BCEF_h$) are based on national allometric studies (Cienciala et al., 2006a, 2006b, 2008a) or biomass compilations that include data for 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. 6-6 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. Since submission of the 2014 inventory, the carbon fraction in woody biomass (*CF*) of 0.50, earlier a generally accepted default constant (IPCC 2003), was replaced by somewhat more conservative values of 0.48 and 0.49 for broadleaved and coniferous tree species, respectively (Tab. 6-6). This is in accordance with the values suggested by IPCC (2006) based on a more extensive literature survey. The ratio of below-ground biomass to above-ground biomass (*R*) was estimated for individual species groups and the corresponding actual growing stock volumes based on the recommended values for forests in temperate zones in Table 4.4 of IPCC (2006). The applicable corresponding values of *R* are listed for 1990 and 2016 in (Tab. 6-6). *R* 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 in Central Europe (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 loss (*L*; Eq. 3) in 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 explicitly nationally reported by CzSO since 2009. 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 that is also linked to the amount of salvage logging (disturbances). To include the biomass loss associated with harvesting, fraction F_{HL} was added 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 fraction, F_{HL}. This estimate was used to account for harvest loss associated with the reported harvest of merchantable wood volume and share of salvage logging until 2010. Since 2011, however, the newly introduced harvest loss estimate of CzSO is used exclusively. The calculation of the total carbon drain (*L*; loss of carbon) associated with wood removals follows Eq. 2.12 (AFOLU 2006) as

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

where $BCEF_h$ represents the biomass conversion and expansion factor applicable to the 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 the 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. 6-6. The specific values of the input variables and conversion factors used to calculate *L* are listed in Tab. 6-7.

Tab. 6-7 Specific input data and factors used in calculation of the carbon loss due to harvest (1990 and 2016 shown) for beech, oak, pine and spruce species groups, respectively

Variable or conversion factor	Unit	Year 1990	Year 2016
		Species group	
		Beech, Oak, Pine, Spruce	Beech, Oak, Pine, Spruce
Harvest drain volume (*H*)	Mm^3	0.95; 0.35; 1.49; 12.16	1.44; 0.43; 1.52; 16.13
Biomass expansion factor ($BCEF_h$)	$Mg\ m^{-3}$	0.782; 0.864; 0.524; 0.587	0.716; 0.830; 0.525; 0.582

The impact of disturbances (Eq. 2.14, AFOLU, 2006) is included in full in the total harvest drain volume (*H*). This reflects the country-specific circumstances with commonly spatially inexplicit (i.e., unknown specific area) expression of forest disturbances with spot-wise occurrence of affected trees and groups of trees. Disturbances in the country are, however, mandatorily registered in terms of salvaged wood volumes. Therefore, the available data on salvage logging from CzSO (and MAF 2016) are also traceable using disturbance origin by categories including natural disaster, air pollution, insect and other (Tab. 6-5). This information is obligatorily reported by the forestry practice, which must always prioritize salvage logging at the expense 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. Consequently, no distinction is made in terms of disturbance impact on carbon pools in the sense of, e.g., Table 2.1 of IPCC (2006), as disturbance is treated as an integral part (although quantifiable by volume share) of harvest loss under the conditions of the predominantly managed forests in the country. Note also that this treatment has no effect on dead organic matter pool, as all above-ground biomass is assumed to be instantaneously oxidized, except for the fraction allocated to biomass burning in association with harvest as described below.

The uncertainty related to the estimate of additional harvest loss is conservatively assumed to be 30%, based on the differences in estimates earlier provided by IFER and that of CzSO representing the nationally reported data. The mean difference in these estimates for the period of 2011-2016 is 27%.

The assessment of the net carbon stock change in organic matter (specifically deadwood) for category 4.A.1 has been revised for this inventory submission and follows the Tier 2 stock-difference method according to Eq. 2.8 of IPCC (2006). The required activity data for the deadwood component were taken from the two statistical inventory programs available in the country as described in Section 6.4.1 above, namely the National Forest Inventory (NFI, FMI 2007) – campaign as of 2001/2004, and the Landscape inventory CzechTerra (Cerny et al. 2015, Cienciala et al. 2015) – campaigns as of 2008/2009 and 2014/2015. Specifically for deadwood, data combined carbon stock in standing as well as lying dead trees. The source data are the mean standing deadwood biomass and the volume of lying deadwood classified in four categories according to the 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/m3), 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). Data for the years between the measurement campaigns were linearly interpolated.

As for litter component, only the data of CzechTerra, 2008/2009 campaign, are available, providing the reference mean carbon stock held in litter (11.1 t C/ha; CzechTerra landscape inventory 2009, Cienciala et al. 2015). These data are not yet adequate for proving carbon stock change estimates in litter for category 4.A.1, which resorts to using Tier 1 assumption of no change (IPCC 2006) for this category.

The assessment of net carbon stock change in soils for category 4.A.1 followed the Tier 1 (default) assumption of carbon stock changes considered to equal zero (Tier 1, IPCC 2006). This is related to both mineral and organic soils. Organic soils occur only in the areas of the Spruce sub-category in 4.A.1 Forest Land remaining Forest Land. They represent protected peat areas in mountainous regions predominated by spruce stands, with no or specific management practices. No such areas occur under the other sub-categories with the predominant species of beech, oak and pine.

Emissions in category 4.A.1 Forest Land remaining Forest Land include, in addition to CO_2, also other greenhouse gases (CH_4, CO, N_2O and NO_X) resulting from burning. This encompasses both prescribed fires associated with burning of biomass residues associated with harvest, and also emissions due to wildfires. The emissions from prescribed burning of biomass residues were estimated according to Eq. 2.27 of IPCC (2006) and the emission and combustion factors in Table 2.5 and 2.6, respectively (IPCC 2006). Eq. 2.27 reads as

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3} \quad (4)$$

where L_{fire} is the amount of greenhouse gas emissions from fire in tons of gas considered (CH_4, N_2O), A is area burned (ha), M_B is the mass of fuel available for combustion (t/ha), C_f is the combustion factor (-) and G_{ef} is the emission factor (g/kg).

Under the conditions in this country, part of the biomass residues is burned in connection with the final cut. Hence, this practice (prescribed burning) 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 are burned. This is less than assumed for the inventory years before 2010 (30%), which corresponds to 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 434 Gg in 2016. These values, as well as the applicable factors used in Eq. 4 to estimate emissions from fire, are listed in Tab. 6-8.

Tab. 6-8 Specific input data and factors used in to estimate emissions of N_2O and CH_4 from prescribed burning in forests (1990 and 2016 shown) according to Eq. (4).

Variable or conversion factor	Unit	Year 1990	Year 2016
Amount of biomass burnt (AxM_B)	Gg	590	434
Combustion factor (C_f)	-	0.62	0.62
Emission factor (G_{ef}) for CH_4	g kg^{-1} dry matter burnt	4.7	4.7
Emission factor (G_{ef}) for N_2O	g kg^{-1} dry matter burnt	0.26	0.26

Note that Tab. 6-8 does not show the factor associated with the release of CO_2 in prescribed burning. This is to prevent double counting, as that part of emissions is already included within the harvest loss (Eq. 3). Finally, Tab. 6-8 also does not list the factors used to estimate CO and NOx gases, which are complementarily also estimated using Eq. 4, with emission factors (G_{ef}) equal to 107 and 3.00, respectively.

The emissions of greenhouse gases from 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). The associated amounts of non-CO_2 gases (CH_4, CO, N_2O and NO_X) were estimated according to Eq. 2.27 (IPCC 2006), which is listed above as Eq. 4. The combustion factor (C_f) used was 0.45 (Table 2.6, IPCC 2006), whereas emission factors for the individual gases as well as the carbon fraction were identical to those for prescribed burning listed above. The amount of biomass (dry matter) burned in wildfires was estimated as 10.2 Gg in 1990 and 10.6 Gg in 2016. The most extreme year of the reporting period was 1997, when about 228 Gg of biomass was burned due to wildfires over an area of almost 3.5 thous. ha. In 1990 and 2016, the reported forest areas under wildfire were 168 and 141 ha, respectively. During the reporting period since 1990, there has been no single year without a reported wildfire. The mean annual forest area affected by forest wildfires equalled 616 ha during the 1990 to 2016 period. The full time series and the associated emissions of non-CO_2 gases can be found in the corresponding CRF Tables.

There are no direct N_2O emissions from N fertilization on Forest Land, as there is no practice of nitrogen fertilization of forest stands in the Czech Republic. Similarly, non-CO_2 emissions related to drainage of wet forest soils are not reported, as this activity no longer occurs in practice.

6.4.2.2 Land converted to Forest Land

The methods employed to estimate emissions in the 4.A.2 Land converted to Forest Land category are similar to those for the category of Forest Land remaining Forest Land, but they differ in some assumptions, which follow the recommendations of AFOLU (IPCC 2006).

For estimation of the net carbon stock change in living biomass on Land converted to Forest Land according to 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 the areas of all conversion types updated annually. Land areas are considered to be under conversion for a period of 20 years, according to the default assumption of IPCC (2006). Under the conditions in this country, all newly afforested lands are considered to be 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 SILVISIM national growth and yield model (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 increments 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 above-ground biomass, the estimated aggregated mean increment for 2016 was 3.26 t/ha, a value matching well those given for temperate forest systems given as defaults in Table 4.12 of IPCC(2006). The estimation of increments in terms of above-ground 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 0.995, 1.247, 0.654 and 0.925 for beech, oak, pine and spruce, respectively. The volume-weighted mean $BCEF_i$ was 0.913 for 2016. The share of below-ground biomass (ratio R) is estimated based on species- and volume-specific values provided in Table 4.4 (IPCC 2006). In 2016, the factor R applicable for 4.A.2 Land converted to Forest Land was 0.216.

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 is 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 the 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 (11.1 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 1:5,000 and 1:10,000 maps, 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 2016), serving as reference levels of soil carbon stock applicable to forest and agricultural soils. Since agricultural soils include both Cropland and Grassland land-use categories, the bulk soil carbon content obtained from the map was adjusted for the two categories. This was performed by applying a ratio of 0.85 relating the soil carbon content between Cropland and Grassland (J. Šefrna, personal communication 2007) and considering the actual areas of Cropland and Grassland in the individual cadastral units. This system permitted estimation of the soil carbon stock change among categories 4.A Forest Land, 4.B Cropland and 4.C Grassland. The estimated quantities of carbon stock change at the level of the individual spatial units were entered into 20-year accumulation matrices distributing carbon into fractions over 20 years (IPCC 2006). These quantities, together with the accumulated areas under the specific conversion categories, were used for estimation of emissions and removals of CO_2. In 2016, the area-weighted mean carbon stock in mineral soil per cadastral unit (n=13 091) equalled 66.5, 58.5 and 68.2 kg C/ha for Forest land, Cropland and Grassland, respectively.

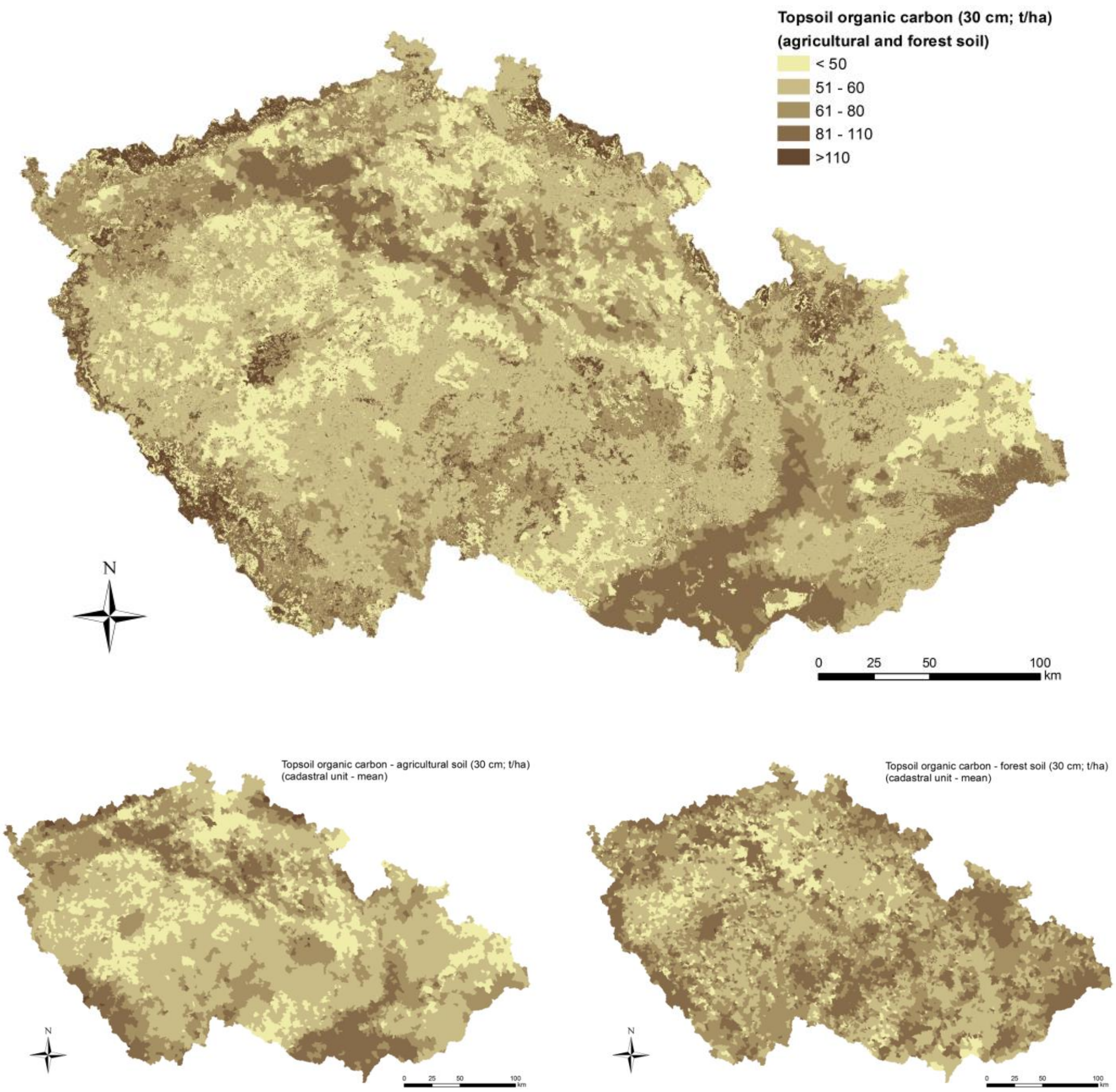

Fig. 6-10 Top - topsoil (30 cm) organic carbon content map adapted from Macků et al. (2007), Šefrna and Janderková (2007); bottom – topsoil carbon content for agricultural (left) and forest (right) soils estimated as cadastral unit means from the source maps. The unit (t/ha) and unit categories are identical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

The net changes in carbon stock in organic soils, occurring only in the sub-category of stands dominated by spruce, were assumed to be insignificant (zero). This is in accordance with the general assumption of the Tier 1 method applicable for forest soils, as no other specific methodology is available for organic soils except for drained ones (IPCC 2006).

Non-CO_2 emissions from burning are not estimated for category 4.A.2 Land converted to Forest Land, as this practice is not employed in this country. The same applies to N_2O emissions from nitrogen fertilization, which is not carried out on forest land in this country.

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 2016.

The uncertainty estimation was guided by the Tier 1 methods outlined in GPG for LULUCF (IPCC, 2003) and IPCC 2006 Gl. (IPCC 2006) employing the following equations:

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

where U_{total} is the percentage uncertainty in the product of the quantities and U_i denotes the percentage uncertainties in each of the quantities (Eq. 3.1, Volume 1, Chapter 3, IPCC 2006).

For the quantities that are combined by addition or subtraction, we used the following equation to estimate the uncertainty:

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

where U_{total} is the percentage uncertainty of the sum of the quantities, U_i is the percentage uncertainty associated with source/sink *i*, and x_i is the emission/removal estimate for source/sink *i* (Eq. 3.2, Volume 1, Chapter 3, IPCC 2006).

It should be noted, however, that Eq. 5 is not fully applicable to the LULUCF sector. Summing negative (removals) and positive (emission) members (x_i) in the denominator of equation 5 may produce unrealistically high uncertainties and can 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 (2006), which 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 combustion factors used in calculation of emissions from prescribed burning (20%) and forest fires (36%), respectively, based on the information in Table 2.6 (IPCC 2006). 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 the 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 at the level of the entire land-use category or at the level of the entire LULUCF sector according Eq. 5. This is calculated on the basis of CO_2 or CO_2 eq. units and the corresponding uncertainty estimates respect the actual direction of the source and sink categories to be combined.

For 2016, 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 21% and 32%, respectively. Correspondingly, the uncertainty for the entire 4.A Forest Land category reached 19%.

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 Gl. (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. The improvements implemented in this inventory submission are listed below.

General and 4.A.1 Forest Land Remaining Forest Land

In response to issues L.6[6] and L.8 of the last review, the activity data and estimates related to biomass burning on forest land remaining forest land, the section was revised to ensure complete adherence to the 2006 IPCC Gl. (IPCC 2006). Now it uses the full set of IPCC (2006) EF parameters documented in NIR. Also, the attribution of CO_2 from the prescribed burning was revised, preserving CO_2 emissions within biomass loss. The revision also concerns emissions from wildfires, with the exception of attribution of CO_2 emissions, which remain reported under wildfires together with CH_4 and N_2O in accordance with IPCC (2006) recommendations.

[6] Note that all references (IDs) made to the review issues relate to the draft ARR document as of 30 January 2018. Hence, these references may change in the final ARR (not available at the time of compiling this report).

4.A.1 Forest Land Remaining Forest Land

- Carbon stock change in biomass:
  Partly in response to review issue L.6, this inventory newly introduced a volume-weighted factor *R* assigning below-ground biomass based on the carbon-density- and species-specific forest stand values as given in IPCC 2006, Table 4.4. *R* was recalculated for the entire time series since 1990. The biomass estimates changed accordingly.
- Carbon stock change estimates for DOM and litter:
  In response to issues L. 3 and L.14 of the last review, the estimates for dead organic matter (DOM) are newly introduced. They are based on the data from the available forest inventory programs, namely the NFI1 (2001-2014) and Landscape inventory CzechTerra CZT1 (2008-2009) and CZT2 (2014-2015). The estimation follows the stock difference method (Eq. 2.19 of IPCC 2006).
- Biomass Burning:
  In response to review issues L.6 and L.8, estimation of emissions from biomass burning was revised using the complete set of combustion and emission factors of IPCC 2006. Also since this inventory submission, CO_2 emissions from prescribed burning are reported as included elsewhere (IE), namely in carbon loss from harvest. This resulted in somewhat more conservative estimates of emissions from biomass burning (CO_2, N_2O, CH_4). The entire time series since 1990 was recalculated.

4.A.2 Land converted to Forest Land

- Carbon stock change in biomass:
  Partly in response to issue L.6, this inventory newly employs the volume-weighted R-factor assigning below-ground biomass based on the carbon-density- and species-specific forest stand values as given in IPCC 2006, Table 4.4. R was recalculated for the entire time series since 1990. The biomass estimates changed accordingly for all land-use conversions including forest land (4.A.2.1, 4.A.2.2, 4.A.2.3, 4.A.2.4, 4.B.2.1, 4.C.2.1, 4.D.2.1 and 4.E.2.1).
- Carbon stock change estimates for DOM and litter:
  In response to issue L. 14, estimates for DOM and litter carbon pools are newly introduced and/or revised. They are based on data from the available forest inventory programs, namely NFI1 (2001-2014) and Landscape inventory CzechTerra CZT1 (2008-2009) and CZT2 (2014-2015). The estimation follows the stock difference method (Eq. 2.19 of IPCC 2006). Note that, apart from category 4.A.2, these improvements also affect DOM estimates for categories 4.B.2.1, 4.C.2.1, 4.D.2.1 and 4.E.2.1.

The effect of these corrections on the total emission estimates for category 4.A Forest Land is shown in Fig. 6-11. On an average, the emission removals decreased by 1.8% compared to the previously reported estimates as assessed for the comparable period of 1990 to 2015. Both 4.A.1 Forest land remaining Forest land and 4.A.2 Land converted to Forest land qualify among the key categories in this inventory submission.

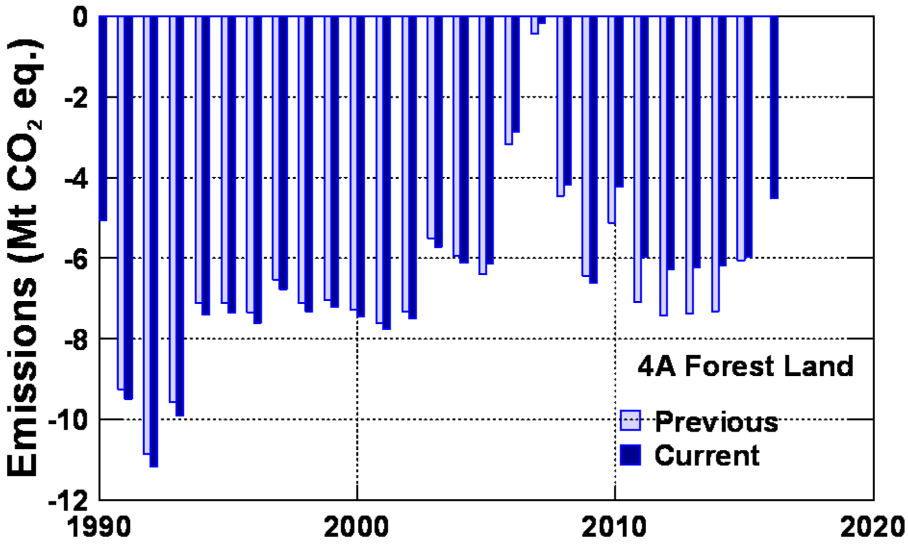

Fig. 6-11 Current and previously reported assessment of emissions for category 4.A Forest Land. The values are negative, hence representing net removals of green-house gases

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 includes improved emission estimates for the carbon stock changes on both Land remaining Forest Land and Land converted to Forest Land. Other improvements are planned by the inventory team. They include 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, broader utilization of the data from the statistical inventory programs is planned, including repeated surveys 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 2016), 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.

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 2016. 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 in less productive regions of alpine and sub-alpine regions. In addition, there is a growing demand for land for infrastructure and settlements.

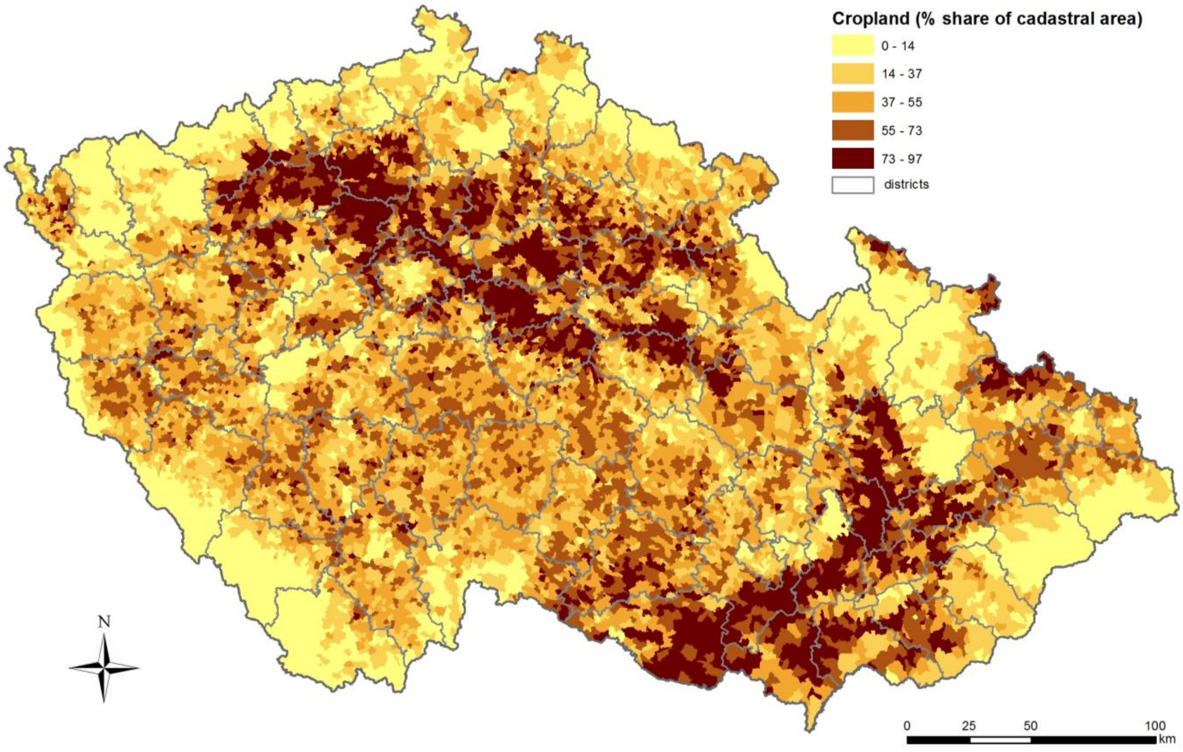

Fig. 6-12 Cropland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2016).

6.5.2 Methodological issues

The emission inventory of Cropland concerns sub-categories 4.B.1 Cropland remaining Cropland and 4.B.2 Land converted to Cropland. The emission inventory of Cropland considers changes in living biomass, dead organic matter and soil. In addition, N_2O emissions associated with soil disturbance during land-use conversion to cropland are quantified for this category.

6.5.2.1 Cropland remaining Cropland

For category 4.B.1 Cropland remaining Cropland, the changes in biomass can be estimated only for perennial woody crops. Under the conditions in this country, this is applicable to the categories of vineyards, gardens (one half of the area considered used for perennial vegetation) and orchards. These activity data are shown in Fig. 6-13.

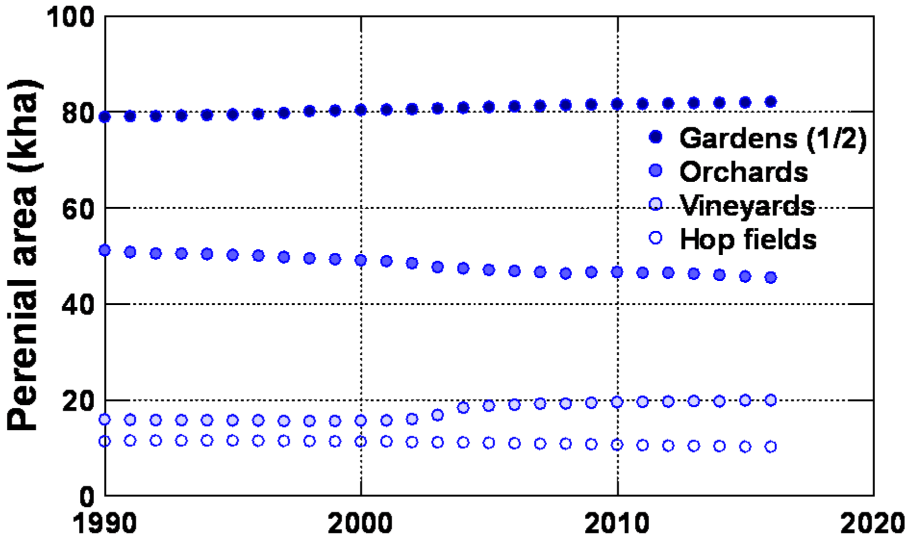

Fig. 6-13 Trend in perennial cropland area in the Czech Republic for the period 1990 to 2016.

To estimate emissions associated with biomass on Cropland, the default factors for the biomass accumulation rate (2.1 t C/ha/year), harvest maturity cycle (30 years) and above-ground biomass carbon stock at harvest (63 t C/ha), Table 5.1 (IPCC 2006) were employed to estimate biomass carbon pool changes for the areas concerned. The estimation can be described by the following Tier 1 equation based on Eqs. 2.7, 2.9, 2.10 of IPCC(2006) as:

$$\begin{aligned} &\textit{Annual change of biomass} \\ &\quad = \textit{Remaining area of perenial cropland} \times \textit{C accumulation rate} \\ &\quad - \textit{New perenial cropland area} \times 0.033 \times \textit{biomass C stock at harvest} \\ &\quad - \textit{Lost perenial cropland area} \times .0.5 \times \textit{biomass C stock at harvest} \end{aligned} \qquad (6)$$

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 newly revised for this category following the recommendation of the last inventory review. It used the country-specific average carbon content on Cropland estimated from the detailed soil carbon maps (Fig. 6-10). Next, the area of cropland was stratified according to specific management activities that determine assignment of appropriate land use, management and input factors as guided by Table 5.5. of IPCC (2006). Seven specific categories were defined for Cropland remaining Cropland. They discern non-perennial and perennial vegetation categories and their specific subtypes and determine the choice of emission factors. These categories and factors are summarized in Tab. 6-9.

Tab. 6-9 Categories of management activities by vegetation category on Cropland remaining Cropland, attributed land use, tillage (management) and input factors and corresponding areas (1990 and 2016 shown).

Management activity by vegetation category	Land use F_{LU}	Tillage F_{MG}	Input F_I	Area in 1990 (kha)	Area in 2016 (kha)
I. Non-perenial, arable land, no fallow	0.69	1.03	1	2 884.0	2 781.6
II. Non-perenial, arable land, fallow	0.82	1.15	0.92	162.3	185.9
III. Non-perenial, gardens (1/2)	0.69	1.08	0.92	78.9	82
IV. Non-perenial, hop fields	0.69	1.08	0.92	11.3	10.1
V. Perenial, gardens (1/2)	1.00	1.15	0.92	78.9	82
VI. Perenial, orchards	1.00	1.15	0.92	157.7	164
VII. Perenial, vineyards	1.00	1.08	0.92	15.8	19.8

The estimation follows Eq. 2.25 assuming a 20-year default period for the time dependence of stock change factors (D) and using the country-specific mean value for the reference carbon stock values in mineral soils (59 t C/ha). The national source of activity data required for the adopted categorization of management on cropland is COSMC, as for the annually updated areas of basic vegetation categories that determine management activities listed in Tab. 6-9. An assumption was made on the shares of perennial and non-perennial gardens, which were assigned identically as one half of the reported areal extent of gardens. Next, the share of fallow arable was obtained from the periodic Farm Structure Surveys conducted in 2016, 2013, 2007, 2005, 2003 and Agricultural Census 2010. These surveys are conducted in the European Union Member Countries following the requirements of the EU/EC legislation. In the Czech Republic, the survey is conducted on the basis of Act No 89/1995 Coll., on the State Statistical Service, as amended and of the Programme for Statistical Surveys for 2016. These data are available at CzSO. The tillage factor (F_{MG}) adopted for arable land (no fallow; Tab. 6-9) was derived on the basis of the country-specific share of tillage methods, which were reported in the Farm Structure Surveys for 2016 and 2010 (CzSO). It represents the weighted mean of F_{MG} as recommended in Table 5.5 of IPCC (2006) for the share of conventional tillage (66%), low tillage (33%) and zero tillage (direct seeding; 1%). The other factors used correspond to the recommended values in Table 5.5 for a temperate moist region (IPCC 2006).

Until the 2014 NIR submission, the Cropland category also included emissions due to liming. As a result of the specific trends 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 have been excluded from 4.B.1 Cropland remaining Cropland and reported under category 3.G Liming in the sector of Agriculture instead.

Non-CO_2 greenhouse gas emissions from burning (CH_4, N_2O) do not occur in category 4.B.1 Cropland remaining Cropland, as 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 the 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 the biomass carbon stock on Grassland prior to the conversion, the default factor of 6.8 t/ha for above-ground and below-ground biomass was used (Table 6.4, IPCC 2006). A biomass content of 0 t/ha was assumed after land conversion to 4.B Cropland.

The estimation of net carbon stock change in dead organic matter concerns land-use conversion from Forest Land. In this case, the input information on standing and lying deadwood was obtained from the available statistical inventories in the country: the National Forest Inventory (FMI 2007) and the recently conducted field campaigns (2009 and 2015) of the CzechTerra landscape inventory (Cerny, 2009; Cienciala et al. 2015, www.czechterra.cz). They provide data on the mean standing deadwood biomass and volume of lying deadwood classified in four categories according to degree of decomposition. These categories are defined as follows: i) basically solid wood; ii) peripheral layers soft, central hard; iii) peripheral layers hard, central soft; iv) totally rotten wood. The amount of carbon held in lying deadwood was estimated as the product of the wood volume, density weighted by the mean growing stock volume of major tree species (0.433 t/m^3), reduction coefficients of 0.8, 0.5, 0.5, 0.2 (Cerny et al., 2002; Carmona et al., 2002) applicable to the above described decomposition categories, respectively, and the carbon fraction in the wood (0.5 t C/t biomass). A default, conservative assumption that no deadwood is present following the land-use change was adopted in this calculation.

Estimation of the carbon stock change in soils for category 4.B.2 Land converted to Cropland in the Czech Republic concerns mineral soils. The soil carbon stock changes following the conversion from Forest Land and Grassland were quantified by the country-specific Tier 2/Tier 3 approach and are described in detail in Section 6.4.2.2 above.

The Land converted to Cropland category represents a source of non-CO_2 gases, namely emissions of N_2O due to mineralization. The estimation followed the Tier 1 approach of Eqs. 2.25 and 11.8 (IPCC 2006). Accordingly, direct N_2O emissions were quantified on the basis of the detected changes in mineral soils employing a default emission factor of 0.01 kg N_2O-N/kg N (EF1, IPCC 2006), and C:N ratio of 15. Linked to this, indirect N_2O emissions from atmospheric deposition of N volatized from managed soils were estimated using Eq. 11.10 and the emission factor 0.0075 (EF5, IPCC 2006).

Other non-CO_2 emissions can be related to those from burning. However, this is not common practice in this country and no other non-CO_2 emissions besides those described above are reported in the LULUCF sector.

6.5.3 Uncertainties and time-series consistency

The methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2015, and this also applies to the Cropland land-use category. The uncertainty estimation was guided by the Tier 1 methods outlined in the 2006 IPCC Gl. (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 (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 to 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 uncertainty associated with reference soil carbon was 10% and the uncertainty of array of individual emission factors used for mineral carbon stock change estimation were taken from Table 5.5 of IPCC(2006). The adopted uncertainty associated with the emission factors involved in estimation of direct and indirect N_2O emissions was 250%.

For 2016, using the above uncertainty values, the total estimated uncertainty for category 4.B.1 Cropland remaining Cropland was 29%. The corresponding uncertainty for category 4.B.2 Land converted to Cropland was 35%. The overall uncertainty for category 4.B Cropland was estimated at 26%, using the 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 Gl. (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 been recalculated following the suggestions of the latest review (L.15) and at the initiative of the inventory team. The improvements implemented in this inventory submission are listed below.

4.C.1 Cropland remaining Cropland

- Carbon stock change in biomass:
  The activity data for biomass were restructured in connection with the newly adopted methodology of mineral carbon stock change estimation (see below). Specifically, the areas of cropland with perennial vegetation include one half of gardens, vineyards and orchards. The estimation strictly uses the factors recommended by IPC Table 5.1 (IPCC 2006) following Tier 1 assessment based on Eqs. 2.7, 2.9, 2.10 of IPCC (2006). The entire time series was recalculated.

- Carbon stock change in mineral soil
  Following the suggestion of the last review (L.15), the estimation of emissions was accordingly revised. It uses the country-specific activity data for soil carbon, management systems and management activities, following Eq. 2.25 of IPCC (2006).The corresponding emission factors were used and/or derived based on Table 5.5 of IPCC(2006). This methodological revision (Tier 1, 2) concerns the entire time series, which was thereby recalculated.

The above implemented changes in the current submission regarding category 4.B Cropland and its biomass and soil carbon stock changes resulted in revised emission estimates. These are about twice as high compared to those reported in the previous inventory submission when comparing the identical period of 1990 to 2015 (Fig. 6-14). None of the individual emission categories for Cropland qualifies among the key categories by quantity or trend in this inventory submission.

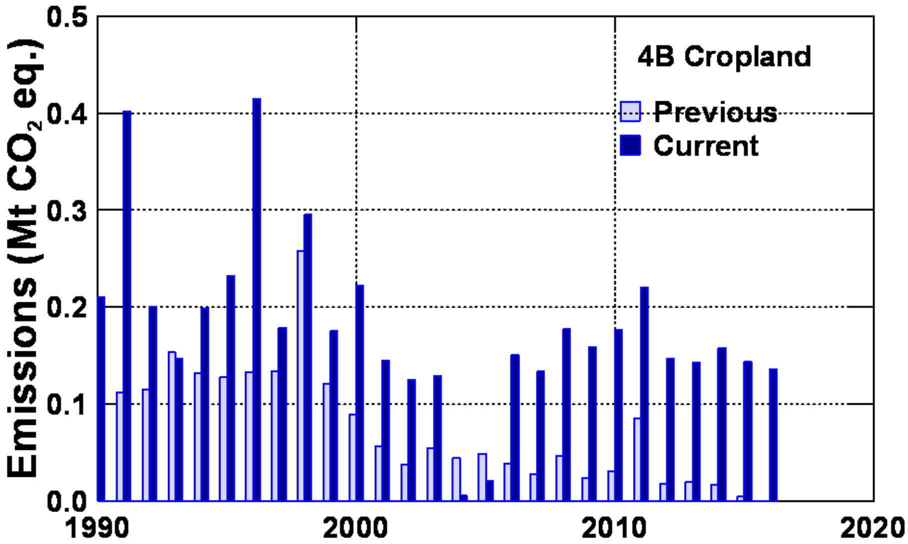

Fig. 6-14 Current and previously reported assessment of emissions for category 4.B Cropland

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 and further improving the spatial detail of emission estimation for soil carbon pools on agricultural land. Other improvements are planned for uncertainty estimates in this category.

6.6 Grassland (CRF 4.C)

6.6.1 Source category description

Through its spatial share of nearly 13% in 2016, 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 six such categories of agricultural land in the database of “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC. This land is mostly used as pastures for cattle and meadows for growing feed.

The importance of Grassland will probably increase in this country, both for its role in production and for preserving biodiversity in the landscape. According to the national agricultural programs, the fraction of Grassland should further increase to about 18% of the area of the country. The predominant 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 2016) since 1990.

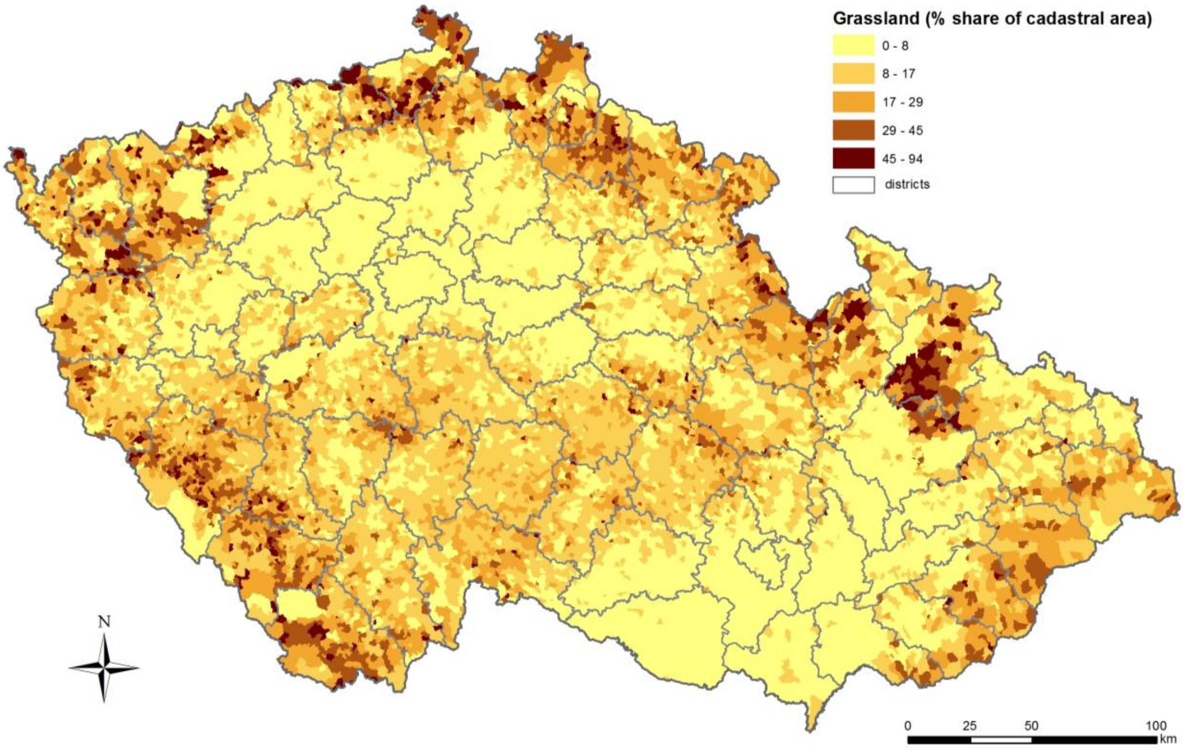

Fig. 6-15 Grassland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2016).

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 newly revised for this category following the recommendations of the last inventory review. It used the country-specific average carbon content on Grassland estimated and derived from the detailed soil carbon maps (Fig. 6-10). Next, the area of grassland was stratified according to specific management activities that determine assignment of the appropriate management and input stock change factors as guided by Table 6.2. of IPCC (2006). Four specific categories were defined for Grassland remaining Grassland. These categories and applicable relative stock change factors are summarized in Tab. 6-10.

Tab. 6-10 Categories of management activities by vegetation category on Cropland remaining Cropland, attributed land use, tillage (management) and input factors and corresponding areas (1990 and 2016 shown).

Management categories on grassland	Land use F_{LU}	Management F_{MG}	Input F_I	Area in 1990 (kha)	Area in 2016 (kha)
I.a Permanent grassland – improved	1.0	1.14	1	324.6	325.6
I.b Permanent grassland – nominally managed	1.0	1.00	-	324.6	325.6
II. Grassland for rough grazing	1.0	0.95	-	8.3	225.7
III. Grassland not used for production	1.0	0.7	-	8.0	9.0

The estimation follows Eq. 2.25 assuming a 20-year default period for the time dependence of stock change factors (D) and using the country-specific mean value for the reference carbon stock values in mineral soils (68 t C/ha). The national source of activity data required for the adopted categorization of grassland is COSMC for the annually updated grassland areas and management activities listed in Tab. 6-10. Next, the share of permanent grassland, grassland for rough grazing and grassland not used for production was obtained from the periodic Farm Structure Surveys conducted in 2016 and 2013, and from the Agricultural Census conducted in 2010. Data were linearly interpolated for other years of the reporting period. These surveys are prepared in the European Union Member Countries following the requirements of the EU/EC legislation. In the Czech Republic, the survey is conducted on the basis of Act No 89/1995 Coll., on the State Statistical Service, as amended and of the Programme for Statistical Surveys for the year 2016. These data are available at CzSO. In the absence of data supporting division of permanent grassland into nominal and improved management, this land area was equally divided into these categories (I.a and I.b in Tab. 6-10) and subjected to further investigation. The emission factors used as listed in Tab. 6-10 correspond to the recommended values in Table 6.2 for grassland management in a temperate moist region (IPCC 2006).

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 3 Agriculture instead.

Non-CO_2 greenhouse gas emissions from burning (CH_4, N_2O) do not occur in category 4.C.1 Grassland remaining Grassland, as this practice does not occur on Grassland in this country.

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 4.A 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 6.8 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 2016. The uncertainty estimation was guided by the Tier 1 methods outlined in the 2006 IPCC Gl. (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 40%, stock change factor for management regimes 11 to 40 % (as in Table 6.2 of IPCC (2006)), 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 2016, using the above uncertainty values, the total estimated uncertainty for category 4.C.1 Grassland remaining Grassland equalled 45%. The corresponding uncertainty for category 4.C.2 Land converted to Grassland equalled 21%. The overall combined uncertainty for category 4. Grassland is 33%.

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 Gl. (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

Since the last submission, the emission estimates have been recalculated following the suggestions of the latest review (L.17). The improvements implemented in this inventory submission are listed below.

4.C.1 Grassland remaining Grassland

- Carbon stock change in mineral soil
  Following the suggestion in the last review (L.17), the methodology was accordingly revised using the country-specific activity data on soil carbon, management systems and management activities, following Eq. 2.25 of IPCC (2006). The corresponding emission factors were used and/or derived based on Table 6.2 of IPCC (2006). This methodological revision (Tier 1, 2) concerns the entire time series that was thereby recalculated.

The above implemented changes in the current submission regarding category 4.B Cropland resulted in changed emission estimates. Specifically, the estimated emission sink decreased by 22% compared to the previously reported data assessed for the 1990 to 2015 period (Fig. 6-16).

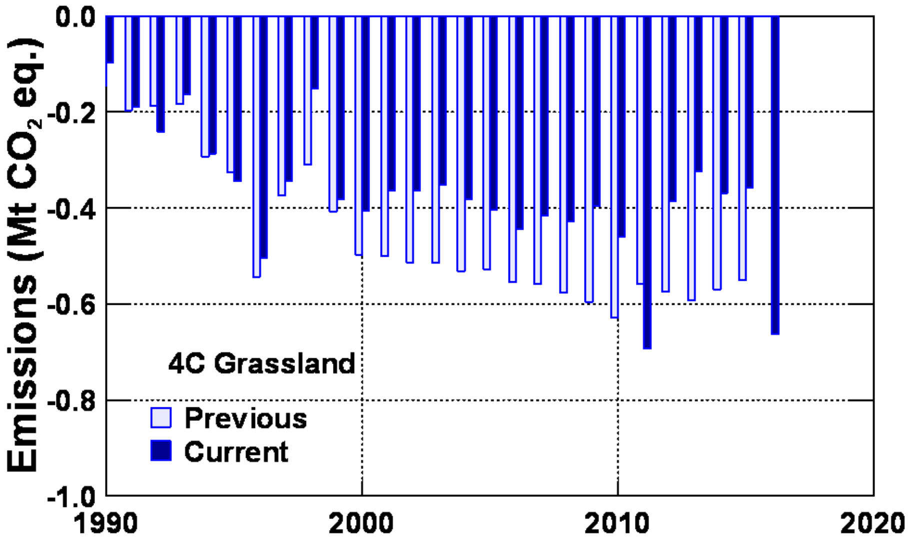

Fig. 6-16 Current and previously reported assessment of emissions for category 4.C Grassland. The values are negative, hence representing net removals of green-house gases.

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 (such as those on likely fire events on grassland), extent of management categories on grassland and more relevant emission factors. Further improvements 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 include riverbeds and water reservoirs such as lakes and ponds, wetlands and swamps. These areas predominantly correspond to the real estate category of water area (ID 11) of the “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC. Additionally, the water-logged areas classified under AACLC ID 14 “Other lands” are also included under 4.D Wetlands (Tab. 6-3). The specific land-use details of the land-use category water area are given in the Amendment to Act No. 357/2013 Coll. (Act on Cadastre). They include definitions of ponds (artificial water reservoir designed primarily for fish farming with complete and regular discharge), riverbeds natural or modified, artificial riverbeds of watercourses, natural water reservoirs, artificial water reservoirs, wetlands (marshes, wetlands, swamps) and water areas with buildings.

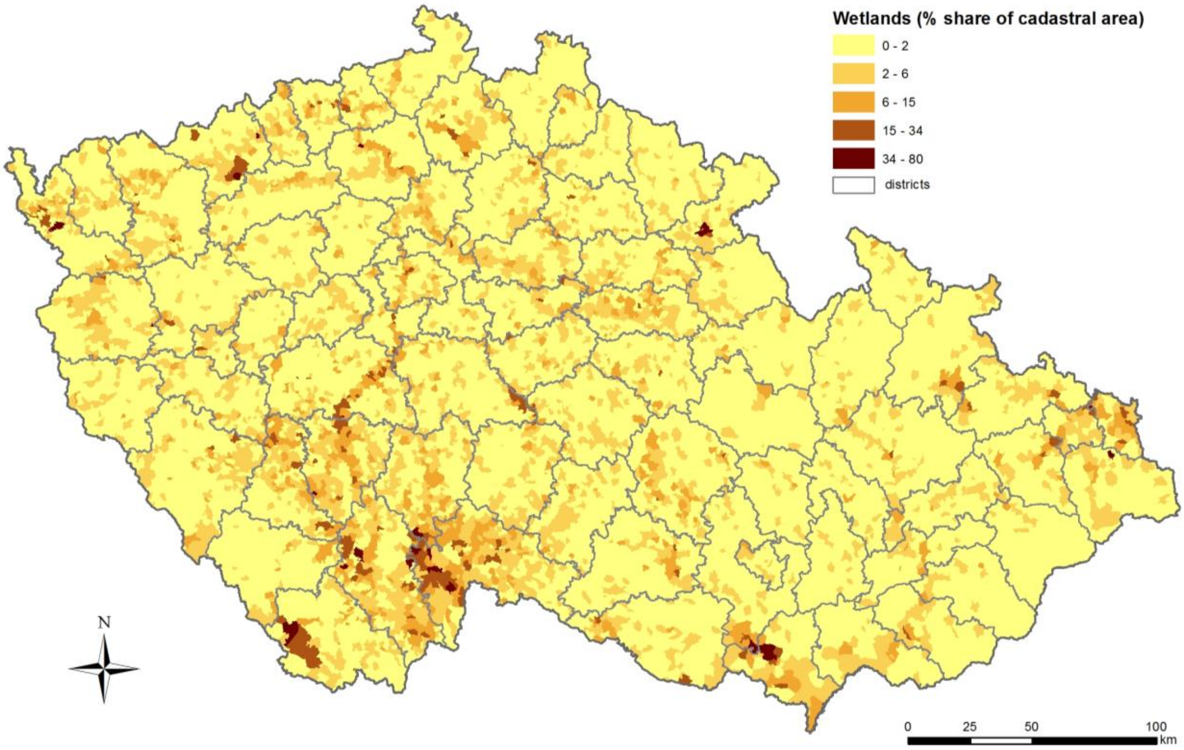

Fig. 6-17 Wetlands – distribution calculated as a spatial share of the category within the individual cadastral units (as of 2016).

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 an 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 a changing climate[7].

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 practically do not occur under the conditions in this country. Peat extraction basically ceased in the early 1990s following adoption of Act No. 114/92 on nature protection. Peat for industrial use now relies on imports (Belarus), with the exception of peat used in balneology. Hence, sub-category 4.D.1 Wetlands remaining Wetlands cannot be attributed to either flooded land or peat extraction lands. Thus, all wetland areas are reported under category 4.D.1.3 other wetlands remaining other wetlands. Correspondingly, the emissions for 4.D.1 Wetlands remaining Wetlands were not explicitly estimated for this sub-category.

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

[7] Based on the land-use history, the growth potential could be considered to be rather large. For example, as of 1990, the category included 50.7 thous. ha of ponds, which represented only 28% of their extent during the peak period in the 16th Century (Marek 2002)

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 employed 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 2016. Similarly as for the other land-use categories, the uncertainty estimation was guided by the Tier 1 methods outlined in the 2006 IPCC Gl. (IPCC 2006) and described in Section 6.4.3. It utilized primarily the default uncertainty values as recommended by IPCC (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 to 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 2016, the estimated uncertainty for category 4.D.2 was 69%.

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. 6-18).

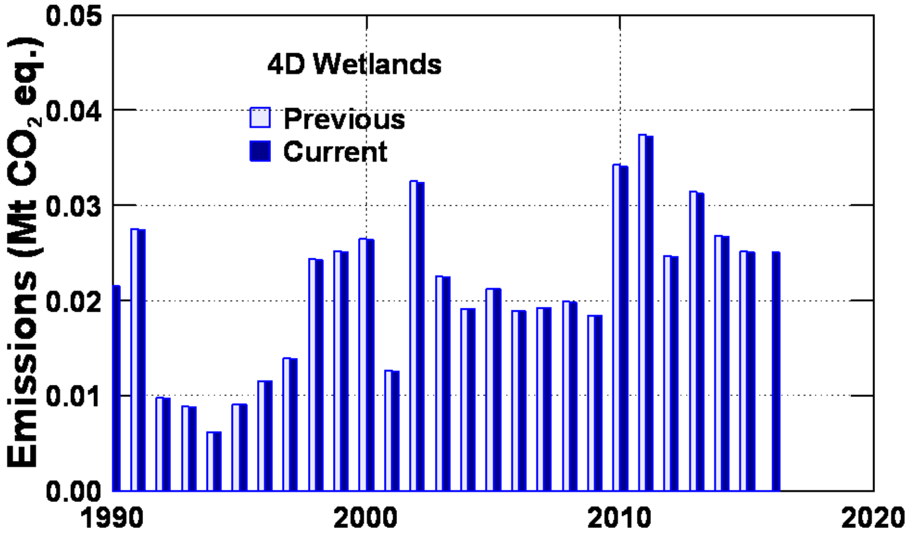

Fig. 6-18 Current and previously reported assessment of emissions for category 4.D Wetlands

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)

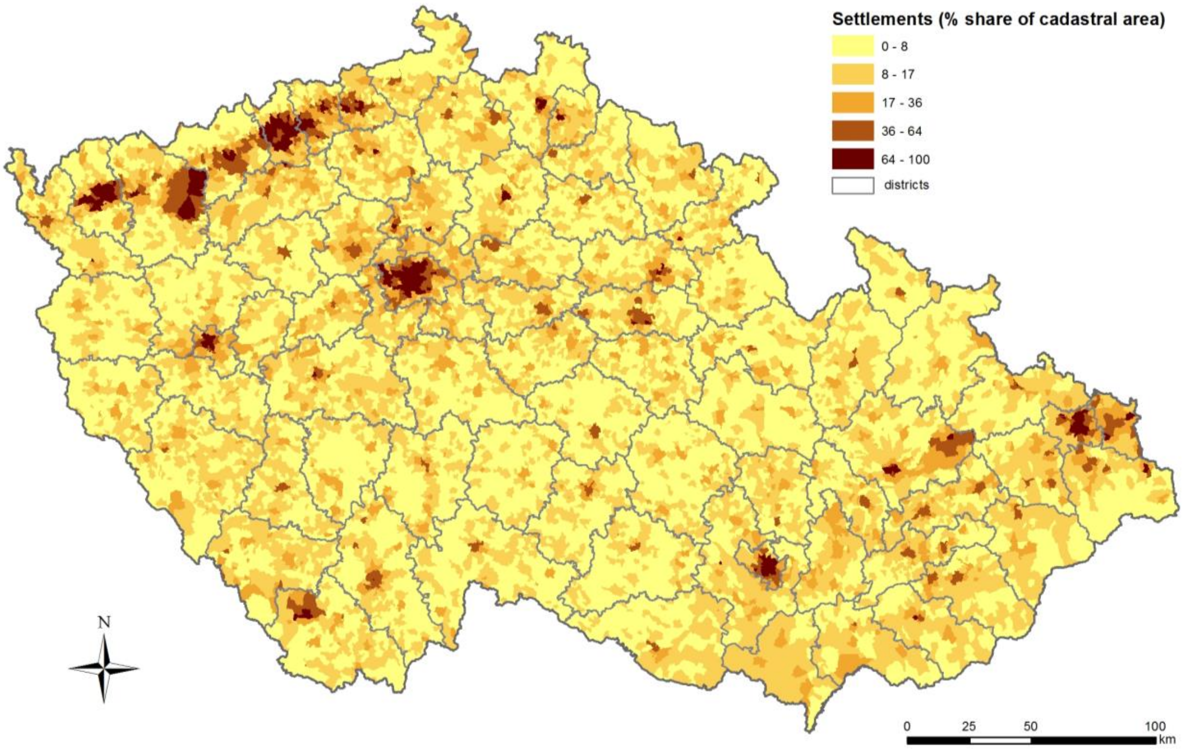

Fig. 6-19 Settlements – distribution calculated as a spatial share of the category within individual cadastral units (as of 2016).

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 previously for the NIR 2013 submission to better match the IPCC (2006) default definition. This inventory submission (NIR 2018) incorporates an additional change to this category, namely merging the land areas previously attributed under category 4.F Other. This decision was substantiated by the fact that, under the conditions in this country, these areas do not remain stable and may undergo land-use change, and thus do not meet the condition of no possible management interventions. This makes land assignment more consistent and transparent, enhancing the ability to track land-use conversions. This solution was also endorsed by the latest in-country expert review team. In this way, category 4.E Settlement currently includes two categories of the "Aggregate areas of cadastral land categories" (AACLC) database, collected and administered by COSMC, namely ID 13 "Built-up areas and courtyards" and ID 14 "Other lands". Of the latter AACLC category, all types of land use as defined in the Amendment to Act No. 357/2013 Coll. (Act on Cadastre) are covered, including "Unproductive land" that was previously assigned to category 4.F Other Land. The only exception is the water-logged area under ID 14 "Other land", which is included within 4.D Wetlands (see also Tab. 6-3). Category 4.E Settlements also includes all land used for infrastructure, as well as that of industrial zones and city parks. Finally, it also includes all military areas (earlier considered as Grassland) in the country.

The category of Settlements, as defined above, currently represents about 10.7 % 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 the Tier 1 assumption of IPCC (2006), the carbon stocks in biomass, dead organic matter (dead wood and litter) and soil are considered in the 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 Settlements. 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 the 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 to conversion was estimated as described in Section 6.4.2. All the biomass is assumed to be lost during the conversion, according to the Tier 1 assumption of IPCC (2006). 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 category 4.E Settlements were consistently employed across the whole reporting period from the base year of 1990 to 2016. The uncertainty estimation was guided by the Tier 1 methods outlined in 2006 IPCC Gl. (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 also applies 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 to 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 2016, 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 Gl. (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

Recalculation was carried out for category 4.E Settlements for this inventory submission because of the revised assignment of land-use categories qualifying for IPCC category 4.E Settlements and the corresponding activity data as described in section 6.8.1 above. The effect of these changes on the estimated emissions is shown in Fig. 6-20. Quantitatively, emission estimates increased on an average by 4.9 % compared to the identical period of 1990 to 2015.

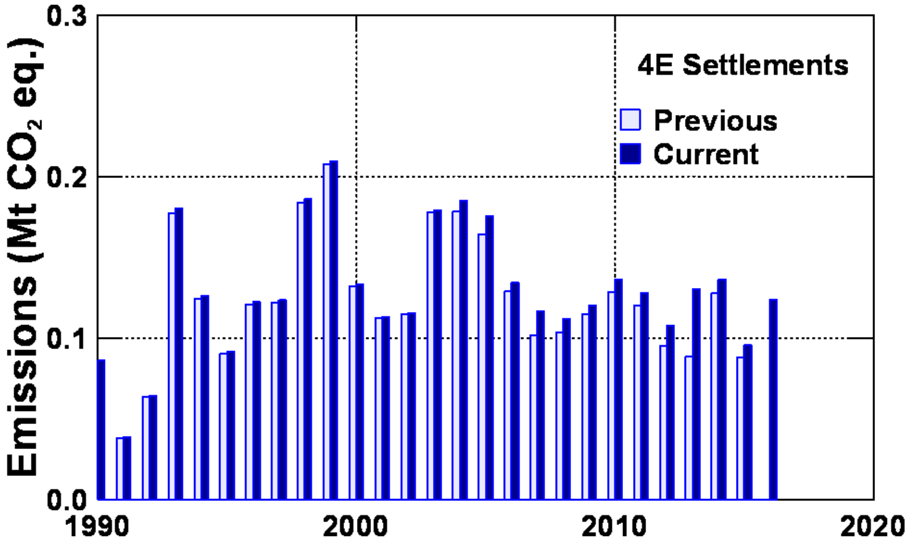

Fig. 6-20 Current and previously reported assessment of emissions for the category 4.E Settlements

6.8.6 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 Settlements. Specifically, the inventory team is working on acquiring suitable activity data to include assessment of carbon stock changes in mineral soils following the recommendation of the latest in-country review (L.19). Further improvements are also planned for uncertainty assessments.

6.9 Other Land (CRF 4.F)

6.9.1 Source category description

Starting with this inventory submission (NIR 2018), IPCC category 4.F Other land is not represented by any land-use category under Czech conditions and the national system of land-use representation and land-use change identification. Prior to this submission, category 4.F Other Land represented unmanaged (unmanageable) land areas, matching the IPCC (2006) default definition. These areas were assessed from the database of “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC. It was part of the AACLC “Other lands” category with the specific land-use category “Unproductive land” assessed from the 2006 land census of COSMC. Under that definition, category 4.F Other land represented 1.3% of the territory of the country. These areas are now fully included under category 4.E Settlements. The reasons for this decision are described in section 6.8.1 above.

6.9.2 Methodological issues

Starting with this inventory submission (NIR 2018), no areas are assigned to category 4.F Other land. Hence, no methodological issues are applicable for this category.

6.9.3 Uncertainties and time series consistency

Starting with this inventory submission (NIR 2018), no areas are assigned to category 4.F Other land. Hence, no uncertainty estimates and time series consistency issues are applicable for this category.

6.9.4 Source-specific QA/QC and verification

Starting with this inventory submission (NIR 2018), no areas are assigned to category 4.F Other land. Hence, no specific QA/QC and verification issues are applicable for this category.

6.9.5 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

With the newly adopted assignment of lands, no emission estimates are applicable for category 4.F Other Land.

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

The inventory team included the former areas of 4.E Other land within category 4.E Settlements, which improves reporting consistency and transparency, while enhancing the ability to track land-use conversions. No other improvements are planned for category 4.F Other land.

6.10 Harvested Wood Products (CRF 4.G)

6.10.1 Source category description

The contribution of Harvested wood products (HWP), mandatorily included by Decision 2/CMP7 in emission inventories under UNFCCC and KP since the 2015 inventory submission, is also estimated for the Czech emission inventory. Changes in the pool of HWP may represent CO_2 emissions or removals, which are included within the LULUCF sector as a specific category (CRF 4.G) in addition to the six IPCC land-use categories. The HWP pool considers primary woody products generated from wood produced in this 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 2014b). 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, 2014b).

The fraction corresponding to the 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 0.021% in 1990 and 2016, respectively), the HWP contribution of this fraction was estimated using instantaneous oxidation, which is the formal requirement of the IPCC guidelines (IPCC 2014b) for estimation of the HWP contribution under the Kyoto Protocol. For the sake of transparency, this conservative approach is also adopted for the HWP estimates under the Convention.

Tab. 6-11 The country-specific shares applicable for the HWP quantities as given for the former Czechoslovakia in the FAO database, derived from the 1993-1997 period

	Production		Import		Export	
Country HWP category	Czech Republic	Slovakia	Czech Republic	Slovakia	Czech Republic	Slovakia
Sawn wood	0.834	0.166	0.868	0.132	0.723	0.277
Wood-based panels	0.716	0.284	0.719	0.281	0.851	0.149
Paper and paperboard	0.655	0.345	0.772	0.228	0.598	0.402

The resulting estimates of the HWP contribution including domestically produced and used wood for the 1990 to 2016 reporting period are shown in Fig. 6-21 below. The emissions fluctuate during the reporting period, where the mean contribution equalled -999 kt CO_2/year. The actual HWP contribution equalled -1713 and -431 kt CO_2 in 1990 and 2016, respectively.

6.10.3 Uncertainties and time series consistency

The uncertainty estimates use the following inputs: roundwood harvest 20%, sawn wood, 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 2016.

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 category 4.G HWP. Hence, the estimates do not differ between the current and the previous submission (Fig. 6-21). The only exception is 2015, where the current and previous estimates differ due to more up-to-date information available in the FAO database on wood production and trade, the source of the activity data used for estimation of HWP emission contribution (see section 6.10.1 above).

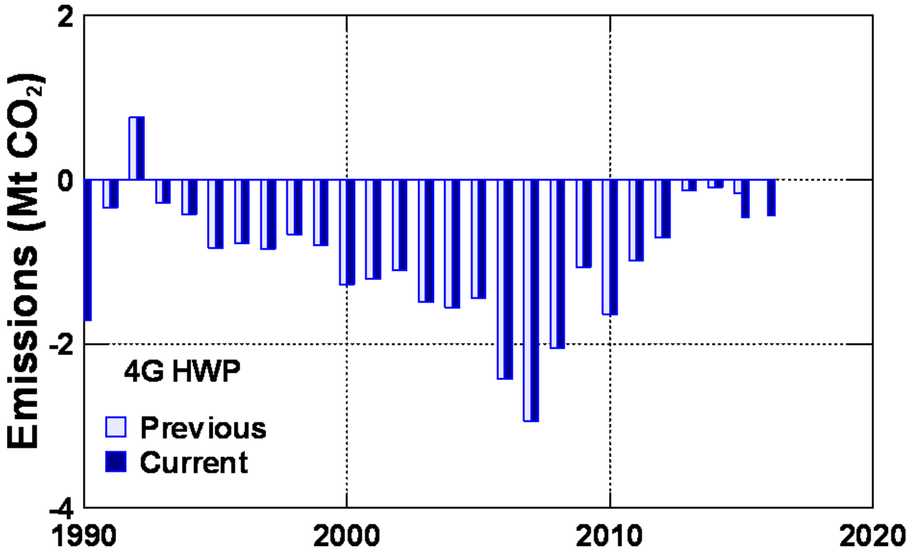

Fig. 6-21 The reported assessment of HWP contribution to emissions in the LULUCF sector for the category 4.G HWP

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

No specific improvements are planned for the next submission for this category.

Acknowledgement

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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 population and 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.

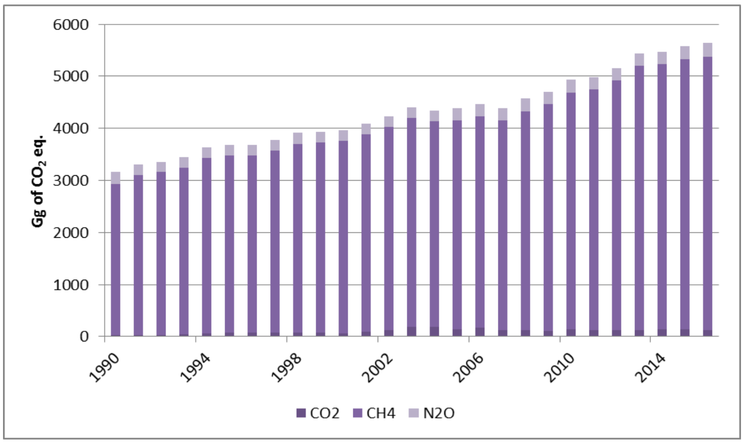


Fig. 7-1 Development of Waste sector by gasses, 1990-2016

The sector encompasses several categories. The main source category of this sector is 5.A Solid waste disposal. In 2016, this category emitted approximately 147 Gg of CH_4, equalling 3670 Gg of CO_2 eq. The second largest source category is 5.D Wastewater Treatment and Discharge, followed by two additional categories, quantifying emissions from waste incineration and from biological treatment of waste. An additional category quantifying emissions from waste management is the incineration of waste for energy purposes which is, however, reported in category 1.A.1.a Other fuels.

The waste sector as a final output sector for all economic activities is very dependent on the state of the economy, the purchasing power of the population and waste management policies. In recent years, there has been a decline of landfilling (although the effect on emissions is delayed due to the time lag in decomposition processes) and an increase in other types of waste management, especially composting which has shown remarkable growth this particular year. As the economy of the Czech Republic is also growing, as is industrial production in the country, emissions from industrial waste water are also steadily 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 (2016)

Category	Gas	KC A1	KC A2	KC A1[1]	KC A1[2]	KC A2[1]	KC A2[2]	% of total GHG[1]	% of total GHG[2]
5.A Solid Waste Disposal on Land	CH_4	LA, TA	LA, TA	yes	yes	yes	yes	2.95	2.83
5.D Wastewater treatment and discharge	CH_4	LA	LA	yes	yes	yes	yes	0.69	0.67

Category	Gas	KC A1	KC A2	KC A1[1]	KC A1[2]	KC A2[1]	KC A2[2]	% of total GHG[1]	% of total GHG[2]
5.B Biological treatment of solid waste	CH_4	LA, TA	LA, TA	yes	yes	yes	yes	0.52	0.50
5.B Biological treatment of solid waste	N_2O	LA, TA	TA	yes	yes	yes	yes	0.05	0.05

KC: key category
[1] including LULUCF
[2] excluding LULUCF

7.2 Solid Waste Disposal (CRF 5.A)

7.2.1 Managed Waste Disposal Sites (CRF 5.A.1)

7.2.1.1 Source category description

The treatment and disposal of municipal, industrial and other solid waste could produce significant amounts of methane (CH_4). The decomposition of organic material, derived from biomass sources (e.g., crops, food, textile, wood), is the primary source of CO_2, released from waste. These CO_2 emissions are not included in the national totals, because the carbon is of biogenic origin and net emissions are accounted for under land use change and forestry.

This source category might also produce emissions of other micropollutants, such as non-methane volatile organic compounds (NMVOCs), as well as smaller amounts of nitrous oxide (N_2O), nitrogen oxides (NO_X) and carbon monoxide (CO). In line with the IPCC 2006 methodology, only CH_4 is addressed in this chapter. An overview of this category is shown in Fig. 7-2.

7.2.1.1 Methodological issues

Waste disposal to SWDS

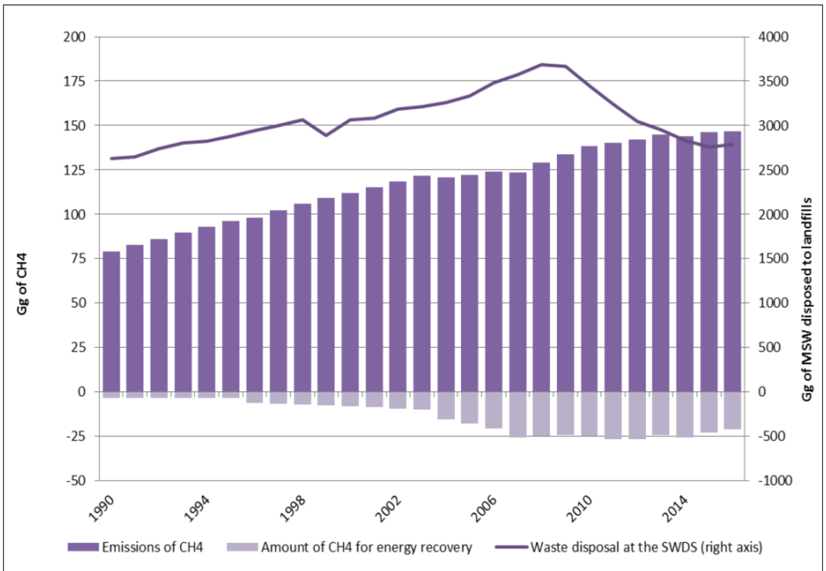


Fig. 7-2 Development of emissions from SWDS and total amount of waste disposed to SWDS 1990-2016

The key activity data for methane quantification from 5.A.1 is the amount of waste, disposed in landfills. The annual disposal is given in Tab. 7-2. The data for annual disposal are obtained from mixed sources, since the application of the FOD model requires data from 1950 to the present day. These data are not available in the country and therefore assumptions about the past had to be used. These assumptions are described in the working paper (Havránek, 2007), but the method can be simply described as intrapolation and extrapolation between points in time; correlation of waste production with the social product (predecessor of the current GDP) as a test method was performed. The higher of the two estimates was used in the quantification.

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 around 60 000 respondents, where reporting obligation to this system is based on the national legislation and it is controlled by Czech Environment Inspection. Since 2011, the waste deposited in landfills has decreased slightly for for the first time in modern history. A decrease in landfilled waste is a long term target of the Czech national environmental policy.

National legislation on landfill management is based on the European legislation. In general, it sets conditions on how landfilling can be done, specifies the relevant actors and state bodies responsible for the administration and control, duties and obligation of all the stakeholders. The main regulations in this area are Act 185/2001 Coll. "Act on waste" and the main directive relevant for the landfilling Decree 294/2005 Coll. "Decree on the conditions for depositing waste in landfills and its use on the surface of the ground". Management of waste is complicated and the full regulative framework can be found on the website of the Ministry of Environment.

Industrial waste, sludge and dual data

In the Czech Republic there are two official data sources on waste. First is above mentioned ISOH while second official source of data on waste is Czech Statistical Office (CZSO) and its data in Eurostat. Data from CZSO are top-down data from statistical survey and they give different picture about landfilling of the waste in the country. This causes confusion during the review process as the top-down and bottom up data differs significantly (for about 750 Gg of waste). Based on suggestion from ARR we hybridized our data sources on waste in a way that we still use ISOH data which does contains IW data (but do not discerns them as such) but we increase them by residual factor from CZSO based on their IW statistics to keep the emissions on conservative level. More details and explanation can be found in Annex A5.4.

Tab. 7-2 MSW/IW disposal in SWDS in the Czech Republic [Gg], 1990-2016

Year	MSW in SWDS	Year	MSW in SWDS	Year	MSW in SWDS	Year	MSW in SWDS
1990	2631	**1997**	2999	**2004**	3260	**2011**	3241
1991	2648	**1998**	3064	**2005**	3330	**2012**	3046
1992	2744	**1999**	2892	**2006**	3481	**2013**	2952
1993	2803	**2000**	3063	**2007**	3574	**2014**	2830
1994	2821	**2001**	3086	**2008**	3684	**2015**	2759
1995	2881	**2002**	3180	**2009**	3666	**2016**	2783
1996	2943	**2003**	3212	**2010**	3445		

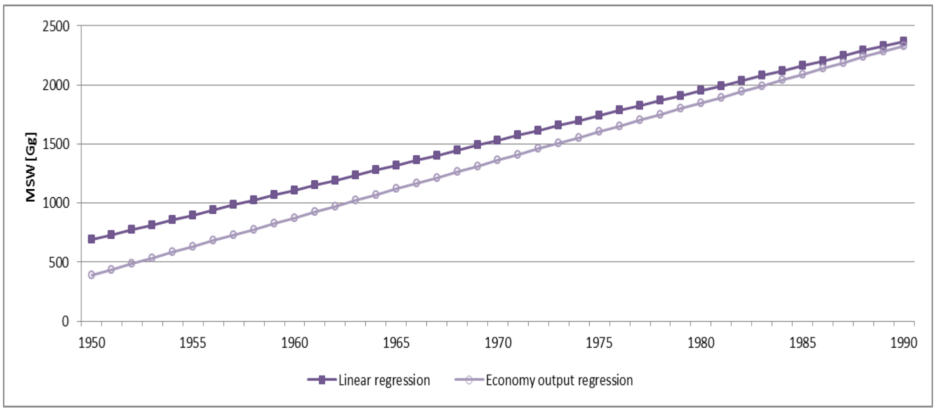


Fig. 7-3 MSW disposal in SWDS in the Czech Republic, 1950-1990

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. As we are generally using bottom up data, sludge is included in total amount of waste landfilled, but it is not identified as such. This does not mean that the emissions are underestimated because the mass deposited in landfills does include sludge (the data are bottom-up total mass data for landfills) and the average DOC obtained using the current waste mixture is larger than the default DOC for sludge.

The table also contains the methane generation rate (k-rate) employed. This rate is closely related to the compostion of a particular substance and the available moisture. The IPCC default k-rates for a wet temperate climate were used (the average temperature of the Czech Republic is about 7 °C and the annual precipitation is higher than the potential evapotranspiration). The average DOC for a particular waste stream is also based on the IPCC default values for individual categories of waste. The average DOC for each particular year is given in the last column of the table.

Tab. 7-3 MSW composition for the Czech Republic used in the quantification (fractions of total, 1950-2016)

	Paper	Food	Textil	Wood and straw	DOC (calculated)
k-*rate*	0.06	0.185	0.06	0.03	
DOC (default)	0.4	0.15	0.24	0.43	
		Share of particular waste streams			
1950-1995	0.22	0.30	0.05	0.08	0.176
1996	0.22	0.29	0.05	0.08	0.179
1997	0.23	0.28	0.06	0.08	0.181
1998	0.24	0.27	0.06	0.08	0.184
1999	0.25	0.26	0.07	0.08	0.187
2000	0.26	0.25	0.07	0.08	0.191
2001	0.27	0.23	0.08	0.08	0.195
2002	0.24	0.25	0.08	0.09	0.194
2003	0.22	0.27	0.07	0.11	0.193
2004	0.19	0.30	0.07	0.13	0.192
2005	0.16	0.32	0.07	0.14	0.191
2006	0.16	0.32	0.07	0.14	0.187
2007	0.17	0.32	0.08	0.13	0.193
2008	0.16	0.32	0.07	0.14	0.188
2009-2016*	0.16	0.35	0.08	0.13	0.194

**Since 2009 last available data is used*

Methane correction factor

The methane correction factor (MCF) is a value, expressing the overall management of landfills in the country. Better-managed and deeper landfills have higher MCF value. Shallow SWDS ensure that far more oxygen penetrates into the body of the landfill to aerobically decompose DOC. The suggested IPCC values are given in Tab. 7-4.

Tab. 7-5 gives the values, used in this inventory. The choice of values is based on data for recent years (1992+) and expert judgement in the early years of the timeline.

Tab. 7-4 Methane correction values (IPCC 2006)

	MCF
Unmanaged, shallow	0.4
Unmanaged, deep	0.8
Managed, anaerobic	1.0
Managed, semi-aerobic	0.5
Uncategorised	0.6

Tab. 7-5 MCF values employed, 1950-2016

	MCF
1950 – 1959	0.6
1960 – 1969	0.6
1970 – 1979	0.8
1980 – 1989	0.9
1990 – 2016	1.0

Oxidation factor

As methane moves from the anaerobic zone to the aerobic and semi-aerobic zones close to the landfill surface, part of it becomes oxidized to CO_2. There is no conclusive agreement in the scientific community on the intensity of the oxidation of methane. The oxidation is indeed site-specific and depends on the effects of local conditions (including fissures and cracks, compacting, landfill cover etc.). No representative measurements or estimations of the oxidation factor are available for the Czech Republic. Some studies are quoted in Straka, 2001, which mentions a non-zero oxidation factor, but these figures seem to be site-specific and have very high values compared to the default value, perhaps due to specific practices at the site. Therefore, they cannot be used as representative for the whole country. However, the methodology (IPCC 2006) suggests that an oxidation factor greater than 0.1 should not be used if no site measurements are available (a larger value adds uncertainty). The author used the recommended oxidation factor of 0.1 in the report.

Delay time

When waste is disposed in SWDS, decomposition (and methanogenesis) do not start immediately. The assumption, used in the IPCC model, is that the reaction starts on the first of January in the year after deposition, which is equivalent to an average delay time of six months before decay to methane commences. It is good practice to assume an average delay of two to six months. If a value greater than six months is chosen, evidence to support this must be provided. The Czech Republic has no representative country-specific value for the delay time, so the author used a default value of 6 months.

Fraction of methane

This parameter indicates the share (mass) of methane in the total amount of Landfill Gas (LFG). A value 0.61 was used in previous calculations of methane emissions from SWDS (NIR, 2004). This figure was based on measurement of a limited number of sites (Straka, 2001). This value is higher than the range of

0.5-0.6 suggested by IPCC. Revision of these values was based on collected data from MIT (MIT, 2005+). MIT receives annual reports from landfills capturing LFG; SWDS report the net calorific value of their captured LFG. This value was compared with the gross calorific value of pure methane and yielded a value of 0.55, which fits well within the IPCC range and is therefore used in the quantification.

Recovered methane

On SWDS in the country, methane is sometimes collected by an LFG collection systems and incinerated for energy purposes. Based on 2006 Guidelines (IPCC 2006), this methane that is being converted to CO_2 and has biogenic origin is not considered to constitute a GHG emission and hence recovered methane (R) is substracted from the total emissions. There is no default value for R, so country estimates were used, based on various sources. As mentioned in the previous paragraph, the Ministry of Industry and Trade conducts an annual survey of all SWDS. All the energy data about LFG used for energy purposes were collected. An attempt is made to update old estimates as much as possible. Since starting the survey in 2005, it has been possible to provide estimates for the time series between 2003 and 2014. The estimates in Straka, 2001 were used for the 1990-1996 period. Linear intrapolation of recovered methane was used for the period between 1996 and 2003. In 2016 more than 70 facilities were recovering LFG in the country.

Total emissions of methane are based on the equation from the IPCC CH_4 model. The detailed time series from 1950, including the breakdown into individual waste components, are given in the paper by Havranek 2007. The following Tab. 7-6 lists methane emissions from this category.

Tab. 7-6 Emissions of methane from SWDS [Gg], Czech Republic, 1990-2016

	CH_4 generation	CH_4 recovery	CH_4 emission
1990	91	3.3	79.2
1991	95	3.3	82.8
1992	99	3.5	86.0
1993	103	3.5	89.5
1994	107	3.5	93.0
1995	110	3.5	96.2
1996	115	6.0	98.2
1997	120	6.6	102.0
1998	125	7.1	105.7
1999	129	7.7	109.4
2000	133	8.2	111.9
2001	137	8.8	115.2
2002	141	9.3	118.3
2003	145	9.9	121.7
2004	150	15.6	120.5
2005	154	18.0	122.3
2006	158	20.6	124.0
2007	163	25.9	123.3
2008	168	24.6	129.3
2009	173	24.5	133.7
2010	179	24.7	138.5
2011	182	26.6	140.0
2012	184	26.6	142.0
2013	185	24.2	144.9
2014	185	25.7	143.8
2015	185	22.7	146.2
2016	184	21.3	146.8

7.2.1.2 Uncertainties and time-series consistency

Overall quantification of the uncertainity for this category is still incomplete. This is considered a high priority and will be conducted in the following years as soon as budget constraints permit. This category entails the difficulty, that the uncertainty does permeate through the whole waste management period of 1950-2016 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. 7-7).

Tab. 7-7 Uncertainty estimates for 5.A category

Gas	Category	AD uncertainity [%]	EF uncetrainity [%]	Origin of the parameters
CH_4	5.A.1 SWDS	30	40	Combined uncertainty of quantification parameters Expert judgement M. Havránek, verification P. Slavíková (CENIA)

7.2.1.3 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.

7.2.1.4 Source-specific recalculations, including changes made in response to the review process

The whole series has been recalculated to be in line with ARR demands on specific inclusion of industrial waste and sludge (IW/S) in to SWDS. We included IW/S correction factor for the period 1995-2016 based on available CZSO data which increased emissions from this category. Based on data comparison shown in Annex we concluded that industrial waste is mostly included in used data source but there is residuum – about 250Gg of IW/S. It did not increase emissions significantly, but there is an growing increase for about 10 Gg of CH_4 a year.

Tab. 7-8 Recalculation of SWDS to include IW/S (1990-2016)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Submission 2017-2015	79.2	82.8	86.0	89.5	93.0	96.2	97.1	99.9	102	105	107	109	112	115
Submission 2018-2016	79.2	82.8	86.0	89.5	93.0	96.2	98.2	102	105	109	111	115	118	121
Difference	0.0	0.0	0.0	0.0	0.0	0.0	1.1	2.1	3.0	3.9	4.7	5.4	6.0	6.6
Percentage difference	0%	0%	0%	0%	0%	0%	1%	2%	3%	4%	4%	5%	5%	6%

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Submission 2017-2015	113	114	116	114	120	124	129	130	131	134	133	135
Submission 2018-2016	120	122	124	123	129	133	138	140	142	144	143	146
Difference	7.1	7.6	8.1	8.5	8.9	9.2	9.5	9.8	10.1	10.3	10.5	10.7
Percentage difference	6.3%	6.7%	7.0%	7.4%	7.4%	7.4%	7.4%	7.5%	7.6%	7.7%	7.9%	7.9%

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

Next years 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.

We still push for harmonisation of ISOH and CZSO data on waste management. We plan to recalculate whole category according to official data should this happen.

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)

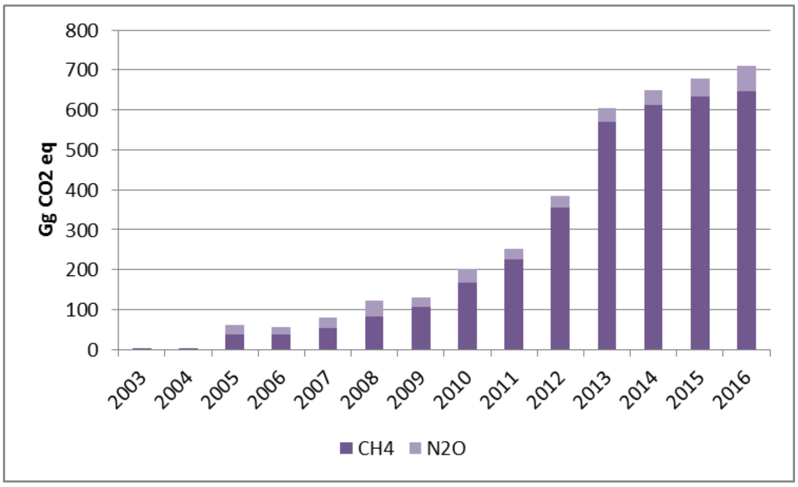


Fig. 7-4 Development of emissions from biological treatment of solid waste, 2003-2016

The biological treatment of waste includes two categories. Aerobic processes for treating organic waste include 5.B.1 Composting and 5.B.2 Anaerobic digestion. Composting is mostly an aerobic process and thus the production of methane is insignificant. Anaerobic digestion has greatly increased in recent years and there is active state support for this type of waste treatment (i.e. energy production from biogas). However, it is a controlled process mainly directed towards capturing the produced biogas and thus emissions from this source category are also relatively small. An overall survey of this source category is shown in Fig. 7-4.

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. 7-9.

Tab. 7-9 Emissions of GHG from composting [Gg], Czech Republic, 2005-2016

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
MSW [kt]	48.7	61.4	79.8	114.4	134.6	144.1	181.9	153.5	202.8	303.1	373.9	420.0
Other waste [kt]	288.8	222.6	296.3	428.7	221.2	358.2	190.0	228.2	247.0	207.2	249.4	469.3
Emission factor [kg CH_4/ton]	4											
Emission factor [kg N_2O/ton]	0.24											
Total Composting CH_4 [Gg]	1.35	1.14	1.50	2.17	1.42	2.01	1.49	1.53	1.80	2.04	2.49	3.56
Total Composting N_2O [Gg]	0.08	0.07	0.09	0.13	0.09	0.12	0.09	0.09	0.11	0.12	0.15	0.21
Total composting GHG [Gg CO_2 eq.]	57.90	48.74	64.52	93.17	61.04	86.17	63.80	65.48	77.16	87.53	106.92	152.53

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 2016.

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

No recalculation has been made.

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 2016. 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. 7-10.

Tab. 7-10 Emissions from Anaerobic digestion stations, 2003-2016

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Number of biogas stations [count]	8	10	9	14	21	49	86	115	186	317	388	404	443	448
Energy [TJ]	121	105	104	291	555	1007	2503	4481	7 294	12630	20002	22674	23015	22357
Conversion [TJ/Gg]	50.009													
Activity data [Gg CH_4] - R	2.8	2.4	2.4	6.5	11.8	22.6	56.1	93.2	150.9	254.4	420.7	449.4	457.3	447.0
Emissions (default 5%) [Gg CH_4]	0.14	0.12	0.12	0.32	0.59	1.13	2.81	4.66	7.55	12.72	21.04	22.47	22.87	22.35

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. 7-11 Uncertainty estimates for 5.B category

Gas	Category	AD uncertainity [%]	EF uncetrainity [%]	Origin of the parameters
CH_4	5.B.1 Composting	20	NA	AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA)
N_2O	5.B.1 Composting	20	NA	AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA)
CH_4	5.B.2 Anaerobic digestion	20	100	AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA)

7.3.2.4 Source-specific QA/QC and verification

The QA/QC plan for the sector was updated during 2015 and 2016. Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. The activity data used for this sector are approved by the data producer and who verifies them before they are used for further calculation.

Since the waste sector is fairly small, external QC is not provided; instead QC is performed by a NIS coordinator and the results are communicated to the sectoral expert.

The activity data from national agencies and ministries are the subjects of internal QA/QC mechanisms and the NIS team has only limited insights into them. Processes are in place at all state agencies and ministries to ensure that they produce accurate data.

7.3.2.5 Source-specific recalculations, including changes made in response to the review process

No recalculation has been made.

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)

This category contains emissions from waste incineration in the Czech Republic. The types of waste, incinerated include industrial, hazardous and clinical waste. Waste incineration is defined as the combustion of waste in controlled incineration facilities. Modern waste incinerators have tall stacks and specially designed combustion chambers, which ensure high combustion temperatures, long residence times, and efficient waste agitation, while introducing air for more complete combustion. This category includes emissions of CO_2, CH_4 and N_2O from these practices.

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.

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

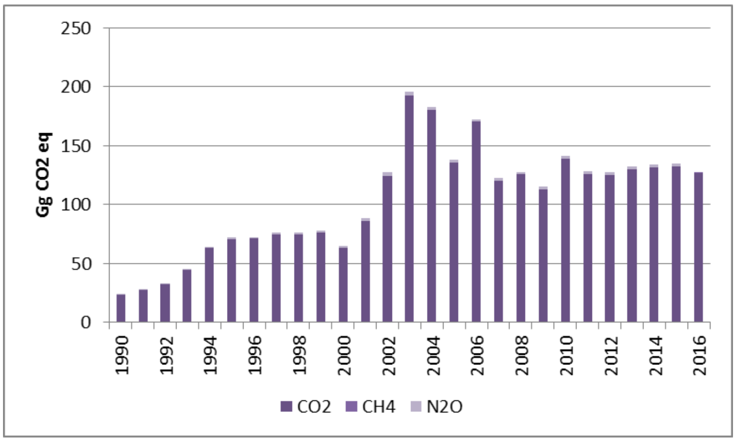


Fig. 7-5 Development of emissions from waste incineration, 1990-2016

In this source category only CO_2 emissions resulting from oxidation of the fraction of fossil carbon in waste (e.g. plastics, rubber, liquid solvents, and waste oil) during incineration are considered in the net emissions and are included in the national CO_2 emissions estimates. In addition, incineration plants produce small amounts of methane and nitrous oxide. All the emissions are reported in category 5.C.1. Estimations of emissions from hazardous/industrial waste (H/IW) biomass are reported under the same category, but the CO_2 emissions are described as an information item and are not included in the national totals.

Estimation of CO_2 emissions from H/IW incineration is based on the Tier 1 approach (IPCC 2006). This assumes that the total fossil carbon dioxide emissions are dependent on the amount of carbon in the waste, on the fraction of fossil carbon and on the combustion efficiency of the waste incineration. Due to the lack of country-specific data for the necessary parameters, the default data for the calculations were taken from the IPCC 2006 Guidelines, see Tab. 7-12. To save room in the table, the results are divided into biogenic and non-biogenic waste fractions only for the important gas – CO_2. Methane and nitrous oxide are listed together in the table although they are reported in the UNFCCC reporter separately for the biogenic and fossil waste fractions.

The activity data are the main issue in this category. This year the 2005-2014 timeline was recalculated to correspond to the official statistics. The activity data are based on the statistical surveys performed by VISOH (VISOH is a public waste management registry and there is also a non-public part ISOH, which is used for inventory activity data). The system uses categorization of waste management activities and this source category is listed in the ISOH system under D10 – incineration on land. The problem is that the system does not contain data before 2002 and incineration data in VISOH-ISOH have been consistent since 2005 when the new methodology began to be used; hence, estimates obtained from MIT were used prior to that date. MIT issued a special report on the history of incineration in the Czech Republic, which was used to derive data for this category prior to 2005. The Czech legislation does not distinguish explicitly between the types of wastes required by the IPCC methodology (there are only two types, “hazardous” waste and “other” waste). However, it is certain that all MSW is incinerated for energy purposes (R1 category by ISOH) and hence the author concluded that category D10 consists of waste components with hazardous quality (which is supported by the evidence in ISOH where applicable). All waste data that are used for the calculation are in wet weight. To correct this for carbon content we use factor 0.9 based on table 2.4 section 2.3 of IPCC Gl2006 for other waste. Methane and nitrous oxide emission factors are for wet waste, hence no correction is applied.

Tab. 7-12 H/IW incineration in 1990 – 2016 with the used parameters and results

	Used factors										
Amount of carbon fraction	0.5										
Fossil carbon fraction	0.9										
Combust efficiency fraction	0.995										
C-CO_2 ratio	3.7										
Emission factor [Gg CH_4/Gg]	5.6E-07										
Emission factor [Gg N_2O/Gg]	1.0E-04										
	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Waste incinerated [Gg]	14.1	43.1	38.4	82.3	84.4	76.7	76.3	79.2	80.2	80.7	76.9
Total CO_2 [Gg CO_2] Fossil	20.8	63.6	56.7	121.7	124.77	113.26	112.70	117.07	118.56	119.19	113.69
Total CO_2 [Gg CO_2] Bio.	2.3	7.0	6.30	13.5	13.86	12.58	12.52	13.01	13.17	13.24	12.63
Total CH_4 [Gg CH_4]	7.9E-06	2.4E-06	2.2E-06	4.6E-06	4.7E-06	4.3E-06	4.3E-06	4.4E-06	4.5E-06	4.5E-06	4.3E-05
Total N_2O [Gg N_2O]	1.4E-04	4.3E-04	3.8E-04	8.2E-04	8.4E-04	7.7E-04	7.6E-04	7.9E-04	8.0E-04	8.1E-04	7.7E-04

The suggested default emission factors for hazardous waste incineration were 100 kg of N_2O per Gg of incinerated HW and 0.56 kg of methane per Gg of incinerated HW. The biogenic emissions of CO_2 from this category were estimated last year. The approach is based on the default factor for fossil carbon, assuming that the rest of the carbon in the material is non-fossil in origin. The oxidation factor 0.995 is used for HW/IW combustion emission quantification. It is suggested that the default factor is 1.0, but this is contradictory to the evidence found in literature and in the bottom ash measurement, where the share of unburnt carbon can be measured, yielding a contradictory oxidation factor implying that all the carbon in the fuel is incinerated. The literature supporting this assumption is reviewed in annex V. The impact on the inventory is negligible; however, a factor of less than 100% is easier to manage in assessing the uncertainty.

7.4.1.3 Uncertainties and time-series consistency

The activity data comes from two sources; hence there could be an inconsistency due to the different data providers. An effort has been made to tackle this inconsistency by choosing 2005 as the year of change to the new AD (in 2005 an effort was made to harmonise the methodology). However, switching to VISOH-ISOH is a more sustainable solution, as the system has institutional and legislative backing at MoE and provides and will probably continue to provide more reliable data about waste incineration in the future.

Tab. 7-13 Uncertainty estimates for 5.C category

Gas	Category	AD uncertainity [%]	EF uncetrainity [%]	Origin of the parameters
CO_2	5.C.1 Waste incineration	15	5	AD Expert judgement M. Havránek; EF IPCC default
N_2O	5.C.1 Waste incineration	20	70	AD Expert judgement M. Havránek; EF IPCC default
CH_4	5.C.1 Waste incineration	20	80	AD Expert judgement M. Havránek; EF IPCC default

7.4.1.4 Source-specific QA/QC and verification

The QA/QC plan of the National inventory system was used for the whole waste category. For this particular subcategory, bottom-up data provided by the official sources (Ministry of Industry and Trade, MIT) and also the data from VISOH-ISOH – information system on waste management run by MoE/CENIA was used. However, the inaccuracy or uncertainty of this data is not quantified but is estimated by expert judgment. The compiler cross-checked the data on incineration with the top-down data, produced by other state agencies.

7.4.1.5 Source-specific recalculations, including changes made in response to the review process

Based on ARR suggestion we applied correction of waste amount for CO_2 quantification. We used fresh weight while methodology was designed for calculation with dry weight. This led to overestimation of emissions. We applied wet/dry correction based on table 2.4 section 2.3 of IPCC Gl.2006 which led to decrease of this particular source category for about 10% for whole timeline. Detailed information is presented in Tab. 7-14.

Tab. 7-14 Recalculation of 5.C category (Gg of CO_2, 1990-2015)

5.C.1.2 Non-biogenig	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Submission 2017-2015	23.15	27.71	32.52	44.41	62.97	70.70	71.07	74.49	74.84	76.46	63.04	86.13	124.05	192.08
Submission 2018-2016	20.83	24.94	29.27	39.97	56.67	63.63	63.96	67.04	67.36	68.81	56.73	77.52	111.64	172.87
Difference	-2.31	-2.77	-3.25	-4.44	-6.30	-7.07	-7.11	-7.45	-7.48	-7.65	-6.30	-8.61	-12.4	-19.2
Percentage difference	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**		
Submission 2017-2015	180.46	135.18	170.32	120.30	125.51	112.80	138.64	125.85	125.22	130.08	131.74	132.43		
Submission 2018-2016	162.42	121.67	153.29	108.27	112.96	101.52	124.77	113.26	112.70	117.07	118.56	119.19		
Difference	-18.0	-13.5	-17.0	-12.0	-12.5	-11.2	-13.8	-12.5	-12.5	-13.0	-13.1	-13.2		
Percentage difference	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%		
5.C.1.1 Biogenic	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Submission 2017-2015	2.57	3.08	3.61	4.93	7.00	7.86	7.90	8.28	8.32	8.50	7.00	9.57	13.78	21.34
Submission 2018-2016	2.31	2.77	3.25	4.44	6.30	7.07	7.11	7.45	7.48	7.65	6.30	8.61	12.40	19.21
Difference	-0.26	-0.31	-0.36	-0.49	-0.70	-0.79	-0.79	-0.83	-0.83	-0.85	-0.70	-0.96	-1.38	-2.13
Percentage difference	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**		
Submission 2017-2015	20.05	15.02	18.92	13.37	13.95	12.53	15.40	13.98	13.91	14.45	14.64	14.71		
Submission 2018-2016	18.05	13.52	17.03	12.03	12.55	11.28	13.86	12.58	12.52	13.01	13.17	13.24		
Difference	-2.01	-1.50	-1.89	-1.34	-1.39	-1.25	-1.54	-1.40	-1.39	-1.45	-1.46	-1.47		
Percentage difference	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%		

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)

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 growth and the share of the particular treatment options. In recent years both population and industrial production is growing, hence trend in past years is upward.

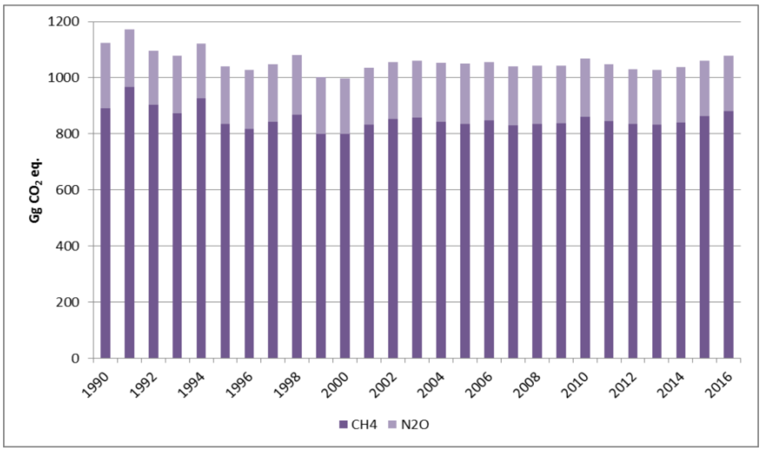


Fig. 7-6 Development of emissions from wastewater treatment and discharge, 1990-2016

7.5.1 Domestic Wastewater Treatment (CRF 5.D.1)

7.5.1.1 Source category description

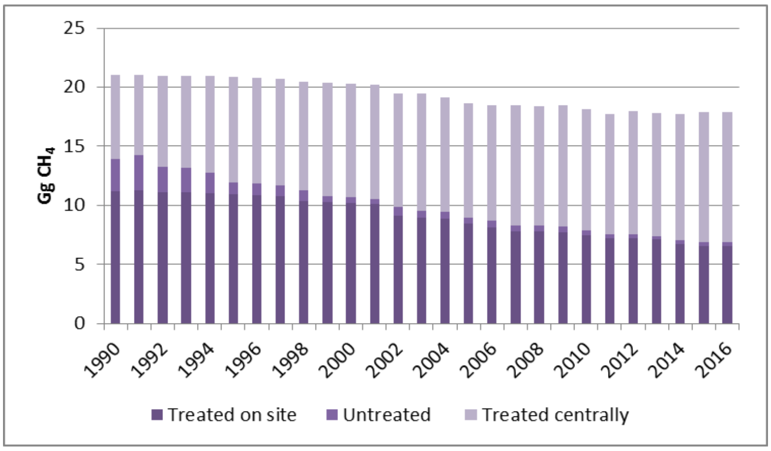


Fig. 7-7 Development of 5.D.1 emission of CH_4 by types of treatment

Treatment of domestic wastewater in the Czech Republic is mostly centralised and more than 82% of the population is connected to sewage systems. The rest of the population, mainly rural population in small municipalities, has on-site treatment facilities – septic tanks, sump tanks, latrines or household treatment plants. Wastewater treatment plants treat about 97% of all the collected water. Anaerobic technology is being increasingly used to produce biogass from sludge.

This category was recalclulated in 2016 to fully reflect the complexity and pathways that are used to treat wastewater in this country, effectively replacing Tier 1.

7.5.1.2 Methodological issues

The content of organic pollution in the water is the basic factor for determining methane emissions from wastewater management. The content of organic pollution in municipal wastewater and sludge is given as BOD_5 (the biochemical oxygen demand).

The current IPCC methodology employs BOD for evaluation of municipal wastewater and sludge and Chemical Oxygen Demand (COD) for industrial wastewater. The new method is based on default Tier 1 where sludge treatment is not considered; however available data about biogass production from sludge treatment are used to reduce TOW (total organic waste). Outline of TOW flow is given in the folowing figure (Fig. 7-8).

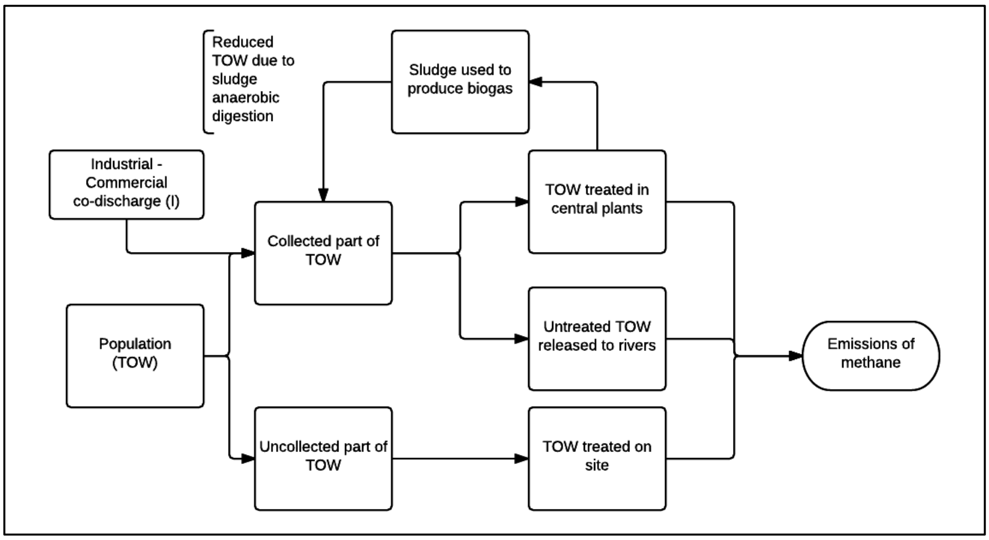


Fig. 7-8 Outline of total organic waste flow in 5.D.1

The basic activity data (and their sources) for determining emissions from this subcategory are as follows, tabelar overview of those factors is given in Tab. 7-15 to Tab. 7-17:

- The number of inhabitants (source: Czech Statistical Office).
- The organic pollution produced per inhabitant (source: IPCC default value).
- The conditions under which the wastewater is treated (source: Czech Statistical Office, with some specific national factors).
- The amount of proteins in the diet of the population (source: FAO).
- The amount of biogas produced from wastewater treatment plants (source: MIT).

The methodological steps as follows:

- Estimation of the total TOW of the country by using the population and default BOD value production.
- Split total TOW into two streams, one is corresponding to TOW collected by central wastewater treatment plants and, the other to uncollected TOW (mixture of latrines, septic tanks, root treatment plants and household biodisc plants, etc.).
- Uncollected TOW is multiplied by the implied EF based on IPCC Gl 2006 resulting in methane emissions.
- Collected TOW is multiplied by the default co-discharge correction factor.
- Biogass produced by wastewater treatment plants is converted to the TOW required to produce this biogass and is substracted from collected TOW.

- Collected TOW is divided into two streams treated TOW and untreated TOW.
- Treated TOW is treated by well managed central treatment plants (default factors) resulting in methane emissions.
- Untreated TOW is discharged in to watersheds resulting in methane emissions
- Methane emissions from all three sources are summed up resulting in emissions from this source category.

Tab. 7-15 Activity data used for 5.D.1 category, 1990-2016, Czech Republic

	Total population [thous. pers.]	Sewer connection [%]	Water treated [%]		Total population [thous. pers.]	Sewer connection [%]	Water treated [%]
1990	10 362	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	10 317	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**	10 429	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**	10 497	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**	10 525	83.9	96.9
2002	10 201	77.4	92.6	**2015**	10 554	84.2	97.0
				2016	10 565	84.7	97.3

Tab. 7-16 Parameters used for 5.D.1 category, 1990-2016

Used parameters			
B_0 [kg CH_4/kg BOD]	TOW [g BOD/person/day]	Correction factor for industrial co-discharge	NCV of CH_4 [MJ/kg]
0.6	60	1.25	50.009

Tab. 7-17 Methane emissions from 5.D.1 category, 1990-2016

	Uncollected TOW emissions [Gg of CH_4]	Untreated TOW emissions [Gg of CH_4]	Treated TOW emissions [Gg of CH_4]	Biogas reduction (fraction of treated TOW)	Total emissions [Gg of CH_4]
MCF	**0.3**	**0.1**	**0.1**		
1990	11.2	2.7	7.2	0.20	21.1
1991	11.3	3.0	6.8	0.20	21.0
1992	11.1	2.2	7.7	0.20	21.0
1993	11.1	2.1	7.8	0.20	21.0
1994	11.0	1.8	8.1	0.20	20.9
1995	10.9	1.0	8.9	0.20	20.9
1996	10.9	1.0	9.0	0.20	20.8
1997	10.8	0.9	9.0	0.20	20.7
1998	10.4	0.9	9.2	0.20	20.5
1999	10.3	0.5	9.6	0.20	20.4
2000	10.2	0.5	9.6	0.20	20.3
2001	10.1	0.5	9.6	0.20	20.2
2002	9.1	0.8	9.6	0.20	19.5
2003	9.0	0.6	9.9	0.19	19.5
2004	8.9	0.6	9.7	0.21	19.2
2005	8.4	0.5	9.7	0.23	18.6

	Uncollected TOW emissions [Gg of CH_4]	Untreated TOW emissions [Gg of CH_4]	Treated TOW emissions [Gg of CH_4]	Biogas reduction (fraction of treated TOW)	Total emissions [Gg of CH_4]
MCF	**0.3**	**0.1**	**0.1**		
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
2016	6.4	0.3	11.0	0.23	17.7

Determination of the N_2O emissions from municipal wastewater is part of a broader complex of calculations, concerned particularly with the area of agriculture. Tier 1 calculation is based on the number of inhabitants and estimation of the average annual protein consumption, together with a correction for co-discharge from industry. Data and factors used for the estimation of this source sub category are shown in Tab. 7-18.

Tab. 7-18 Indirect N_2O [Gg] from 5.D.1 and 5.D.2, 1990-2016, Czech Republic

	Proteins [g/capita/day[8]]	Population [number, thous. pers.]	Fnpr [kg N/kg protein]	Fnon-noc	Find-com	Nefluent [kg N/yr]	EF [kg N_2O/kg N]	Emissions [Gg N_2O]
1990	105.77	10 362				100016115		0.786
1991	92.98	10 309				87463239		0.687
1992	87.37	10 317				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	0.16	1.25	1.25	84634767	0.005	0.665
2001	92.84	10 224				86615776		0.681
2002	92.97	10 201				86538394		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	10 429				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

[8] *The latest available data is used for 2014 and 2016;, data for Czechoslovakia are used for 1990-1992.*

	Proteins [g/capita/day[8]]	Population [number, thous. pers.]	Fnpr [kg N/kg protein]	Fnon-noc	Find-com	Nefluent [kg N/yr]	EF [kg N_2O/kg N]	Emissions [Gg N_2O]
2013	87.47	10 511				83892749		0.659
2014	87.47	10 525				84005003		0.660
2015	87.47	10 554				84236949		0.662
2016	87.47	10565				84328266		0.663

The values of the factors in the table are the default factors. Factor Fnon-con is average between default factor for developed countries (1.4) and developing countries (1.1) to reflect nature of Czech wastewater treatment system in transition. The activity data about population were obtained from the Czech Statistical Office and the amount of proteins consumed in the Czech Republic was derived from the nutrition statistics of FAO (Faostat, 2017).

7.5.1.3 Uncertainties and time-series consistency

The whole time series was recalculated and should be more consistent in terms of data sources. The uncertainty in this category is high because the data about organic pollution are based on the population alone and the science behind the formation of N_2O is also not robust and varies significantly.

Tab. 7-19 Uncertainty estimates for 5.D.1 category

Gas	Category	AD uncertainity [%]	EF uncertainity [%]	Origin of the parameters
CH_4	5.D.1 Domestic wastewater	21	50	Combined uncertainty of quantification parameters Expert judgement M. Havránek
N_2O	5.D.1 Domestic wastewater	26	50	AD Expert judgement M. Havránek; EF IPCC default

7.5.1.4 Source-specific QA/QC and verification

Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. Activity data used for this sector are approved by the data producer who verifies them before they are used for calculation.

Because the waste sector is fairly small, an external subject is not used to provide QC; instead QC is performed by a NIS coordinator and the results are communicated to the sectoral expert.

Activity data from national agencies and ministries are the subjects of internal QA/QC mechanisms and the NIS team has only limited insights into them. Processes are in place on all state agencies and ministries to ensure that state agencies produce the correct data.

7.5.1.5 Source-specific recalculations, including changes made in response to the review process

No recalculation has been made.

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

It is planned to quantify the uncertainity range in a similar way as in category 5D2 using the upper and lower margins of the esimates to estimate the uncertainity in more quantitative terms. This aspect is of moderate importance.

7.5.2 Industrial Wastewater (CRF 5.D.2)

7.5.2.1 Source category description

This source category deals with emissions from the treatment of industrial wastewaters. Most of the industries in the country have their own wastewater treatment systems; however, a significant fraction of industries are part of municipal sewage systems. This does not create a problem, as both categories 5.D.1 and 5.D.2 are based on production statistics not on collection systems. Industrial waste water (IWW) treatment at bigger companies in the country is mostly managed on spot, utilizing aerobic techniques to treat the water. Anaerobic treatment of sludge is being increasingly used. There is no double counting in category 5B, as the data allow division between waste AD and water treatment digestion (and are sufficiently precise to allow division between domestic waste water and IWW). Separated sludge that is not used for biogas production is treated by a mixture of aerobic treatment options. Development of the category is shown in Fig. 7-9.

7.5.2.2 Methodological issues

This entire category was recalculated this year. The recalculation method is based on Tier 1 of the methodology; however, we used country-specific data to ensure that it is based more on the available statistics. The main activity data for estimation of the methane emissions from this subcategory is determination of the amount of degradable pollution in industrial wastewaters. This part is identical with the previous calculation and was not changed. Specific production of pollution – the amount of pollution per production unit – kg COD / kg product is used in this source category. This value is then multiplied by the production or the value obtained from the overall amounts of industrial wastewater and from a qualified estimate of their concentrations (in kg COD/m^3). The approach used is based on the IPCC 2006 Guidelines. The necessary activity data were taken from the the annual report of CZSO (Statistical Yearbook) and the other parameters required for the calculation were taken from the 2006 Guidelines (IPCC 2006). In addition, it was estimated that the amount of sludge equaled 10% of the total pollution in industrial waters (25% was assumed in the Meat and Poultry, Paper and Pulp and Vegetables, Fruits and Juices categories). These estimates are based on Dohanyos and Zábranská (2000); Zábranská (2004), see Tab. 7-16. The fraction of industrial water treated by a particular technology is based on CZSO data about industrial waste water (IWW) treatment. Wastewater is divided into two big groups – untreated, which is water that is released into the watershed without treatment (now almost non-existent) and treated water. Treated water is managed in well-maintained aerobic facilities. Sludge separated from IWW is treated aerobically or anaerobically for methane production. Since sludge data is generally unavailable in the country we reverse use of R. Based on R we estimate necessary amount of sludge COD which is subtracted from total. The effect on total emission is identical, but we keep treatment streams separated. Data about R have been obtained on an annual basis from MIT renewable statistics since 2003; data about R prior 2003 are based on expert estimates. The detailed flow of quantification is shown in Fig. 7-10.

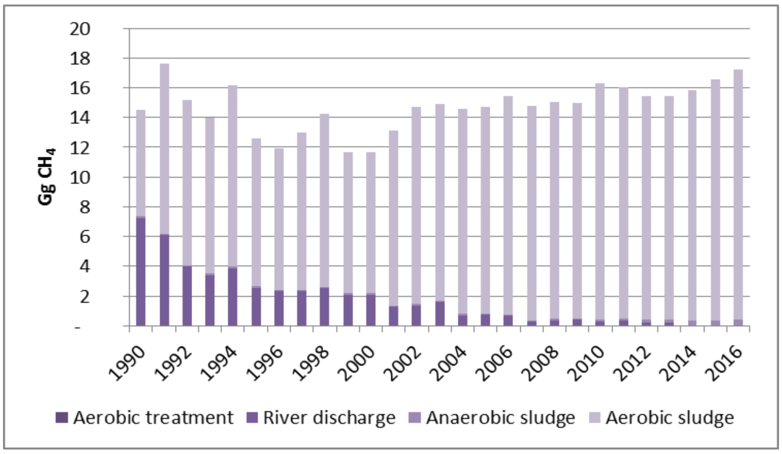


Fig. 7-9 Development of 5.D.2 by types of emission sources

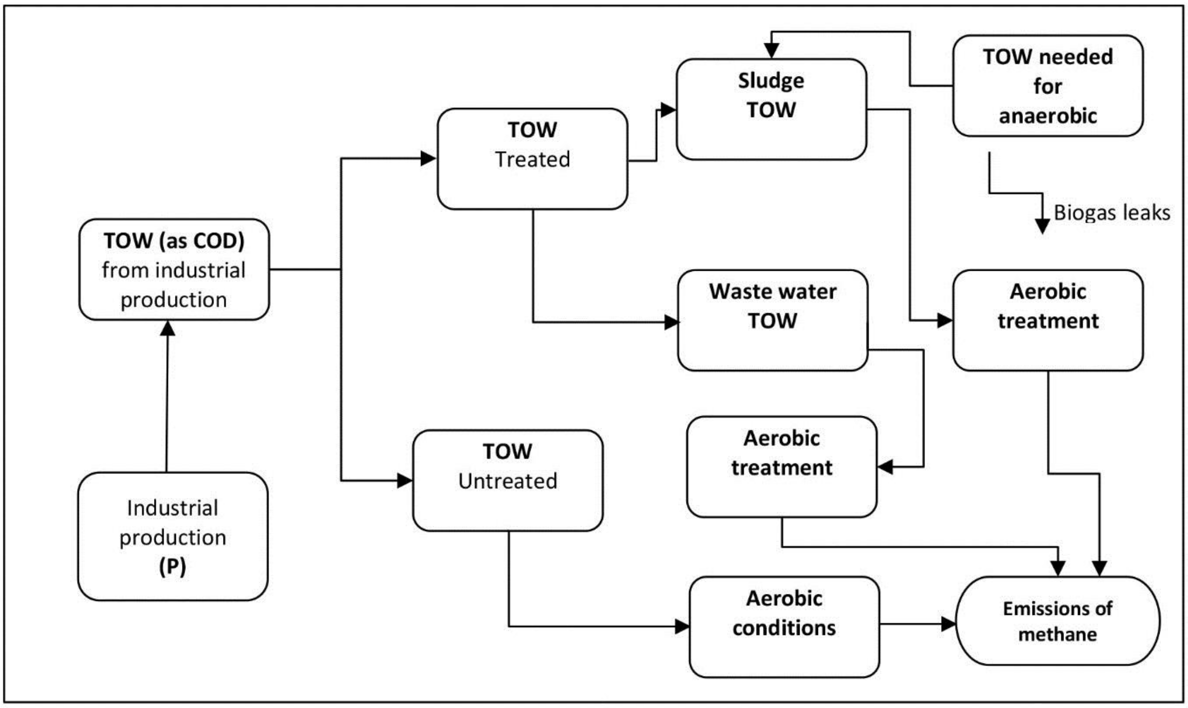


Fig. 7-10 Outline of total organic waste flow in 5.D.2

Tab. 7-20 Industrial production data and used water generation and COD content factors, 1990-2016

	Alcohol Refining	Dairy Products	Beer & Malt	Meat & Poultry	Organic Chemicals	Petroleum Refineries	Plastics and Resins	Pulp & Paper (combined)	Soap and Detergents	Starch production	Sugar Refining	Vegetable Oils	Vegetables, Fruits & Juices	Wine & Vinegar
COD suggested [kg/m3]	11	2.7	2.9	4.1	3	1	3.7	9	0.9	10	3.2	0.9	5	1.5
Wastewater [m3/ton of product]	24	7	6.3	13	67	0.6	0.6	162	3	9	11	3.1	20	23
Industrial production [mil. tonnes]														
1990	0.076	1.326	2.335	0.852	0.268	7.297	0.692	0.714	0.122	0.028	0.574	0.139	0.140	0.054
1991	0.091	1.118	2.175	0.779	0.188	6.445	0.554	0.566	0.079	0.021	0.565	0.119	0.140	0.056
1992	0.093	1.055	2.262	0.586	0.207	6.620	0.561	0.556	0.084	0.028	0.534	0.140	0.143	0.045
1993	0.092	1.142	2.124	0.497	0.227	6.205	0.584	0.524	0.054	0.038	0.518	0.094	0.137	0.051
1994	0.079	1.091	2.173	0.455	0.299	7.165	0.726	0.616	0.041	0.033	0.428	0.098	0.130	0.050
1995	0.078	0.906	2.200	0.436	0.302	7.096	0.673	0.492	0.042	0.033	0.506	0.115	0.135	0.046
1996	0.076	0.869	2.209	0.451	0.331	7.081	0.743	0.468	0.053	0.030	0.602	0.122	0.130	0.054
1997	0.072	0.900	2.243	0.457	0.294	7.000	0.796	0.527	0.053	0.030	0.598	0.128	0.130	0.056
1998	0.064	0.960	2.238	0.487	0.314	7.000	0.833	0.587	0.046	0.034	0.492	0.130	0.128	0.055
1999	0.068	0.949	2.202	0.497	0.310	7.000	0.862	0.467	0.046	0.038	0.420	0.126	0.133	0.056
2000	0.068	0.949	2.202	0.497	0.310	7.000	0.862	0.467	0.046	0.038	0.420	0.126	0.133	0.056
2001	0.057	0.851	2.343	0.531	0.216	7.000	0.869	0.598	0.050	0.049	0.482	0.109	0.129	0.061
2002	0.056	0.871	2.458	0.653	0.197	3.537	0.819	0.671	0.062	0.067	0.517	0.101	0.131	0.087
2003	0.056	0.871	2.458	0.653	0.197	3.537	0.819	0.671	0.062	0.067	0.517	0.101	0.131	0.087
2004	0.042	0.978	2.537	0.653	0.153	3.560	1.263	0.705	0.047	0.069	0.526	0.100	0.121	0.084

	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
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
2016	0.021	1.278	2.968	0.350	0.165	-	1.343	0.949	0.022	0.088	0.602	0.133	0.131	0.068

In accordance with the 2006 Guidelines (IPCC 2006), the maximum theoretical methane production B_0 was considered to be equal to 0.25 kg CH_4/kg COD. This value is in accordance with the national factors, presented in Dohanyos and Zábranská (2000).

Calculation of the emission factor for wastewater is based on the amount of recovered methane and the qualified estimate of the ratio of the use of individual technologies, during the entire recalculated time series.The MCFs used for quantification are shown in Tab. 7-21.

Tab. 7-21 Used MCF for Industrial waste water treatment

	Sea. river and lake discharge	Aerobic treatment plant (well managed)	Aerobic treatment plant (ill managed)	Anaerobic digester for sludge	Anaerobic reactor	Anaerobic shallow lagoon	Anaerobic deep lagoon
Lower bound	0	0	0.2	0.8	0.8	0	0.8
Default MCF	0.1	0	0.3	0.8	0.8	0.2	0.8
Upper bound	0.2	0.1	0.4	1	1	0.3	1

For the quantification we assume that wastewater that is treated in wastewater treatment plants (i.e. not released in to the watershed) is separated to a wastewater and sludge. Wastewater is treated aerobically. Because default MCF values were used, this treatment option does not produce any emissions. Sludge is divided into two parts. One is treated anaerobically producing methane (that is recovered) and emissions. The second part of the sludge is treated aerobically resulting, also in emissions.

Tab. 7-22 Emissions of CH_4 [Gg] from 5.D.2, 1990-2016, Czech Republic

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CH_4 emission	14.5	17.6	15.2	14.0	16.2	12.6	11.9	13.0	14.3	11.7	11.7	13.1	14.7
Recovered CH_4	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
CH_4 emission	14.9	14.6	14.7	15.4	14.8	15.0	15.0	16.3	16.0	15.4	15.4	15.9	16.6
Recovered CH_4	1.8	1.7	1.5	1.2	1.5	1.7	2.0	2.1	2.4	4.7	4.6	6.6	7.0
	2016												
CH_4 emission	16.9												
Recovered CH_4	8.00												

7.5.2.3 Uncertainties and time-series consistency

The uncertainty in most of the factors (default IPCC values) is determined according to the 2006 Guidelines. The overall uncertainty assessment (e.g. Monte-Carlo variation of unncertainity ranges) has not yet been fully quantified and it is anticipated that a software tool will be implemented for this purpose in the coming years.

In previous years, an IPCC expert team reviewed the waste sector and suggested and developed new uncertainty ranges that are listed in Tab. 7-23. During recalculation, all the variables were inserted in the equation as a parameters with lower and upper ranges and central (default where appliable) values. Based on this parametrisation, we were able to estimate the upper and lower boundaries of the emission estimate for this source category, as is shown in Fig. 7-11 (please note log scale in graph as there is three orders difference). The range now corresponds to the full scale of the uncertainity assesment, and indicates the minimum and maximum obtainable values by the distribution of the parameters used in the emission estimates; we foresee that running parametrized Monte Carlo simulation will lower the uncertainity range.

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

Gas	Category	AD uncertainity [%]	EF uncetrainity [%]	Origin of the parameters
CH_4	5.D.2 Industrial wastewater	40	50	Combined uncertainty of quantification parameters + IPCC Default values, Expert judgement M. Havránek

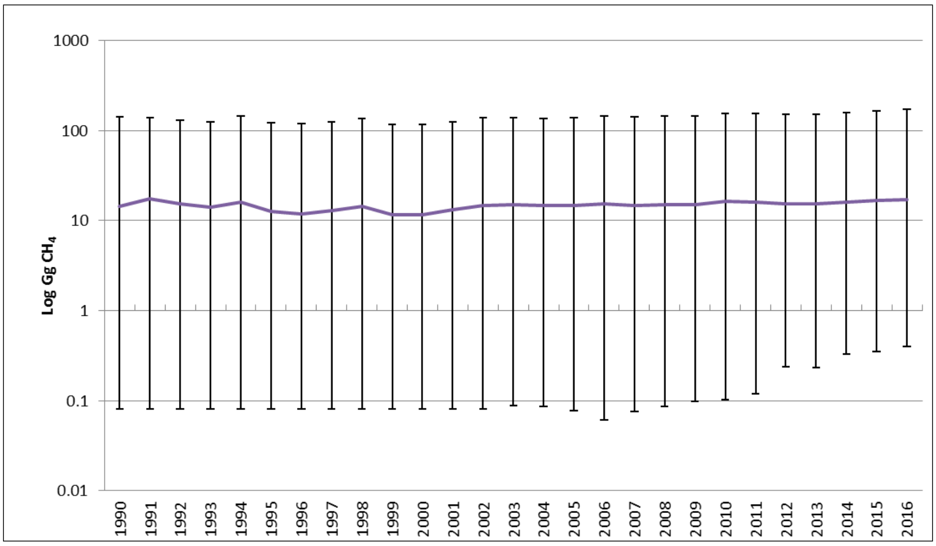


Fig. 7-11 Maximum uncertainty range for 5.D.2 (log scale), 1990-2016

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

No recalculation has been made.

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 whole time series were recalculated because of changes in the activity data – adding of industrial waste (for details see 5.A.1). The results are shown in Tab. 7-24. Reporting format of this category in NIR was harmonised with CRF which requires reporting of Gg of CO_2 rather than Gg of C.

Tab. 7-24 Long-term stored carbon, 1990-2016, Czech Republic

	Long-term stored carbon [Gg CO_2]	Accumulated Long-term stored carbon (since 1950) [Gg CO_2]
1990	765	15558
1991	770	16328
1992	801	17129
1993	820	17949
1994	826	18775
1995	917	19692
1996	950	20642
1997	983	21625
1998	1020	22645
1999	978	23623
2000	1055	24678
2001	1082	25760
2002	1110	26870
2003	1116	27986
2004	1127	29114
2005	1145	30259
2006	1178	31437
2007	1248	32685
2008	1253	33938
2009	1282	35220
2010	1203	36423
2011	1131	37553
2012	1061	38615

	Long-term stored carbon [Gg CO_2]	Accumulated Long-term stored carbon (since 1950) [Gg CO_2]
2013	1028	39642
2014	985	40627
2015	959	41586
2016	968	42554

8 Other (CRF sector 6)

No sector 6 is defined in the Czech inventory.

9 Indirect CO_2 and nitrous oxide emissions

9.1 Description of sources of indirect emissions in GHG inventory

The estimation of indirect CO_2 and N_2O emissions is based on the official Czech inventories for the precursor gases (CO, NMVOC, NH_3 and NO_x) reported under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the CH_4 emissions reported to the UNFCCC.

A detailed description of the methodology used to estimate these emissions should be available in Czech Informative Report (IIR), Submission under UNECE / CLRTAP Convention. Precursor gases totals correspond under both submissions, the differences between reporting formats (NFR-CRF) are taken into account.

In this chapter, indirect emissions and precursor gases are estimated from all sectors, except Agriculture and LULUCF, i.e. sectors Energy, IPPU and Waste. Tab. 9-1 presents a summary of emissions estimates for precursors and SO_x for the period from 1990 to 2016 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 2016 for NMVOC by 29.31%, for CO by 24.57.% and for NO_X by 77.76%. SO_x (reported as SO_2) emissions decreased by 93.80% compared to 1990 level. NH_3 decreased by 88.68% in 2016 compared to the year 1990 (estimated data).

Tab. 9-1 Precursor emissions and their trends from 1990 – 2016

	NO_X	NO_X w/o LULUCF	CO	CO w/o LULUCF	NMVOC	SO_X	NH_3
1990	738.52	739.68	1067.78	1109.69	300.70	1870.91	65.72
1991	723.47	724.34	1153.04	1183.64	263.24	1767.49	40.13
1992	699.43	700.34	1158.25	1190.30	248.04	1554.42	20.92
1993	684.06	685.11	1189.87	1226.89	224.28	1466.04	11.46
1994	441.29	442.37	1070.90	1109.07	247.01	1284.80	9.71
1995	418.85	419.87	927.52	963.38	207.24	1090.23	8.18
1996	437.65	438.98	960.26	1007.29	257.10	931.11	7.17
1997	461.65	463.08	976.05	1026.67	263.80	977.45	8.91
1998	408.21	409.47	802.10	846.47	258.61	438.27	5.39
1999	375.14	376.31	720.96	762.06	239.94	264.35	5.89
2000	291.70	292.77	947.76	985.49	257.88	232.61	5.24
2001	303.38	304.49	957.74	997.02	298.63	228.69	5.42
2002	287.47	288.67	923.11	965.38	295.20	222.61	5.63
2003	287.28	288.78	929.26	982.08	290.54	217.41	6.00
2004	290.04	291.42	917.37	965.82	278.99	215.10	6.00
2005	281.01	282.32	832.62	878.87	266.86	208.43	6.29
2006	275.64	277.27	857.44	914.70	266.51	206.72	6.45
2007	272.44	274.56	864.21	938.68	260.31	212.02	6.69
2008	253.71	255.38	804.78	863.63	251.85	170.01	6.97
2009	235.03	236.45	802.13	851.81	246.68	168.70	7.06
2010	225.31	226.80	823.42	875.88	241.85	163.83	7.03
2011	212.44	213.10	804.77	827.95	229.69	167.49	7.08
2012	198.79	199.50	803.48	828.34	224.46	160.11	7.12
2013	185.12	185.77	821.21	844.28	222.59	145.01	7.12
2014	176.89	177.62	798.26	823.91	216.40	132.49	7.15
2015	171.30	172.11	802.62	831.29	215.81	127.90	7.25
2016	164.23	165.07	805.39	835.32	212.58	115.92	7.44
Trend	-77.76%	-77.68%	-24.57%	-24.73%	-29.31%	-93.80%	-88.68%
NEC	**286**		**-**		**220**	**265**	**101**

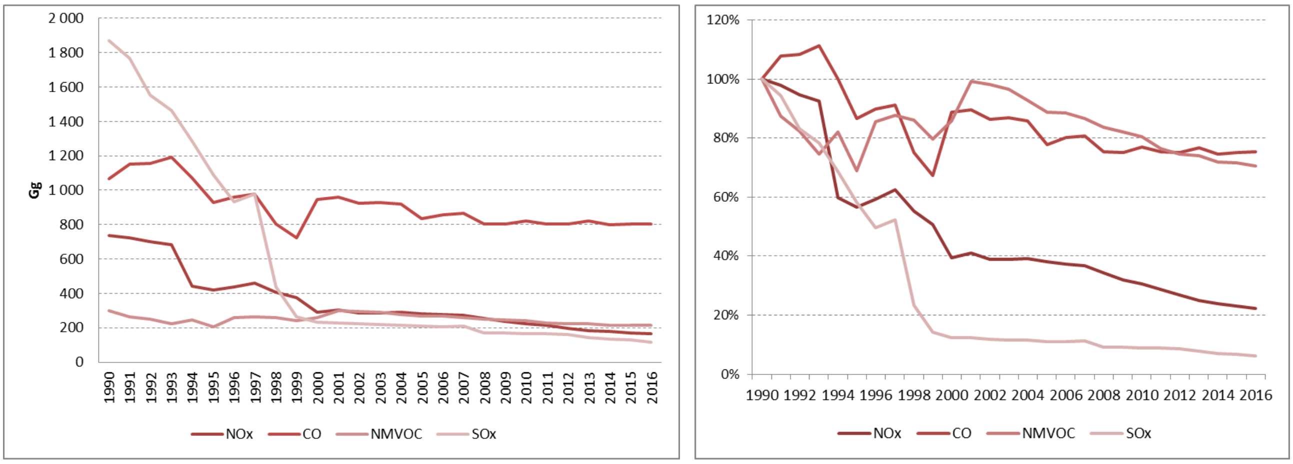


Fig. 9-1 Indexed emissions of precursor gases for 1990-2016 (1990 =100%), [%] (right); Overall trend of precursor gases (left)

On Fig. 9-1 can be observed the overall decreasing trend, in percentage of precursor gases, where year 1990 is equal to 100%, further the overall trend in percentual share of total indirect GHG can be examined.

The categories with highest amounts of precursor gases for NO_X are 1.A.1 Energy Industries, 1.A.3 Transport and 1.A.4 Other sectors; for CO are 1.A.2 Manufacturing industries and construction, 1.A.3 Transport, 1.A.4 Other sectors; for NMVOC are 1.A.3 Transport, 1.A.4 Other sectors and 2.D Non-energy products from fuels and solvent use; for SO_X are 1.A.1 Energy industries, 1.A.2 Manufacturing industries and construction and 1.A.4 Other sectors. Total production from the main CRF categories can be seen on Tab. 9-2.

Tab. 9-2 Precursor GHG emissions in sectors of origin for 2016

	NO_X [Gg]	CO [Gg]	NMVOC [Gg]	SO_X [Gg]	NH_3 [Gg]
Total emissions	**164.23**	**805.39**	**212.58**	**115.92**	**7.44**
1. Energy	160.67	765.22	135.67	111.35	7.01
1A Fuel combustion	160.28	765.13	128.11	108.04	7.01
1A1 Energy Industries	48.40	11.98	5.43	63.12	0.04
1A2 Manufacturing industries and construction	20.95	115.55	1.62	17.74	0.13
1A3 Transport	38.66	66.58	20.02	1.18	2.15
1A4 Other sectors	52.14	570.90	101.03	26.01	4.68
1A5 Other	0.13	0.13	0.01	0.00	0.00
1B Fugitive emissions from fuels	0.38	0.08	7.55	3.31	0.00
2. Industrial processes and product use	2.83	40.11	71.79	4.52	0.20
2A Mineral industry	0.01	0.00	0.07	0.00	0.09
2B Chemical industry	1.24	0.16	1.42	3.95	0.08
2C Metal industry	1.50	39.85	0.18	0.54	0.00
2D Non-energy products from fuels and solvent use	-	-	69.86	-	0.00
2G Other product manufacture and use	0.08	0.09	0.26	0.03	0.03
3. Agriculture	-	-	-	-	-
4. LULUCF	0.84	29.93	-	-	-
5.Waste	0.74	0.06	5.11	0.05	0.22

9.2 Production of indirect emissions from precursor gases

9.2.1 Indirect N_2O emissions from nitrogen oxides

Emissions of NO_X are formed during the combustion of fuels, depending on the temperature of combustion, the content of nitrogen in fuels and the excess of combustion air. NO_X emissions decreased from 739 to 164.2kt during the period 1990 - 2016. In 2016, NO_X emissions were 77.8% below the 1990 level. Slightly more than 98% of total NO_X emissions originate from 1. Energy, mainly subsectors 1.A.1 Energy industries (29.5%), with subsector 1.A.1a Public electricity and heat production (27.2%); 1.A.3 Transport (23.5%), with 1.A.3.b Road transportation (21.3%) and 1.A.4 Other sectors (31.7%), mainly from 1.A.4.c Agriculture/Forestry/Fishing (19.4%) (Fig. 9-2). Hence the indirect N_2O emissions correspondingly decreased from 3.53 to 0.79 kt in 2016.

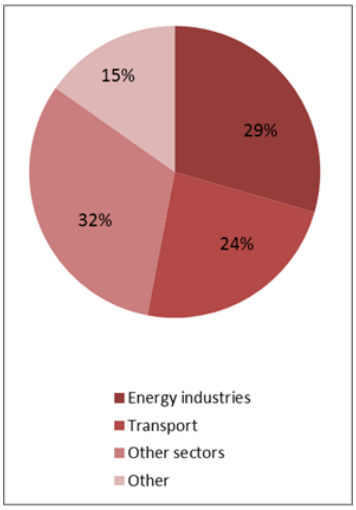


Fig. 9-2 The share of sectors on NOx emissions in 2016

9.2.2 Indirect N_2O from ammonia

Emissions of anthropogenic NH_3 for 2016 are mainly produced from categories: 1.A.4 Other sectors (63.0%), 1.A.3 Transport (28.9%) and 1.A.2 Manufacturing industries and construction (1.8%) Rest (6.4%) includes sectors 1B, 2. and 5. (Fig. 9-3). In 2016, emissions of NH_3 were 7.44 kt. The declining trend of the emissions is calculated based on the latest research of NH_3 emissions in the period between 1990 and 2000. Total indirect N_2O emissions from NH_3 for 2016 are 0.09 kt.

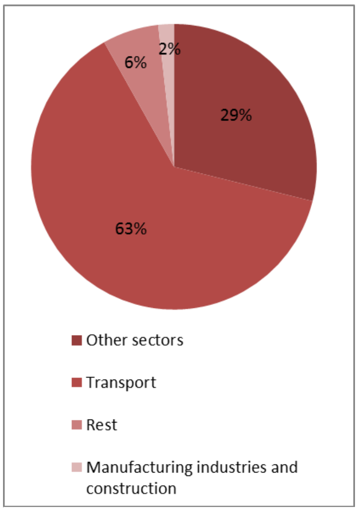


Fig. 9-3 The share of sectors N_2O emissions in 2016

9.2.3 Indirect CO_2 from carbon monoxide

Emissions of CO are produced during the combustion of carbon-containing fuels at low temperatures and by insufficient amount of combustion air. CO emissions decreased from 1,068 to 805.4 kt during the period 1990 - 2016. In 2016, CO emissions were 24.6% below the 1990 level. In 2016, approximately 95% of total CO emissions originated from 1. Energy, subsectors 1.A.2 Manufacturing industries and construction (14.3%); 1.A.3 Transport (8.3%), mostly resulting from 1.A.3.b Road transportation (8.0%) and 1.A.4 Other sectors (70.9%), mainly from 1.A.4.b Residential stationary combustion (67.6%) (Fig. 9-4). Further subsector 2.C Metal industry contributes with 4.9% to the total emissions. Total indirect CO_2 emissions from CO in 2016 are 63.3kt, which is 96.1% less than 1990.

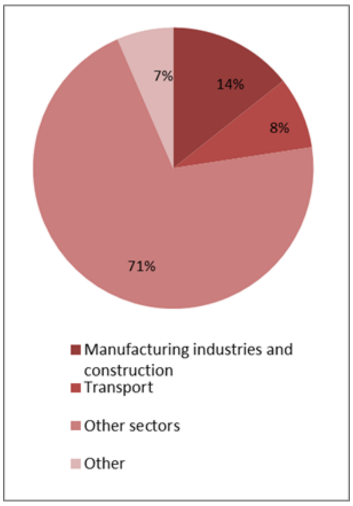


Fig. 9-4 The share of sectors on CO emissions in 2016

9.2.4 Indirect CO_2 from non-methane volatile organic compounds

NMVOC emissions decreased from 300.7 to 212.5 kt during the period between 1990 and 2016. In 2016, NMVOC emissions were 29.3% below the 1990 level. There are three main emission source categories: firstly 1.A.4 Other sectors (47.5%); mostly resulting from 1.A.4.b Residential stationary combustion (45.5%) and secondly 2.D Non-energy products from fuels and solvent use (32.9%), and 1.A.3 Transportation (9.4%). (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 of CO_2 from NMVOC in 2016 are 177.3kt, which is 73.2% less than 1990.

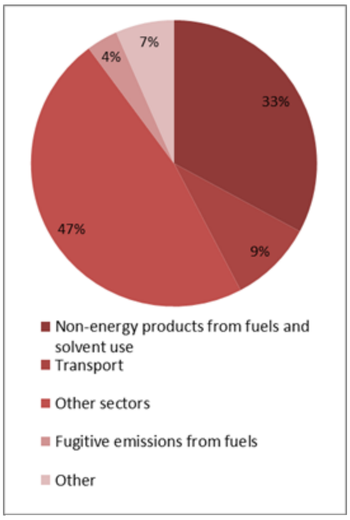


Fig. 9-5 The share of sectors on NMVOC emissions in 2016

9.2.5 Indirect CO_2 from methane

CH_4 emissions, used for the calculation of indirect emissions are mainly produced from categories 1.B.1 Solid fuels. For more information on CH_4 emissions, consult respective chapters. Total indirect CO_2 emissions from CH_4 produced in 2016 are 524.84 kt, which is 67.68% less than in 1990.

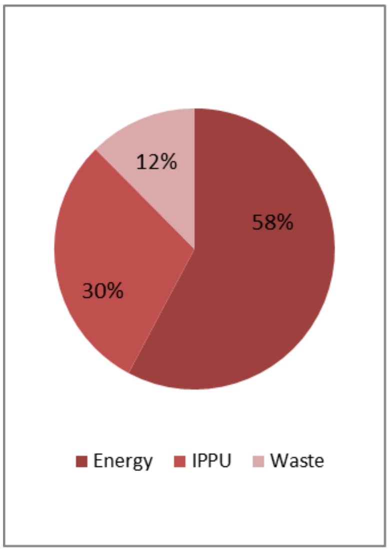
9.3 Production of indirect CO_2 and N2O emissions from source categories

Estimations of indirect CO_2 and N_2O for the whole time series for each sector can be observed on Tab. 9-3.

Tab. 9-3 Time series and trend of indirect emissions per sector and total

	Energy		IPPU		Waste		Total	
	CO_2 [kt]	N_2O [kt]	CO_2 [kt]	N_2O [kt]	CO_2 [kt]	N_2O [kt]	CO_2 [kt]	N_2O [kt]
1990	1276.64	4.26	747.22	2.82	97.88	NE	2121.74	7.08
1991	1129.40	3.87	775.40	1.75	106.35	NE	2011.15	5.63
1992	1070.36	3.52	804.33	0.95	99.45	NE	1974.13	4.47
1993	1051.06	3.33	776.02	0.56	96.16	NE	1923.23	3.89
1994	1002.41	2.16	640.85	0.47	101.94	NE	1745.20	2.63
1995	987.56	2.05	665.74	0.40	91.89	NE	1745.19	2.44
1996	968.50	2.12	659.09	0.35	89.92	NE	1717.51	2.47
1997	951.15	2.26	657.77	0.43	92.62	NE	1701.54	2.68
1998	916.91	1.97	537.97	0.27	95.46	NE	1550.34	2.24
1999	836.57	1.82	475.76	0.29	88.10	NE	1400.44	2.11
2000	781.25	1.44	288.41	0.41	88.00	0.002	1157.65	1.86
2001	738.97	1.50	285.39	0.32	91.72	0.003	1116.07	1.83
2002	688.96	1.43	279.33	0.34	94.03	0.004	1062.31	1.78
2003	678.62	1.43	272.91	0.34	94.60	0.004	1046.13	1.78
2004	647.89	1.45	264.94	0.26	92.86	0.004	1005.69	1.71
2005	698.63	1.41	261.57	0.28	91.89	0.076	1052.09	1.76
2006	721.53	1.38	281.90	0.26	93.39	0.063	1096.81	1.70
2007	674.33	1.37	282.32	0.20	91.55	0.085	1048.20	1.65
2008	669.55	1.28	263.48	0.30	91.87	0.114	1024.89	1.70
2009	626.25	1.20	237.59	0.20	92.14	0.076	955.98	1.47
2010	631.81	1.15	236.74	0.17	94.78	0.115	963.33	1.43
2011	628.12	1.09	220.46	0.19	93.02	0.099	941.60	1.38
2012	603.85	1.02	203.83	0.19	91.92	0.107	899.60	1.32
2013	500.44	0.96	210.41	0.14	91.67	0.106	802.52	1.20
2014	493.68	0.92	214.41	0.12	92.58	0.115	800.68	1.16
2015	480.13	0.90	223.69	0.13	94.78	0.130	638.40	1.15
2016	442.39	0.86	227.70	0.18	95.32	0.185	765.41	1.23
Trend	**-65.3%**	**-79.8%**	**-69.5%**	**-93.5%**	**-2.6%**	**NA**	**-63.9%**	**-82.7%**

In all sector is noticed a decrease in emissions, only in Waste sector the trend is more or less steady.



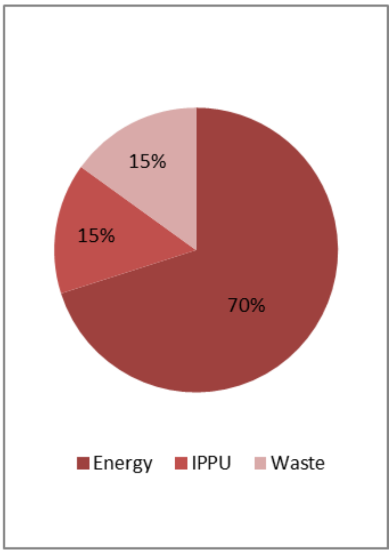


Fig. 9-6 Division of indirect emission of CO_2 (left) and N_2O (right) between the producing sectors for 2016 (in %)

On Fig. 9-6 is visually presenting percentual division of indirect emissions of CO_2 and N_2O between the examined sectors.

Energy sector covers 57.8% of the total production of indirect CO_2 and 70.1% of the total production of indirect N_2O. 97.6% of the N_2O emissions from Energy are from 1.A Fuel combustion; 36.2% from which are from 1A.4 Other sectors, followed by 1.A.1 Energy industries (27.1%) and (24.8 %) 1.A.3 Transport.

For sector IPPU, the main category, producing indirect CO_2 is 2.D Non-energy products from fuels and solvent use, with its NMVOC production, resulting to 68.8% of the total production from this sector. The most of the remaining emissions from the sector are attributed to category 2.C Metal industry (27.6%).

Indirect N_2O emissions from IPPU are divided between the two categories: 2.B Chemical industry (45.6%) and 2.C Metal industry (47.5%). The total share of IPPU sector from the total production of indirect CO_2 is 11.1% and concerning indirect N_2O is 1.2%.

Sector Waste represents 12.4% from the total indirect CO_2 emissions and 15.1% from total N_2O emissions. Almost 100% from the Waste production of indirect CO_2 emissions are emitted from category 5.D Wastewater treatment and discharge and all the emissions from the indirect production of N_2O are produced from category 5.C Incineration and open burning of waste.

9.4 Methodological issues

The above reported data is obtained from the Czech Informative Report (IIR), Submission under UNECE / CLRTAP Convention. The inventory is performed every year, in accordance with the national legislation for the prevention of air polluting and reduction of air pollution from 2012. The inventory combines the direct approach, i.e. the collection of data reported by the sources operators with the data from model calculations based on data, reported by the sources operators or gained within statistical surveys, carried out primarily by CzSO. The results of emission inventories are presented as emission balances processed according to various territorial and sector structures. Further, after obtaining the data, synchronization between the two reporting systems categorization (NFR-CRF) is conducted.

9.4.1 Indirect CO_2 emissions

Indirect emissions of CO_2 were calculated using the default IPCC Tier 1 method. The following equations were used for calculating the indirect emissions, respectively from CO, CH_4 and NMVOC.

$$Emissions_{CO2} = Emissions_{\ CO} \cdot \frac{44}{28}$$

$$Emissions_{CO2} = Emissions_{\ CH4} \cdot \frac{44}{16}$$

$$Emissions_{CO2} = Emissions_{NMVOC} \cdot Percent\ carbon\ in\ NMVOC\ by\ mass \cdot \frac{44}{12}$$

where percent carbon in NMVOC used for sectors Energy, IPPU (except category 2.D) and Waste is the default 60% given in IPCC 2006 Gl.

For estimation of indirect emissions from NMVOC from category 2.D Non-energy products from fuels and solvent use, it was assumed for years 1990-2016 that the average percent of carbon content is 80% by mass based on 2006 IPCC Gl.. 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 Gl. and it was used for the following NFR categories:

- Domestic solvent use including fungicides

- Coating applications
- Degreasing
- Dry cleaning
- Chemical products
- Printing
- Other solvent use.

9.4.2 Indirect N_2O emissions

The indirect N_2O emissions from atmospheric deposition of nitrogen other than agriculture and LULUCF sources are estimated based on the amount of nitrogen emitted in the country multiplied with an emission factor, assuming 1% (default) of the nitrogen in the emissions to be converted to N_2O. The calculation method is the IPCC default Tier 1. Indirect N_2O emissions were calculated using equation 7.1 (IPCC 2006, Vol. 1, section 7.3.1.).

9.5 Uncertainties and time-series consistency

In the process of calculation of emission inventories, data provided by the operators of stationary sources of air pollution, statistic data of the Czech Statistical Office (data on fuel consumption, number of vehicles, number of livestock and area of cultivated land) and data from the Population and housing census which was conducted in 2011 (information on household heating) are used. Further, emission factors and other sources of data are applied.

The data, from which the inventory has been compiled, are of varying quality. Emissions of individual point sources set on the basis of measurements are determined with less uncertainty than the emissions calculated on the basis of statistical data. The uncertainty of the emissions from point sources is below 5% (e.g. emissions from large combustion sources), the uncertainty of emission data based on a sophisticated model (e.g. emissions from household heating and exhaust emissions from transport) ranges between 10–15%. The uncertainty of emissions calculated from statistical data and predefined emission factors is estimated according to the methodology of the EMEP/EEA air pollutant emission inventory guidebook and ranged from 50 up to 200 % (e.g. emissions from the use of solvents, animal production and non-combustion emissions from transport).

9.6 Source-specific QA/QC and verification

The emission estimates are based on the activity data taken from the Czech Informative Report (IIR), Submission under UNECE / CLRTAP Convention and follow the recommendations and QA/QC procedures of IPCC 2006 Guidelines (IPCC 2006). Source specific QA/QC is conducted in line with the QA/QC plan (Tier 1) of the National Inventory System.

9.7 Source-specific recalculations, including changes made in response to the review process and impact on emission trend

No methodological changes were made. Recalculations were made on relevant sectors.

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 Recalculations performed in the submission 2018

10.1.1.1 Recalculation in sector 1.Energy

10.1.1.1.1 Updated activity data after QA procedures

<u>1.A.1.a.ii - Other fuels, 2014 –2015</u>

Whole amount of combusted municipal waste (Other fuels) was updated for 2014 and 2015. 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	Original data	Updated data
		2014	**2014**	**2015**	**2015**
Municipal waste (non-renewable - fossil)	[TJ/year]	2 409	2 511	2 382	2 481
Municipal waste (renewable - bio)	[TJ/year]	3 613	3 766	3 573	3 722

Consequently, emissions were recalculated as well.

1.A.2 – Liquid fuels, 1994 – 2015

Computational error in activity data used in distribution autoproducers consumption, 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. However, total amount of emission remains unchanged in 1.A.2**.** Details of the changes are apparent from Tables.

Tab. 10-2 Updated activity data for combustion of liquid fuels

Sector	Recalculation in years
1.A.2.b Non-ferrous metals	1994 to 2015
1.A.2.c Chemicals	1994 to 2000, 2005 to 2015
1.A.2.d Pulp, paper and print	1994 to 2013
1.A.2.e Food processing, bevarages and tobacco	1994 to 2012, 2014, 2015
1.A.2.f Non-Metalic Minerals	1994 to 2013, 2015
1.A.2.g Non-specified Industry	1994 to 2015

10.1.1.1.2 Updated activity data for 1.A.3.d Domestic Navigation

Activity data for Diesel oil consumption was updated for year 2015 (original 171.8 TJ to updated 128.8 TJ). Emissions were revised consequently.

10.1.1.1.3 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 – 2015, however in same cases the changes are even before year 2010.

The major changes are in net calorific value of solid fuels for 2010-2015. These changes resulted in changes in activity data across all sectors. For some fuels (Lignite and Bituminous Coal), this change also resulted in a change in emission factors. Changes before 2010 is related to changes in Coal Tars fuel consumption.

In years 2011 – 2015 were updated consumption of some liquid fuels (Fuel Oil Low Sulphur, Fuel Oil High Sulphur a Heating and other gasoline) in 1.A.1.a.i sector.

Also, for 2010-2015 the consumption of gaseous fuels was updated in 1.A.2 and 1.A.4.a.

Consequently, emissions were recalculated as well.

Tab. 10-3 Updated activity data for combustion of solid fuels

Sector	Recalculation in years
1.A.1.a.i Electricity Generation	2010 to 2015
1.A.1.c Manufacture of solid fuels and Other Energy Industries	2010 to 2015
1.A.2.a Iron and steel	2009 to 2015
1.A.2.b Non-ferrous metals	2009, 2011 to 2013
1.A.2.c Chemicals	2010 to 2015
1.A.2.d Pulp, paper and print	2010 to 2015

1.A.2.e Food processing, bevarages and tobacco	2010 to 2015
1.A.2.f Non-Metalic Minerals	2010 to 2015
1.A.2.g Non-specified Industry	2009 to 2015
1.A.4.c Agriculture/Forestry/Fishing/Fish Farms	2010 to 2015

10.1.1.1.4 Improvement in 1.A.4.b

It was carried out refinement in activity data and emission factor in 1.A.4.b with using country specific net calorific value for fuels Lignite, Bituminous Coal, Brown Coal Briquettes and Coke.

The whole time series (1990 – 2015) was recalculated. Consequently, emissions were recalculated as well.

10.1.1.1.5 Recalculation in 1.D.1.a Aviation

During the QA/QC process we discovered a discrepancy in reporting of 2013, 2014 for jet kerosene in 1.D.1.a Aviation (international bunkers). The discrepancy was corrected in current submission. Please see table below.

Tab. 10-4 Jet kerosene revised estimates

Fuel Consumption		**2013**	**2014**
Original value	TJ	11931.31	12240.91
Revised value	TJ	11929.15	12328.02
Difference in FC	TJ	-2.16	87.11
Original emission estimates		**2013**	**2014**
CO_2	kt	853.09	875.23
CH_4	kt	0.00597	0.00612
N_2O	kt	0.02413	0.02476
Revised emission estimates		**2013**	**2014**
CO_2	kt	852.93	881.45
CH_4	kt	0.00596	0.00616
N_2O	kt	0.02413	0.02494
Difference in emissions	kt	**2013**	**2014**
CO_2	kt	-0.15	6.23
CH_4	kt	-0.000001	0.000044
N_2O	kt	-0.000004	0.000176

10.1.1.2 Recalculation in sector 2 Industrial Processes and Product Use

10.1.1.2.1 Mineral Industry (2.A)

During QC procedures, a rounding error was identified in the amount of CO_2 emissions reported under category 2.A.1 Cement Production for year 2010. The error was corrected. Since 2012, emissions were recalculated due to revision of EU ETS data used for calculations.

Since 2014, emissions were recalculated for category 2.A.2 Lime Production due to revision of EU ETS data used for calculations.

Category 2.A.3 Glass Production was recalculated since 1990. Emissions for 1990-2009 are calculated according to the Tier 1 methodology described in IPCC 2006 with CS emission factor. Since 2010 emissions are calculated according to the Tier 3 methodology. Data since 2010 are obtained from EU ETS forms.

The subcategory 2.A.4.a Ceramics was recalculated by using updated activity data since 2010, mainly due to double counting between 2.A.4.a and 2.A.4.d. For 1990-2009, emissions are calculated by using Tier 1 methodology with country specific emissions factor. Country specific emission factor was determined as average emission factor from EU ETS data for years 2010-2013 and thus emission estimes changed also for 1990-2009. Since 2010, emissions are calculated by using Tier 3 methodology.

The subcategory 2.A.4.d Other was recalculated due to a double counting between 2.A.4.d Other and 2.A.4.a Ceramics since 2011.

10.1.1.2.2 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 years 2013 to 2015. The errors were corrected.

The subcategory 2.B.4.a Caprolactam was recalculated due to updated activity data for years 2014 and 2015.

The category 2.B.10 Other non-energy use in chemical industry was recalculated by using updated natural gas consumption data and due to harmonization with calculations in sector Energy.

The category 2.B.10 NSCR was recalculated for years 2013 to 2015. Data obtained directly from EU ETS forms was used for emission estimates.

10.1.1.2.3 Metal Industry (2.C)

2.C.1 Iron and Steel Production was recalculated since new updated activity data of bituminous coal are available for 2014-2015. The data are officially updated by CzSO.

10.1.1.2.4 Electronics Industry (2.E)

The category 2.E.1 Integrated Circuit or Semiconductor was recalculated due to updated activity data about SF_6 and NF_3 consumption in semiconductor production since 2006.

10.1.1.2.5 Product Uses as Substitutes for Ozone Depleting Substances (2.F)

Initial emission factors for subcategories 2.F.1.a and 2.F.1.c were revised to 3% and operation emission factors for subcategories 2.F.1.b, 2.F.1.c and 2.F.1.d were revised to 3.5%, 13% and 20%. Emission estimates were calculated with using revised emission factors.

Subcategory 2.F.1.e Mobile Air Conditioning was recalculated due to methodology changes in collection of activity data. Activity data are obtained from statistics of Ministry of the Interior of the Czech Republic, Ministry of Transport of the Czech Republic, Automotive Industry Association, Car Importers Association and data from internet car bazaar. Emissions from filling, from stocks and from disposal are calculated separately by using calculated data from sources mentioned above. Lifetime of the cars was revised to 15 years by using data obtained from Automotive Industry Association. Operation emission factor was revised to 20%.

During QC procedures, an error was indentified in emission calculation for 2.F.1.f. The error was corrected and emissions were recalculated since 1995.

10.1.1.2.6 Other Product Manufacture and Use (2.G)

The amount of emissions of SF_6 from subcategory 2.G.2.b Accelerators was investigating during inventory preparation. In the Czech Republic, accelerators are used in radiotherapy centres and one accelerator is used in research institute. Total amount of emissions is reported int the new category 2.G.2.B.

10.1.1.3 Recalcualtions in sector 3 Agriculture

10.1.1.3.1 Manure Management (3.B)

Consistent parameters for manure management of solid manure (Chapter 5.2.2.2.) were used following recommendation from the last review process. The right use of a "dry lot" and "solid storage" animal waste system parameters were discussed with relevant expert opinions. According to Dr. Klir from the Crop Research Institute, the solid storage is the proper animal waste system currently used in Czech Republic. The recalculation of the whole time series was prepared with EF3 0.005 (Table 10.21, 2006 IPCC GL). This resulted in decrease of total emission in average by about 6.3 %.

Consistent region specific default value from 2006 IPCC GL in the reporting of CH_4 and N_2O emissions from manure management of swine were used for estimation following next recommendation from the last review process. According to the information from Institute of Animal Science (Dr. Rozkot), the breeding of swine in the Czech Republic is on the Western Europe level (welfare, feeding situation etc.). Therefore the new Nex rate available for Western Europe was used in recalculation of the whole time series with Nex rate 0.68 (instead of 0.74) (Table 10.19, 2006 IPCC GL). This resulted in decrease of direct and indirect N emissions from MM in average by about 1.8 %

During the last review, the Czech Republic confirmed a mistake in estimation of nitrogen excretion in the sheep category in 2008. The erroneous data was corrected.

According to the last review recommendation the population data of poultry was split into two categories: broilers and other poultry. This distribution allows using specific emission factors for each category and gas. Additionally, the technical error in calculation of weighted value of methane emission factor was corrected. The complete time series since 1990 were recalculated. It resulted in decrease of total emissions from manure management of poultry category in average by about 9 %. The decrease of emissions is linked to changes of ration between number of broilers and other poultry.

10.1.1.3.2 Agricultural soils (3.D)

This section (3D) of the Czech GHG inventory was revised before the 2017 submission on the recommendation of ERT 2016 and for the first time is described in current submission.

The correction in calculation of amount of nitrogen from manure applied to the managed soils was a subject of the recommendation by ERT 2016. This issue was closed only in March 2017. Therefore, it could not be reflected in the 2017 submission. The corrective action concerned the calculation of N_{MMS_Avb} (eq. 10.34), which produces input data for estimation of $F_{AM.}$. The mistake in estimation of animal manure applied to soil was corrected. The whole time series was recalculated. This resulted in decrease of N_2O emissions from managed soil by about 5 % (submission 2016).

3.D.1 2 Organic N fertilizers

Activity data on N in sewage sludge applied to soil for the period 1990 -2001 was included in estimation according the recommendation of the last review process. The relevant part of the time series was recalculated. The data on sewage sludge applied to the soil are officially available since 2002. The data of the previous period were estimated by statistical methods (linear fitting).

3.D.1 5 Mineralization/immobilization

To avoid double counting in N_2O emissions from the mineralization of soil organic matter only N_2O emissions from mineralization of Cropland remaining Cropland is reported in Agricultural sector. The whole time series was recalculated. The recommendation of the last review process and footnote 4 of CRF table 3D were implemented in this way.

3.D.2 Indirect N_2O emissions from managed soils

The last review process considered overestimation indirect N_2O emissions from manure management. The recalculation of NMMS_Avb, input of Fon, in the whole time series corrected erroneous reporting of activity data for estimation of N_2O emissions from management of agricultural soils. Indirect emissions decreased by about 11 % (Submission 2017).

10.1.1.3.3 Liming (3.G)

According to the recommendation of the last review process the Czech Republic estimates emissions from application of dolomite and limestone separately. The amount of dolomite applied in agriculture was estimated as 10 % share of the limestone applied as a fertilizer. This was confirmed by agricultural experts from the Crop Research Institute in Prague. Specific emission factors were used for dolomite and for limestone. This recalculation resulted to increase of CO_2 emission from liming by about 1 % and increase of the share of this category on the total emission in Agriculture sector by about 0.2 % (submission 2017).

10.1.1.4 Recalculations in sector 4 LULUCF and KP LULUCF Activities

10.1.1.4.1 LULUCF – General and 4.A.1 Forest Land remaining Forest Land

The activity data and estimates related to biomass burning on forest land remaining forest land, the section was revised to ensure a complete adherence to 2006 IPCC Gl. (IPCC 2006). Now it uses a full set of IPCC (2006) EF parameters that are documented in the NIR. Also, the attribution of CO_2 from the prescribed burning was revised, preserving CO_2 emissions under biomass loss. The revision also concerns emissions from wildfires, with exception of attribution of CO_2 emissions, which remain reported under wildfires together with CH_4 and N_2O in line with IPCC (2006) recommendations.

Further on the initiative of the national inventory team, the land-use category “4.F Other Land” was reclassified as “4.E Settlements”. This is because the nature of the land formerly included in Other Land corresponds better to Settlements, which include all land that is (or is possible to be) anthropogenically altered. Therefore, land areas of all categories were recalculated for entire time series since 1969. The affected emission estimates affects mostly the land use categories concerned, i.e., Settlements and Other Land, but to a minor degree also all other land-use categories where associated land-use conversions were previously identified.

10.1.1.4.2 LULUCF – 4.A.1 Forest Land remaining Forest Land

- Carbon stock change in biomass

Newly introduced in this inventory is the volume-weighted *R*-factor assigning below-ground biomass based on the carbon-density- and species-specific forest stand values as given in IPCC 2006, Table 4.4. *R* was recalculated for the entire time series since 1990. The biomass estimates changed accordingly.

- Carbon stock change estimates for DOM and litter

Estimates for dead organic matter (DOM) are newly introduced for this emission category. They are based on the data from available forest inventory programs, namely NFI1 (2001-2014) and Landscape inventory CzechTerra CZT1 (2008-2009) and CZT2 (2014-2015). The estimation follows the stock difference method (Eq. 2.19 of IPCC 2006).

- 4(V) Biomass Burning

Estimation of emissions from biomass burning was revised using a complete set of combustion and emission factors of IPCC 2006. Also since this inventory submission, CO_2 emissions from prescribed burning is reported as included elsewhere (IE), namely in carbon loss from harvest. This resulted in somewhat more conservative estimates of emissions from biomass burning (CO_2, N_2O, CH_4). The entire time series since 1990 was recalculated.

10.1.1.4.3 LULUCF – Land converted to Forest Land

Carbon stock change in biomass

Newly introduced in this inventory is the volume-weighted *R*-factor assigning below-ground biomass based on the carbon-density- and species-specific forest stand values as given in IPCC 2006, Table 4.4. *R* was reassessed for the entire time series since 1990. The biomass estimates changed accordingly for all land-use conversions including forest land (4.A.2.1, 4.A.2.2, 4.A.2.3, 4.A.2.4, 4.B.2.1, 4.C.2.1, 4.D.2.1 and 4.E.2.1).

Carbon stock change estimates for DOM and litter

Estimates for DOM and litter carbon pools are newly introduced and/or revised. They are based on the data from available forest inventory programs, namely NFI1 (2001-2014) and Landscape inventory CzechTerra CZT1 (2008-2009) and CZT2 (2014-2015). The estimation follows the stock difference method (Eq. 2.19 of IPCC 2006). Note that apart the category 4.A.2, these improvements also affect DOM estimates for the categories 4.B.2.1, 4.C.2.1, 4.D.2.1 and 4.E.2.1.

10.1.1.4.4 LULUCF – 4.B.1 Cropland remaining Cropland

Carbon stock change in biomass

AD for biomass were restructured in connection with the newly adopted methodology of mineral carbon stock change estimation (see below). Specifically, the areas of cropland with perennial vegetation includes a half of gardens, vineyards and orchards. The estimation uses strictly the factors recommended by Table 5.1 following Tier 1 assessment based on Eqs. 2.7, 2.9, 2.10 of IPCC (2006). The entire time series was recalculated.

Carbon stock change in mineral soil

The estimation of emissions was revised using country-specific activity data on soil carbon, management systems and management activities, following Eq. 2.25 of IPCC (2006). The corresponding emission factors were used and/or derived based on Table 5.5 of IPCC (2006). This methodological revision (Tier 1, 2) concerns the entire time series that was thereby recalculated.

10.1.1.4.5 LULUCF – 4.C.1 Grassland remaining Grassland

Carbon stock change in mineral soil

The estimation of emissions was revised using country-specific activity data on soil carbon, management systems and management activities, following Eq. 2.25 of IPCC (2006). The corresponding emission factors were used and/or derived based on Table 6.2 of IPCC (2006). This methodological revision (Tier 1, 2) concerns the entire time series that was thereby recalculated.

10.1.1.4.6 LULUCF – Land converted to Settlements

Carbon stock change in biomass

In connection with an adjusted definition of Settlements (see a detailed explanation under General above), the land areas associated with land use conversions to Settlements changed for the period 2004 to 2017. Therefore, the concerned emission estimates were recalculated.

10.1.1.4.7 LULUCF – Harvested Wood Products

Emission related to 4.G HWP was recalculated for years 2014 and 2015 due to the rectified data of wood products newly available at FAO database, the activity data used for the assessment of category 4G - HWP.

10.1.1.4.8 KP LULUCF – FM – Forest Management

Carbon stock changes in DOM

This reporting newly includes estimates for DOM, including carbon stock changes in lying and standing deadwood. The estimates are based on the data from available forest inventory programs, namely the National Forest Inventory (NFI1 2001-2014) and the Landscape inventory CzechTerra CZT1 (2008-2009) and CZT2 (2014-2015). The estimation follows the stock difference method (Eq. 2.19 of IPCC 2006).

Biomass Burning

Estimation of emissions from biomass burning was revised using a complete set of combustion and emission factors of IPCC 2006. CO_2 emissions emission estimates from prescribed burning are reported as included elsewhere (IE), namely within carbon loss from harvest. The entire time series since 1990 was recalculated.

Carbon stock change in biomass

Newly introduced in this inventory is the volume-weighted *R*-factor assigning below-ground biomass based on the carbon-density- and species-specific forest stand values as given in IPCC 2006, Table 4.4. *R* was reassessed for the entire time series since 1990. The biomass estimates changed accordingly for below-ground biomass component.

10.1.1.4.9 KP LULUCF - Afforestation and reforestation and Forest management

The discrepancies between the estimates of Afforestation and reforestation and Forest management and Convention reporting of categories 4.A.1 and 4.A.2 were identified for the years since 2010. The inventory team identified a technical error in area attribution that affected KP LULUCF estimates from 2010 to 2016(2017). After correction, a full consistency between KP LULUCF and Convention was achieved also for the above period. Since both KP LULUCF and LULUCF fully share the estimation methods, there is no discrepancy any more for forest-related categories under KP LULUCF and Convention. Note, however, that the entire time series was recalculated due to the improved EF for biomass and DOM estimates that affect emission estimation for forests under both KP LULUCF and Convention.

10.1.1.4.10 KP LULUCF - Afforestation/Reforestation and Deforestation

Carbon stock change in biomass

Newly introduced in this inventory is the volume-weighted *R*-factor assigning below-ground biomass based on the carbon-density- and species-specific forest stand values as given in IPCC 2006, Table 4.4. *R* was reassessed for the entire time series since 1990. The biomass estimates changed accordingly for ARD activities. The quantitative effect of these recalculations was marginal.

Carbon stock change estimates for DOM and litter

The estimates for DOM and litter carbon pools are newly introduced and/or revised. They are based on the data from available forest inventory programs, namely NFI1 (2001-2014) and Landscape inventory

CzechTerra CZT1 (2008-2009) and CZT2 (2014-2015). The revised estimates are applicable for both AR and D activities.

10.1.1.4.11 KP LULUCF - Carbon stock changes in the HWP pool

HWP from land subject to forest management

Emission contribution from HWP was recalculated for years 2015 and 2016 due to the rectified data of wood products at FAO database, the activity data used for the assessment of HWP contribution.

10.1.1.5 Recalculations in sector 5 Waste

10.1.1.5.1 5.A Solid waste disposal

Category 5A Solid waste disposal was recalculated, based on ICR recommendation. Industrial waste correction was included in whole time series which led to increased emissions from this source category.

10.1.1.5.2 5.C. Waste incineration

Recalculation was conducted based on ICR recommendation. Correction factor for wet waste was introduced in to calculation which led to decreased emission in whole time series.

10.1.1.5.3 5.E. Long-term storage of carbon

Due to changes in 5.A. Long-term carbon storage was updated as well. Whole time series was recalculated and increased amount of stored carbon was the result.

10.2 Implications for emission levels

Tab. 10-5 Implications on emission levels on example on 2015 emission levels

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference %	Impact of recalculation on total emissions excl. LULUCF%	Impact of recalculation on total emissions incl.LULUCF %
Total National Emissions and Removals	116 936.26	125 820.37	8 884.11	7.60%	6.71%	7%
1. Energy	97 973.60	98 957.27	983.67	1.00%	0.74%	1%
A. Fuel combustion activities	93 585.84	94 569.51	983.67	1.05%	0.74%	1%
1. Energy industries	53 628.86	53 678.15	49.29	0.09%	0.04%	0%
2. Manufacturing industries and construction	9 921.80	9 700.31	-221.49	-2.23%	-0.17%	0%
3. Transport	17 747.55	17 744.33	-3.22	-0.02%	0.00%	0%
4. Other sectors	11 906.82	13 065.91	1 159.09	9.73%	0.88%	1%
5. Other	380.81	380.81	0.00	0.00%	0.00%	0%
B. Fugitive Emissions from Fuels	4 387.76	4 387.76	0.00	0.00%	0.00%	0%
1. Solid fuels	3 774.33	3 774.33	0.00	0.00%	0.00%	0%
2. Oil and natural gas	613.43	613.43	0.00	0.00%	0.00%	0%
C. CO_2 transport and storage	NO	NO	NA	NA	NA	NA
2. Industrial processes and product use	11 863.96	11 985.27	121.31	1.02%	0.09%	0%
A. Mineral industry	2 533.91	2 575.79	41.88	1.65%	0.03%	0%
B. Chemical industry	2 071.06	2070.59	-0.47	-0.02%	0.00%	0%
C. Metal industry	6 895.94	6 975.84	79.90	1.16%	0.06%	0%
D. Non-energy products from fuels and solvent use	139.55	139.55	0.00	0.00%	0.00%	0%
G. Other product manufacture and use	223.50	223.50	0.00	0.00%	0.00%	0%
H. Other	NO	NO	NA	NA	NA	NA
3. Agriculture	8 482.99	15 898.12	7 415.13	87.41%	5.60%	6%
A. Enteric fermentation	2 895.96	5 754.89	2 858.93	98.72%	2.16%	2%
B. Manure management	1 779.28	3 315.36	1 536.08	86.33%	1.16%	1%
C. Rice cultivation	NO	NO	NA	NA	NA	NA
D. Agricultural soils	3 457.76	5 531.71	2 073.95	59.98%	1.57%	2%
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	162.89	1 187.63	1 024.74	629.09%	0.77%	1%
H. Urea application	187.10	108.53	-78.57	-41.99%	-0.06%	0%
I. Other carbon-containing fertilizer	NO	NO	NA	NA	NA	NA
J. Other	NO	NO	NA	NA	NA	NA
4. Land use, land-use change and forestry (net)	-6 640.69	-6 532.02	108.67	-1.64%	0.08%	0%
A. Forestland	-6 052.84	-5 967.69	85.15	-1.41%	0.06%	0%
B. Cropland	4.67	131.92	127.25	2725.37%	0.10%	0%
C. Grassland	-550.34	-358.28	192.06	-34.90%	0.15%	0%
D. Wetlands	25.18	25.09	-0.09	-0.37%	0.00%	0%
E. Settlements	88.12	95.81	7.69	8.73%	0.01%	0%
F. Other land	7.55	NO,NA	NA	NA	NA	NA
G. Harvested wood products	-164.15	-460.00	-295.85	180.23%	-0.22%	0%
H. Other	NO	NO	NA	NA	NA	NA
5. Waste	5 256.41	5 511.73	255.32	4.86%	0.19%	0%
A. Solid waste disposal	3 385.21	3 653.77	268.56	7.93%	0.20%	0%
B. Biological treatment of solid waste	678.57	678.57	0.00	0.00%	0.00%	0%
C. Incineration and open burning of waste	134.83	121.59	-13.24	-9.82%	-0.01%	0%
D. Waste water treatment and discharge	1 057.79	1 057.79	0.00	0.00%	0.00%	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	895.14	895.14	0.00	0.00%	0.00%	0%
Aviation	895.14	895.14	0.00	0.00%	0.00%	0%
Navigation	NO	NO	NA	NA	NA	NA
Multilateral operations	NO	NO	NA	NA	NA	NA
CO_2 emissions from biomass	16 193.69	16 193.69	0.00	0.00%	0.00%	0%
CO_2 captured	NO	NO	NO	NO	NO	NO
Long-term storage of C in waste disposal sites	40 084.60	41 586.48	1 501.88	3.75%	1.13%	1%
Indirect N_2O	308.79	344.49	35.70	11.56%	0.03%	0%
Indirect CO_2	798.70	638.40	-160.30	-20.07%	-0.12%	0%

10.3 Implications for emission trends, including time-series consistency

10.3.1 Implications for emission trend and time-series consistency of CO_2

The influence of the recalculations for the emission trend of CO_2 are illustrated on Fig. 10-1. Both curves are following the same pattern. The CO_2 emissions are higher on average by 1%, through the whole time period.

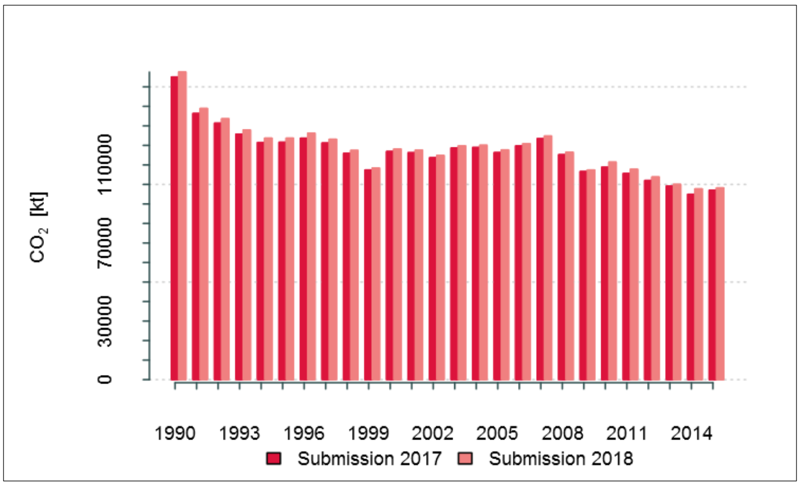


Fig. 10-1 Difference in trends of CO_2 emissions in index form, between the submissions 2017 and 2018, due to recalculations (1990 = 100%)

10.3.2 Implications for emission trend and time-series consistency of CH_4

The influence of the recalculations for the emission trend of CH_4 are illustrated on Fig. 10-2. Both curves are following the same pattern. The CH_4 emission trend is higher on average by 1.3%, through the whole time period.

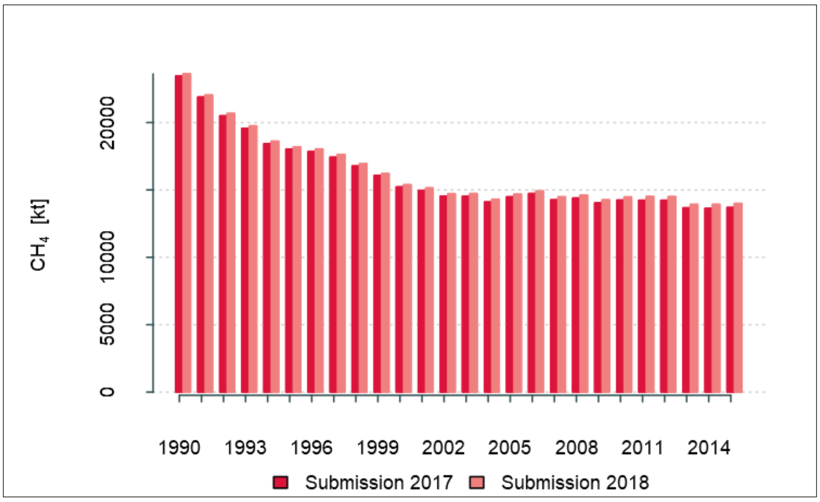


Fig. 10-2 Difference in trends of CH_4 emissions in index form, between the submissions 2016 and 2017, due to recalculations (1990 = 100%)

10.3.3 Implications for emission trend and time-series consistency of N_2O

The influence of the recalculations for the emission trend of N_2O are illustrated on Fig. 10-3. Both curves are following the same pattern. The N_2O emission trend is lower on average 7.4%, through the whole time period.

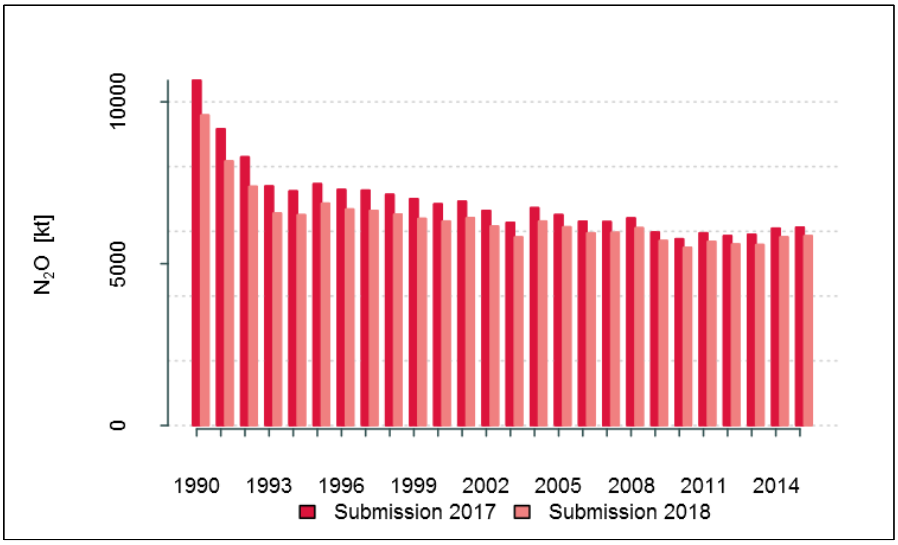


Fig. 10-3 Difference in trends of N_2O emissions in index form, between the submissions 2016 and 2017, due to recalculations (1990 = 100%)

10.3.4 Implications for emission trends and time-series consistency of F-gases and SF_6

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

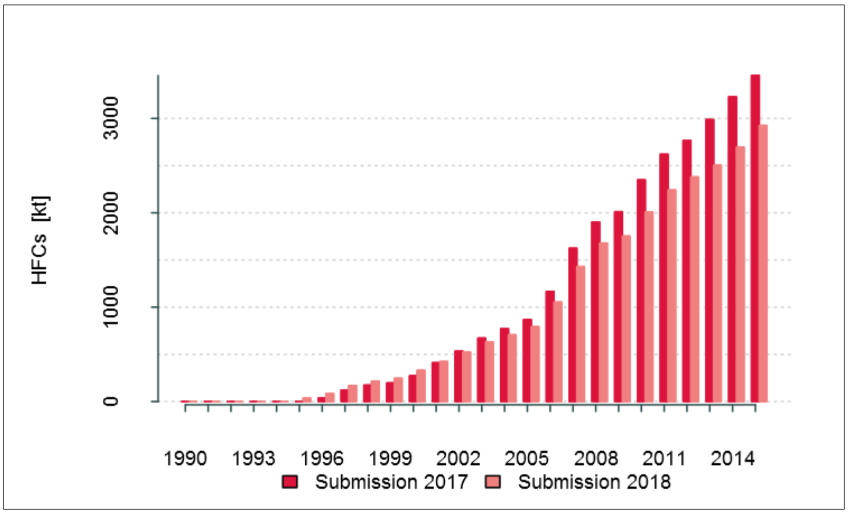


Fig. 10-4 Difference in trends of HFCs emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

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

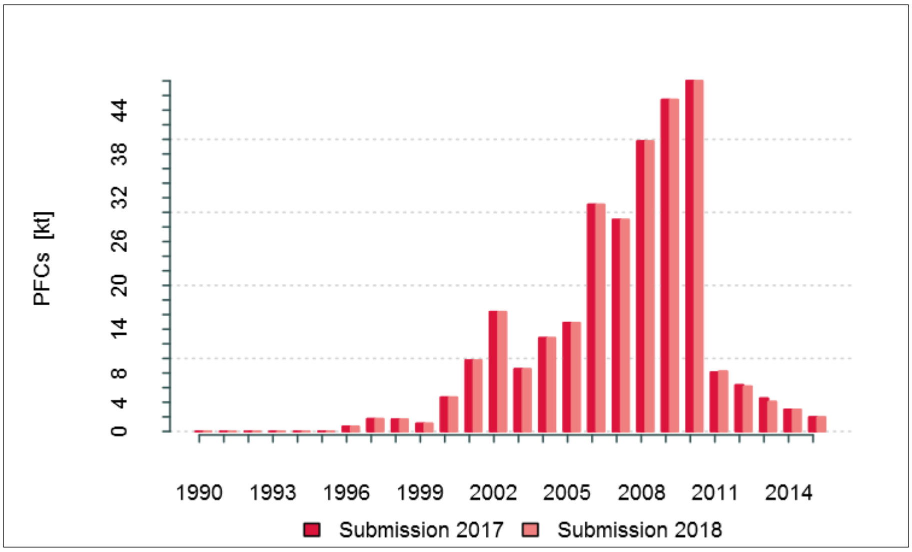


Fig. 10-5 Difference in trends of PFCs emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

The influence of the recalculations for the emission trend of SF_6 are illustrated on Fig. 10-6. Both curves are following the same pattern.

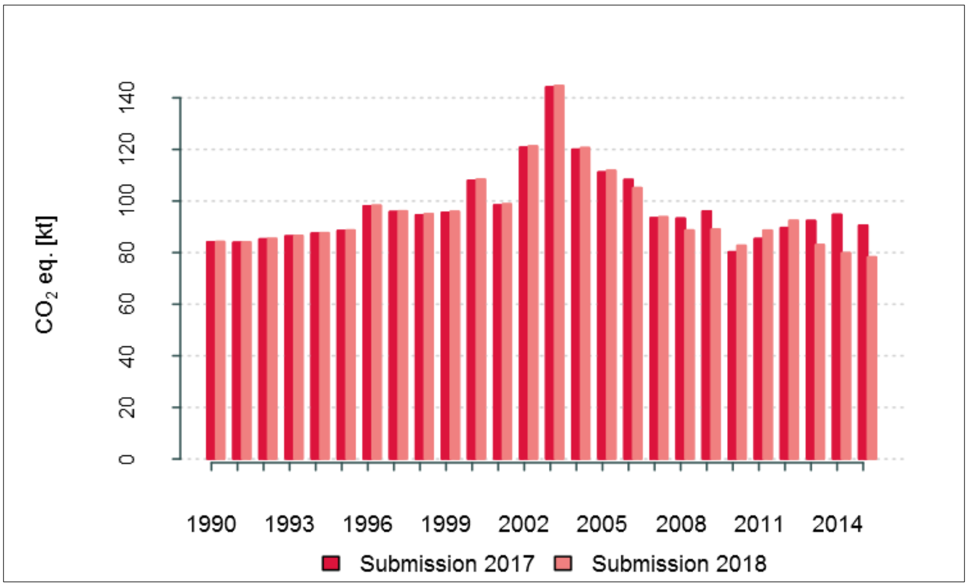


Fig. 10-6 Difference in trends of SF_6 emissions in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

10.3.5 Implications for emission trends and time-series consistency of total emissions

The influence of the recalculations for the emission trend of total emissions, including LULUCF are illustrated on Fig. 10-7. Both curves are following the same pattern. The total emissions including LULUCF in trend is higher on average by 0.8% through the whole time period.

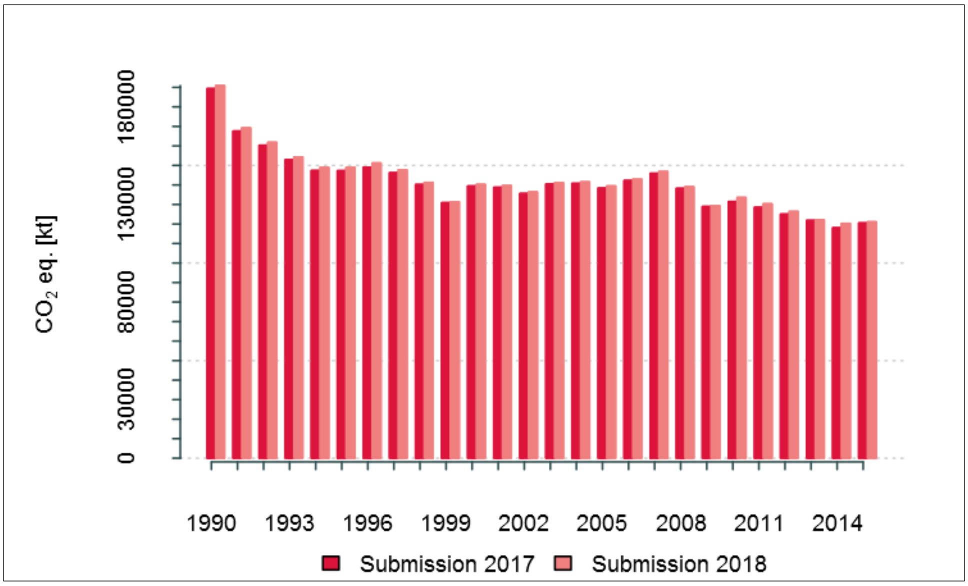


Fig. 10-7 Difference in trends of total emissions including LULUCF in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

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 0.5% through the whole time period.

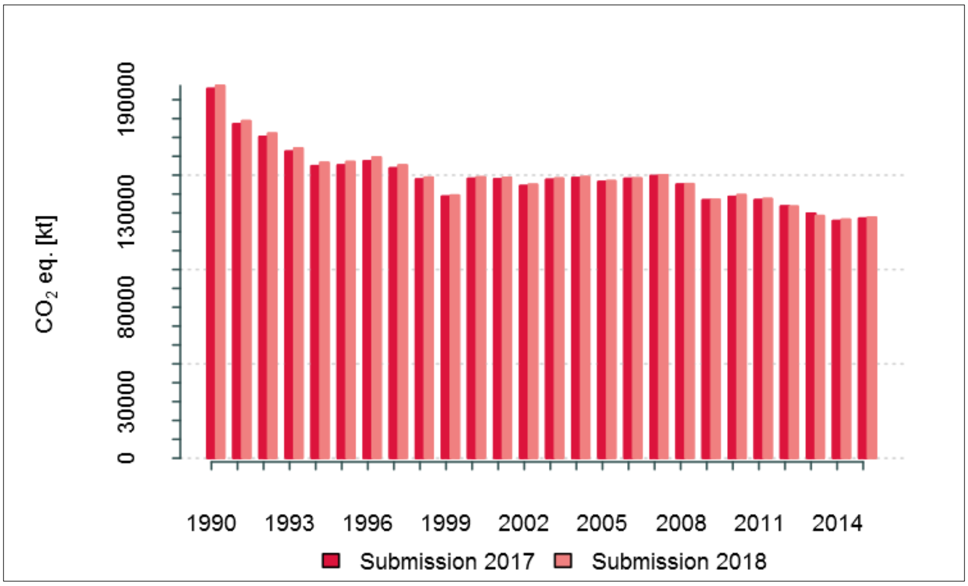


Fig. 10-8 Difference in trends of total emissions excluding LULUCF in index form, between submission 2016 and 2017, due to recalculations (1990 = 100%)

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, 2016). In this report, attention is focused on the two last reviews.

In September 2017, the Czech Republic was subject to the in-country review. No ‘potential problems’ were formulated, thus no resubmission after the review was carried out.

Further, till the submission of this inventory, only draft ARR was available to the inventory team. It means, that the recommendations might not have been resolved in this year’s inventory.

10.4.1 Overview of implemented improvements in the 2018 submission

The following table summarises the main changes and that were performed in 2018 (2016) submissions in comparison with previous submissions.

For changes in methodological descriptions please see Tab. 10-7.

Tab. 10-6 Table of implemented improvements in the 2018 submission

Topic/Category, gas	Description of the change	Reason (motive) of the change	Reference to NIR or CRF Table
Sector: General issues			
Archiving	Revised archiving routines, technicalities of archive improved	In-country review 2017 recommendation	**NIR, chapter 1.3.3**
Key category analysis	Category list updated	In-country review 2017 recommendation	**NIR, chapter 1.5 Annex 1**
Uncertainty analysis	Sectoral uncertainties updated	Improvement suggested by Party	**NIR, chapter 1.6 Annex 2**
Sector: Energy – emissions from combustion			
1.A.1.a	Other fossil fuels – activity data	Change of activity data after QA/QC procedure	**NIR, chapter 3.**
1.A.2.	Liquid fules – activity data	Change of activity data after QA/QC procedure	**NIR, chapter 3.**
1.A.4.b	Solid fules – EF CO_2, activity data	Improvement suggested by Party	**NIR, chapter 3.**
1.A.3.	New structure of the whole chapter. New detailed tables and graphs	UN FCCC in contry review, autumn 2017	**NIR, chapter 3.2.17.5.1.**
Sector: Industrial processes and Other Product Use			
2.A.3	Implementation of the Tier 3 methodology	Improvement suggested by Party	**NIR, chapter 4.2.3**
2.C	Actvitiy data updated	Improvement suggested by Party	**NIR, chapter 4.4.**
2.F.1	Update of emission factors	EU ESD review recommendation	**NIR, chapter 4.7.1.1**
2.F.1.e	New methodology for preparation of activity data	Change of the methodology after UNFCCC review	**NIR, chapter 4.7.1.1**
2.G.2.b	New source category accelerators added into the inventory	Survey of other uses of SF_6 after the UNFCCC review	**NIR, chapter 4.8..2**
Sector: Agriculture			
3	General update of the structure and content of NIR text	ERT recommendation	**NIR text**
3.A, 3.B CH_4 N_2O	Update of activity data (weight data, cattle categories)	Improvement suggested by Party	**NIR, chapter 5.2.**
3.B.	AWMS system explained and confirmed	ERT recommendation	**NIR, chapter 5.2.2.2**
3.B N_2O	Solid storage management system confirmed and systematically used in estimations	ERT recommendation	**NIR, chapter 5.2.2.2**
3.B N_2O	Suitable Nex rate for swine implemented	ERT recommendation	**NIR, chapter 5.2.2.2.3.**
3.B N_2O	Erroneous data corrected (Sheep, N excreted, 2008)	ERT recommendation	**NIR, chapter 5.2.2.2.3.**
3.B N_2O	Methodological update: Poultry category was split to broilers and other poutry	ERT recommendation	**NIR, chapter 5.2.2.2.3.**
3.D, N_2O	Update of activty data: the complete time serie	ERT recommendation	**NIR, chapter 5.4.2**

	data of the amount of sewage sludge		
3.D, N_2O	Calculation of amount of nitrogene from manure applied to the soils corrected	ERT recommendation	**NIR, chapter 5.4.2**
3.D, N_2O	Double counting in mineralization/immobilization category avoided	ERT recommendation	**NIR, chapter 5.4.2**
3.D.2, N_2O	Implementation of corrective actions in estimation of Indirect emissions from soils	ERT recommendation	**NIR, chapter 5.4.2.3**
3.G.	Methodological update: Liming activity data split to limestone and dolomite	ERT recommendation	**NIR, chapter 5.7**
Sector: LULUCF			
4.A.1, 4.A.2	Below-ground biomass carbon stock - revised EF (R-factor)	Implementation of 2006 IPCC Guidelines, suggestion by Party	**NIR, chapter 6.4.2**
4.A.1	Corrections incl. revised EF for burning	Implementation of 2006 IPCC Guidelines, suggestion of ERT and Party	**NIR, chapter 6.4.2**
4. A.1	Carbon stock change in DOM (deadwood and litter) implemented using new AD	Implementation of 2006 IPCC Guidelines, suggestion by Party	**NIR, chapter 6.4.2**
4. B.1	Carbon stock change in biomass and mineral soils using new AD	Implementation of 2006 IPCC Guidelines, suggestion by ERT and Part	**NIR chapter 6.5.2**
4. C.1	Carbon stock change in mineral soils using new AD	Implementation of 2006 IPCC Guidelines, suggestion by ERT	**NIR, chapter 6.6.2**
4. E, 4. F	Improved attribution of land areas for 4.F, newly included under 4.E.	Implementation of 2006 IPCC Guidelines, suggestion by Party, consulted by ERT	**NIR, chapters 6.8 and 6.9**
Sector: Waste			
5.A	Addition of Industrial waste correction to SWDS	Improvement suggested by ICR	**NIR, chapter 7**
5.C	Correction factor wet-dry waste	Improvement suggested by ICR	**NIR, chapter 7**
5.E	Update due to changes in landfilled amount in 5.A	Improvement suggested by ICR	**NIR, chapter 7**

Tab. 10-7 Methodological descriptions in submission 2018

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
Total (Net Emissions)			
1. Energy			
A. Fuel Combustion (Sectoral Approach)		√	
1. Energy Industries		√	
2. Manufacturing Industries and Construction		√	
3. Transport	√	√	
4. Other Sectors		√	
5. Other			
B. Fugitive Emissions from Fuels			
1. Solid Fuels			
2. Oil and Natural Gas and Other emissions from Energy Production			
C. CO_2 transport and storage			
2. Industrial Processes		**√**	
A. Mineral Industry	√	√	
B. Chemical Industry		√	
C. Metal Industry		√	
D. Non-energy Products from Fuels and Solvent Use			
E. Electronics Industry		√	
F. Product Uses as Substitutes for ODS	√	√	
G. Other Product Manufacture and Use	√	√	
3. Agriculture	**√**	**√**	
A. Enteric Fermentation			
B. Manure Management	√	√	More detailed information for each recalculation is provided in Table 10-1 and in relevant Chapters of NIR
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	NO	NO	
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			

F. Long-term stored carbon		√	
6. Other (as specified in Summary 1.A)	**NO**	**NO**	
KP LULUCF			
Article 3.3 activities			
Afforestation/reforestation		√	
Deforestation			
Article 3.4 activities			
Forest management	√	√	
Cropland management (if elected)			
Grazing land management (if elected)			
Revegetation (if elected)			
Wetland drainage and rewetting (if elected)			
HWP		√	
Memo Items:			
International Bunkers			
Aviation			
Marine			
Multilateral Operations			
CO_2 Emissions from Biomass			
CO_2 Captured			
Long-term storage of C in waste disposal sites			
Indirect N_2O			
NIR Chapter	**DESCRIPTION**		**REFERENCE**
	Please tick where the latest NIR includes major changes		**If ticked please provide some more detailed information**
Chapter 1.2 Institutional arrangements			
Chapter 1.6 QA/QC plan			

10.4.2 Improvement plan

Provisional Improvement plan was included in the NIR already last year and in this submission was updated and supplemented. This plan is in accordance with the recommendation of the international Expert Review Team (ERT) and concentrates particularly on introduction the more sophisticated procedures of the higher Tiers. These procedures employ country-specific emission factors and other parameters required for determining greenhouse gas emissions. However, it is rather difficult to obtain the data required for these purposes, especially at the present time, when only limited funds are available for the national inventory. Thus, it is planned to introduce the procedures of the higher Tiers gradually, over a longer time interval. In accordance with the IPCC methodology, emphasis is simultaneously put on Key categories. The following table gives the anticipated timetable for introduction of these procedures. As announced in the last submission, the country-specific emission factor for estimating CO_2 emissions from combustion of Natural Gas has been determined (please see Annex 2). These factors were already employed in this submission (see Chapter 3).

In addition to the planned introduction of the procedures of the higher Tiers in the individual sectors, the Improvement plan also includes a more general aspect. For instance last year have been revised uncertainty estimates. A substantial improvement in this respect has already appeared in this submission (see Chapter 1).

Furthermore Improvement Plan also includes using of EU ETS data for the purposes of national inventory. Substantial effort is put into implementation of this issue. In this submission EU ETS data were used for emission estimates in some subcategories in 2.A Mineral Product (e.g. 2.A.1 Cement Production). EU ETS data would be useful tool for QA/QC procedures also in Energy sector.

With the implementation of this issue could help also MS assistance project (Assistance to MS with KP Reporting) which is now under operation. Issue of implementation of EU ETS data was raised by the Czech Republic. Another issues concerning Energy and IP sector were raised in this assistance project.

Tab. 10-8 Plan of improvements for key categories

Sector	Key Categories (KC)	GHG	Type of KC	Present situation	Planned improvement	For submission
General	Uncertainty estimates			Research of uncertainties held in 2012	Improvement of uncertainty estimates	2019
1.A.1	Energy industries - Solid Fuels	CO_2	LA,TA	Activity data in 1.A.1.a. reported under 1.A.1.a.i	Distribution of fuel consumption in each subsector of 1.A.1.a	2019
1.A	1A.3.b Transport - Road Transportation	CO_2	LA,TA	Activity data for PC and LDT are reported together	Split activity data for PC and LDT to their own categories	2019
1.A	1A.3.b Transport - Road Transportation	CO_2, N_2O,	LA,TA	Old Czech Emission Model	Copert 5	2019
1.A	1A.3.b Transport - Road Transportation	CO_2	LA,TA	Tier 1 approach to estimate CO_2 emissions from liquid fuels in road transportation	Tier 2 approach to estimate CO_2 emissions from liquid fuels in road transportation, applying a country-specific carbon content for fuels	2019
1.A.4	Other sectors - Gaseous Fuels	CO_2	LA,TA	Activity data fluctuation in 1991 till 1995	Detailed research of data at the beginning of 90s is planned for the future submissions	2019-2020
1.A.2	Manufacturing industries and construction - Gaseous Fuels	CO_2	LA, TA	All CO_2 emissions from metallurgical coke used in blast furnaces are reported under the Industrial processes sector (2.C.1)	Detailed research of both blast furmance and converter gases, which are combusted outside metallurgical complexes	2019
1.A.4	Other sectors – Solid Fuels	CO_2	LA, TA	Activity data fluctuation in 1991 till 1995	Detailed research of data at the beginning of 90s is planned for the future submissions	2019-2020
1.B.1.a	Coal Mining and Handling	CH_4	LA, TA	Tier 1 Abandoment mines	Tier 2 Abandoment mines	2019, 2020
1.A.1	Energy industries – Gaseous Fuels	CO_2	LA,TA	Activity data in 1.A.1.a. reported under 1.A.1.a.i	Distribution of fuel consumption in each subsector of 1.A.1.a	2019
1.B.2.b	Natural Gas	CH_4	LA, TA	*1.B.2.a.iii.1.* – NE	Collection of activity data	2019-2020
1.A.1	Energy industries - Liquid Fuels	CO_2	LA,TA	Activity data in 1.A.1.a. reported under 1.A.1.a.i	Distribution of fuel consumption in each subsector of 1.A.1.a	2019
2.B.8	2.B.8. Petrochemical and carbon black production	CO_2	LA	Tier 1	Country specific EFs for steam cracking ethylene production for CO_2 emissions	2019,2020
2.C.1	Iron and Steel Production	CO_2	LA	Tier 2	Tier 3	2019,2020
2.F.1	2.F.1 Refrigeration	AD		Further developing of calculation model	Preparation of activity, data, divider, emission factors	2019,2020

	and Air Conditioning Equipment (CO_2 eq.)					
3	3.B Manure management	CH_4	LA,TA	Tier 2	Swine, tier 2 method implementation	2021
3	3.B Manure managementn	N_2O	LA,TA	Tier 2	Swine, tier 2 method implementation	2021
3	3.B Manure managementn	N_2O	LA,TA	Country specific	Update of AWMS distribution scheme	2020
3	3.B Manure managementn	N_2O	LA,TA	Tier 2	Harmonization with reporting iunder UNECE	2021
3	3.D.1. Direct emissions from managed soils	N_2O	LA,TA	Tier 2	Harmonization with reporting iunder UNECE	2021
3	3.D.1 Agricultural Soils, Indirect Emissions	N_2O	LA	Tier 2	Harmonization with reporting iunder UNECE	2021
3	3.B Manure management	CH_4	LA,TA	Tier 2	Swine, tier 2 method implementation	2021
3	3.B Manure managementn	N_2O	LA,TA	Tier 2	Swine, tier 2 method implementation	2021
3	3.B Manure managementn	N_2O	LA,TA	Country specific	Update of AWMS distribution scheme	2020
3	3.B Manure managementn	N_2O	LA,TA	Tier 2	Harmonization with reporting iunder UNECE	2021
3	3.D.1. Direct emissions from managed soils	N_2O	LA,TA	Tier 2	Harmonization with reporting iunder UNECE	2021
3	3.D.1 Agricultural Soils, Indirect Emissions	N_2O	LA	Tier 2	Harmonization with reporting iunder UNECE	2021
4	4.A.1 Forest Land remaining Forest Land	CO_2	LA,TA	Tier 2	Revision of EF on carbon content in wood according to the latest scientific evidence and improved uncertainty estimates	2020
4	4.A.2 Land converted to Forest Land	CO_2	LA,TA	Tier 2	Revision of EF on carbon content in wood improved uncertainty estimates	2020
4	4.G Harvested Wood Products	CO_2	LA,TA	Tier 2	Revision of EF on carbon content in wood as in 4.A may also concern this category	2020
5	5.A Solid Waste Disposal	CO_2 CH_4	LA, TA	Tier 1	Review of factor F	2019
5	5.C Incineration and Open Burning of Waste	CO_2 N_2O CH_4		Uncertainty assessment based on research from 2012	Update of uncertainty assessment	2019
5	5.D Wastewater Treatment and Discharge	N_2O CH_4	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 2018.

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 2016.

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 2016 (MAF 2017). 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 2018 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
- **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
- **FM activities relate to emissions and removals correspondingly as described in category 4.A.1 Forest land remaining Forest land**

In this way, AR activities generally always represent land-use conversion from a land-use category other than Forest Land to the land use category of Forest Land. Similarly, D is an activity when Forest Land is converted to other types of land-use, as shown above. These links are retained consistently for the entire reporting period, similarly as for the adopted methodology. This ensures consistent treatment of the activity data and methodologies across 2CP, as well as for the reporting period under the Convention, i.e., since 1990, and in some applicable instances since 1969. Other details can be found below.

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

Since only one activity of the listed Article 3.4 activities is reported by the Czech Republic, no precedence conditions and/or hierarchy among Article 3.4 activities are applicable.

11.2 Land-related information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

Land areas associated with LULUCF activities are identified within a geographic boundary encompassing units of land or land subject to multiple activities under article 3.3 and 3.4 activities (i.e. reporting method 1, IPCC 2014). Considering the small area of the country and its specific conditions, there is no applicable stratification that would justify reporting for smaller than a country-level unit. This is also supported by the attributes of the available activity data. However, the land-use representation and land-use change identification system developed for KP and UNFCCC reporting purposes permit a truly detailed spatial assessment and identification of AR and D activities at the level of the individual cadastral units. The system is exclusively based on the annually updated data on land use from the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) at the level of approximately 13 thousand individual cadastral units (Fig. 11.1). For this submission, the land use representation and land use change identification system was further refined as described in Chapter 6.2. Specifically for 2016, 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.

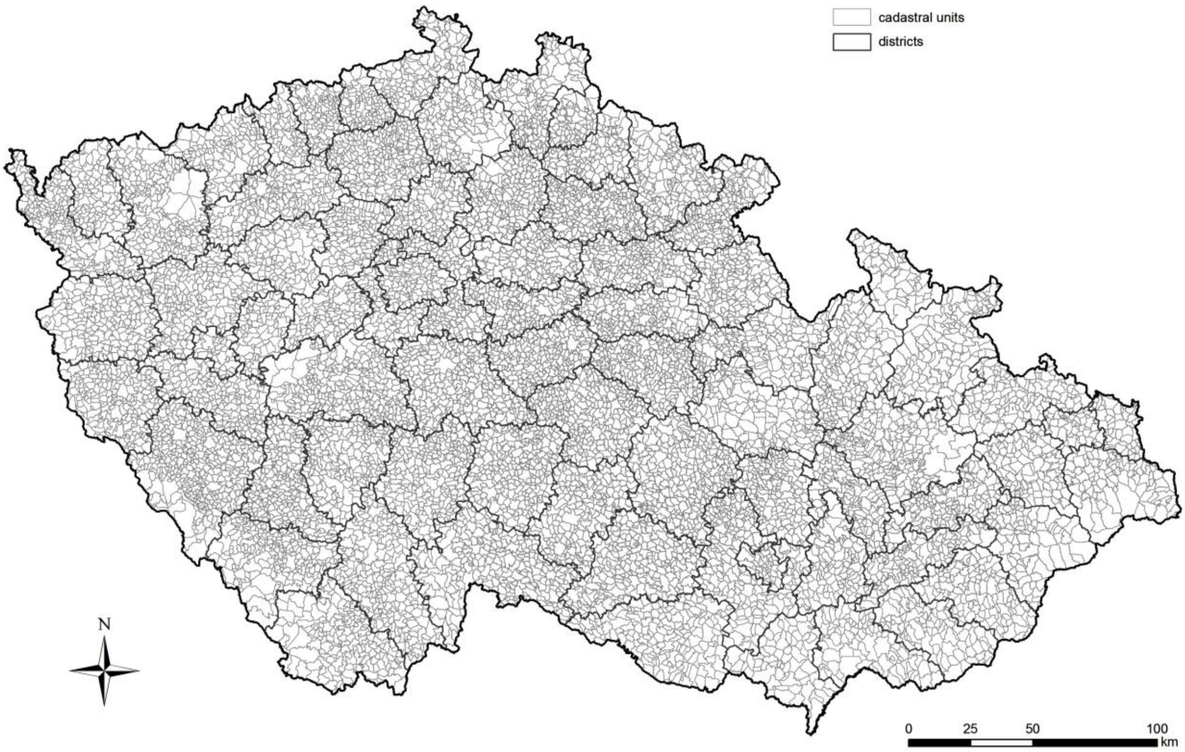


Fig. 11.1: The spatial detail of the land use representation and land-use change identification system used for detecting land use change associated with ARD activities. In 2016, the areas of ARD were estimated at the level of 13 091 individual cadastral units.

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	0.51	0.00	0.77
2004	0.66	0.80	0.07	0.78	0.00	2.30	0.10	0.07	0.02	0.53	0.00	0.72
2005	0.75	0.93	0.01	0.72	0.00	2.42	0.09	0.09	0.03	0.50	0.00	0.70
2006	1.03	0.62	0.04	0.56	0.00	2.25	0.07	0.04	0.03	0.38	0.00	0.52
2007	0.82	0.56	0.02	1.14	0.00	2.54	0.05	0.07	0.03	0.33	0.00	0.46
2008	0.67	0.49	0.08	1.09	0.00	2.33	0.11	0.05	0.03	0.31	0.00	0.50
2009	0.71	0.67	0.10	1.24	0.00	2.71	0.08	0.12	0.03	0.33	0.00	0.56
2010	1.01	0.63	0.14	1.16	0.00	2.94	0.11	0.09	0.06	0.38	0.00	0.63
2011	0.71	0.62	0.10	1.63	0.00	3.06	0.27	0.18	0.08	0.35	0.00	0.88
2012	0.74	0.70	0.05	1.13	0.00	2.62	0.07	0.11	0.04	0.30	0.00	0.51
2013	0.69	0.57	0.04	1.16	0.00	2.47	0.09	0.07	0.06	0.36	0.00	0.58
2014	0.67	0.43	0.05	2.12	0.00	3.27	0.08	0.09	0.04	0.37	0.00	0.57
2015	0.71	0.48	0.06	1.30	0.00	2.54	0.06	0.09	0.03	0.26	0.00	0.44
2016	0.62	0.42	0.05	0.99	0.00	2.08	0.07	0.09	0.04	0.34	0.00	0.54

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 2016 period, corresponding to a cumulative area of 60.0 kha. For the same period, the mean area of D reached 0.7 kha per year, which amounts to 17.9 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	2591.2	34.0	2625.2
1995	397.2	159.2	461.6	1537.7	38.9	35.4	2630.1	2594.7	29.9	2624.6
1996	399.9	160.9	460.8	1536.4	38.1	34.7	2631.0	2596.2	27.5	2623.7
1997	403.3	160.9	460.3	1537.2	36.0	33.8	2631.8	2598.0	24.8	2622.8
1998	409.9	161.3	462.9	1532.5	33.7	33.3	2633.8	2600.5	20.8	2621.3
1999	412.7	163.3	458.9	1537.6	32.2	29.5	2634.5	2605.0	15.4	2620.4
2000	417.0	165.3	457.5	1536.6	31.0	29.6	2637.3	2607.7	12.0	2619.7
2001	422.2	166.5	456.2	1535.7	29.8	28.5	2639.2	2610.7	8.7	2619.4
2002	428.1	168.0	454.1	1531.5	28.3	32.7	2643.1	2610.3	8.3	2618.6
2003	435.5	169.6	452.7	1525.2	27.0	33.9	2644.2	2610.3	7.4	2617.6
2004	441.1	170.4	450.3	1521.5	26.8	35.5	2645.7	2610.3	6.6	2616.9
2005	447.2	171.1	448.7	1517.5	26.3	36.3	2647.4	2611.1	5.0	2616.2
2006	451.7	173.0	446.8	1514.1	25.9	37.4	2649.1	2611.7	3.9	2615.6
2007	457.6	174.2	444.8	1509.9	26.1	38.6	2651.2	2612.7	2.5	2615.2
2008	464.6	176.6	442.9	1502.3	27.1	39.5	2653.0	2613.6	1.1	2614.7
2009	471.0	177.8	440.9	1496.7	27.6	41.1	2655.2	2614.1	0.0	2614.1
2010	475.3	179.8	439.5	1491.2	28.1	43.2	2657.4	2613.3	0.0	2613.3
2011	480.2	181.9	437.4	1486.0	29.1	45.0	2659.8	2612.7	0.0	2612.7
2012	486.1	183.5	435.8	1478.9	30.0	47.4	2661.9	2612.2	0.0	2612.2
2013	492.7	185.2	434.2	1471.4	30.5	49.5	2663.7	2611.5	0.0	2611.5
2014	501.2	185.3	431.7	1463.6	33.1	51.2	2666.4	2610.9	0.0	2610.9
2015	506.0	186.2	430.7	1461.4	31.4	52.5	2668.4	2610.4	0.0	2610.4
2016	511.5	187.9	428.3	1458.2	31.0	52.8	2669.9	2609.8	0.0	2609.8

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.

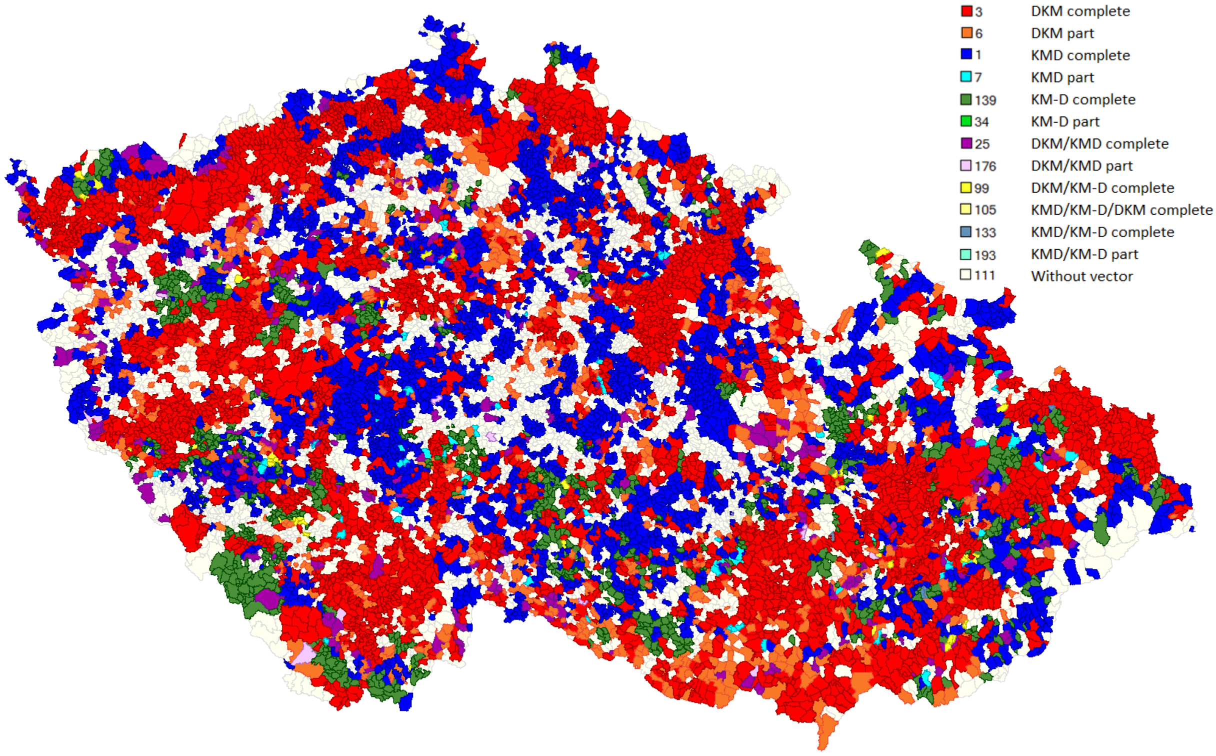


Fig. 11.2: The ongoing digitalization of the Czech cadastral land use information with units identified by categories of source map origin, coordination system and scale (DKM, KMD, KM-D and their combination) and completeness labelled by individual colours. Based on the information of COSMC as of 2013.

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 2016). The information as reported in the CRF tables represents sum-up values of the individual cadastral units, involving 10 major land use types of the original categorization and the time span from 1969 to 2016. It should also be noted the reconciled official land use information of COSMC undergoes continuous updating and accuracy improvement due to the progressing digitalization of the original maps. The resulting digital maps are distinguished by the source information and its coordination system. As also noted in section 6.2 of the NIR text (see also Footnote 3), the LULUCF inventory consults the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) on the issues related to the information on land areas in the Czech Republic. To illustrate the process of ongoing digitalization of cadastral maps in the county, we include the map of the recent state of the art in this process (Fig. 11.2, based on COSMC). It gives an overview of the national cadastral system under the process of digitalization, with different categories by source map origin, coordination system, scale and completeness labelled by individual colours. Evidently, this gradual digitalization leads to rectified area information on individual cadastral parcels, units and therefore also on the entire country. This also explains the nature of the ongoing area rectifications in the official reports on areas of land and land use categories in the country. In early 2017, on a request of the inventory team, COSMC provided a new statement commenting the current digitalization progress and commenting issues linked to area rectification and origin of the land use changes that are officially reported by COSMC on behalf of the country.

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The KP LULUCF reporting of the Czech Republic is based on the annually updated data from the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) at the level of about 13 thousands individual cadastral units (Fig. 11-1), which represent the Czech cadastral system. At that level, land use change is identifiable, using the standard identification codes and names of the Czech cadastral system and COSMC.

The spatial resolution of the adopted land-use representation and land-use change identification system is depicted in Figs. 11-3 and 11-4, which show the identified units with AR and D activities, respectively, in 2016.

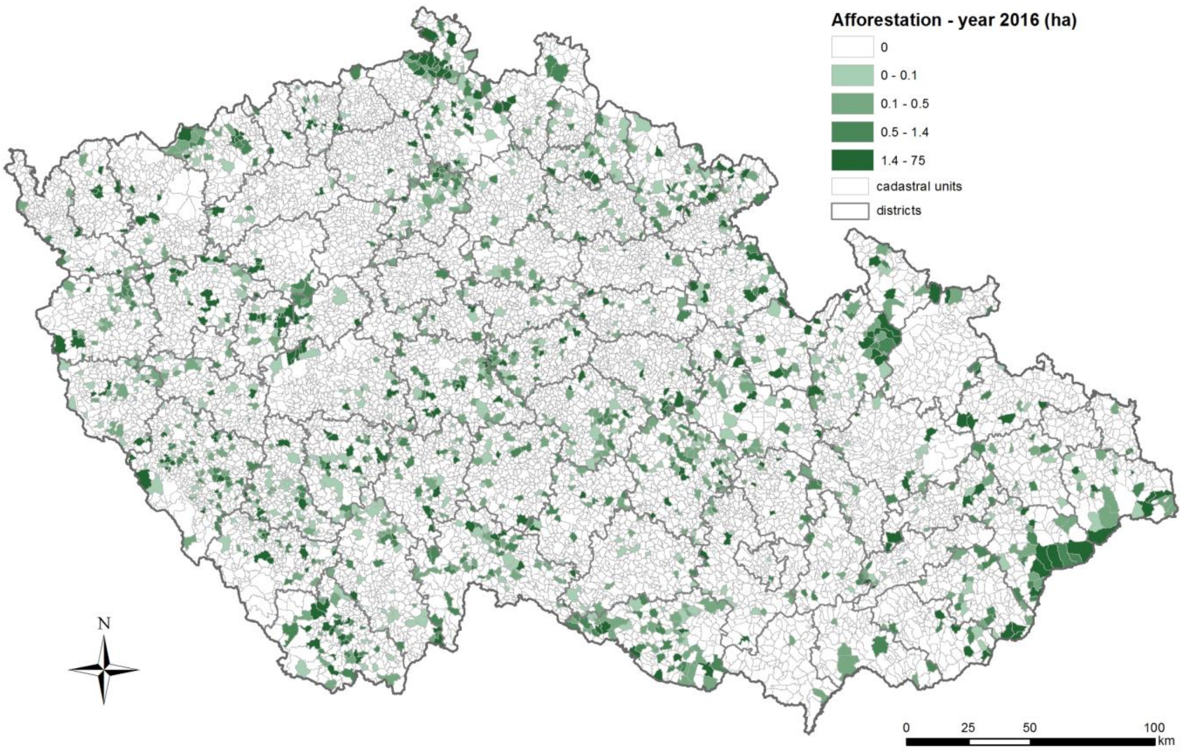


Fig. 11-3: The cadastral units with identified afforestation (AR) activities in 2016.

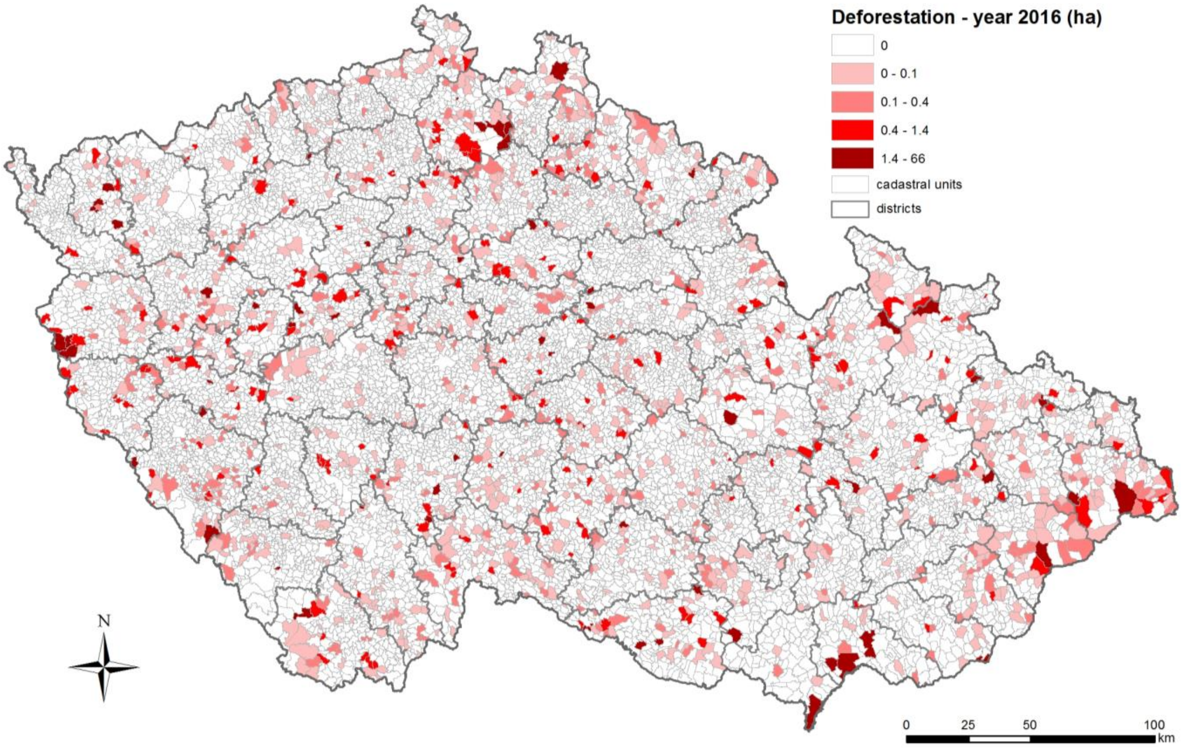


Fig. 11. 4: The cadastral units with identified deforestation (D) activities in 2016.

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 2018 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 IPCC (2006) 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 2018 submission should be consulted.

In the KP LULUCF reporting., the emissions and/or removals of CO_2 are quantified for changes in five ecosystem carbon pools, namely above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter. Additionally, the CO_2 emission contribution is estimated for Harvested wood Products (HWP), which may also concern AR and D activities.

Changes in above-ground biomass carbon pool were estimated primarily on the basis of forest taxation data in Forest Management Plans (further denoted as FMP), disaggregated in line with the country-specific approaches at the level of the four major tree species groups, namely beech, oak, pine and spruce (Chapter 6.4 of NIR 2018).

The attributing of carbon stock change to the below- and above-ground components, required for the reporting under Kyoto Protocol, was determined by root/shoot ratio (*R*). *R* was revised for this inventory submission, reflecting tree species and growing stock volumes as described in NIR chapter 6.4.2.

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 2018. 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 2018). Complementarily, for sub-categories involving Wetland and Settlements, “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, a newly implemented estimate of the net carbon stock change in organic matter (deadwood) has been introduced for this inventory submission based on the Tier 2 stock-difference method according to Eq. 2.8 of IPCC (2006), in response to the review issue KL.5[9] and . The methodological details are presented in Section 6.4.2.1 of the NIR 2018 text.

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 due to the YASSO soil model concept, which is used for justification when omitting these carbon pools in Section 11.3.1.2 below.

Additional greenhouse gases (CO_2, CH_4 and N_2O) are reported from biomass burning. Burning is explicitly confined to the activity of FM and thus matches the corresponding estimates under the Convention for the land-use category 4A1 Forest Land remaining Forest Land. These emissions are estimated identically as described in Section 6.4.2.1 of the NIR 2018 text.

There are no N_2O emissions from N-fertilization and soil drainage, which are therefore not applicable for the reporting period. On the contrary, N_2O emissions are reported for deforestation of Forest land that is converted to Cropland. This estimation is identical to that reported under the Convention and described in NIR 2018, Section 6.5.2.2 for land use category 4.B.2.1.

The estimates for the emission contribution from carbon stock 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).

[9] Note that all references (IDs) made to the review issues relate to the draft ARR document as of 30 January 2018. Hence, these references may change in the final ARR (not available at the time of compiling this report).

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

A justification is provided for for omitting the soil carbon pool and inherently the litter carbon pool from the reporting under FM activity. It is assumed that, under the conditions of current forestry practices in the country and at the country-level scale, forest soils do not represent a net source of CO_2 emissions. Justification for this approach is based on the targeted peer-reviewed modelling analysis performed for the actual circumstances of FM in the country (Cienciala et al., 2008b). It uses the well-established YASSO soil model (Liski et al., 2003, 2005) in combination with the similarly well-known and established EFISCEN forest scenario model (e.g., Karjalainen et al., 2002) and the actual data for forest biomass, growth performance and growing conditions in the country. The analysis shows that, under the adopted sustainable forest management practices implemented in the Czech Republic, the forest soil carbon pool (including litter) does not decrease, i.e., it is not a net source of emissions. The study contains further details on the country-specific model application, definition of scenarios and results related to both biomass and soil carbon pools, including the probable effect of changing climatic conditions. It also contains a discussion that elucidates the aspect of the YASSO model concept of litter input and aggregated output for litter/organic and mineral soil layers and its justification, as well as the reasoning with respect to the Kyoto protocol LULUCF reporting requirements. There is a wealth of literature on YASSO model applications that can be further consulted (www.environment.fi/syke/yasso).

To conclude, the forest soil carbon pool and inherently the litter carbon pool under current forest management practices and growth trends can be assumed not to be a source of emissions. The underlying assumptions will be further verified.

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

The indirect and natural GHG emissions and removals were not factored out.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

This inventory includes changes in biomass estimates due to the revised root/shoot ratio, which affect estimates in all KP LULUCF activities (AR, D, FM). Next, emission estimates form burning and forest have been revised and deadwood carbon stock estimates have been newly introduced for FM. These changes required recalculation of emission estimates for all reporting years and the currently reported estimates are herewith revised compared to those in the previous submission.

This submission also rectified a minor error of area-based attribution (for the periof 2010-2015) of biomass carbon stock change to Forest Management, which was identifiled in connection with the latest review (KL.12). This issue, together with the implemented improvements concerning root/shoot ratio, revised emission estimates for AR and FM acrtivities, ensuring maximum consistency between the Convention and KP LULUCF reporting.

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 2016, the estimated overall uncertainty for AR activities was 32.3%. The overall uncertainty for D was 62.1%. For FM the overall uncertainty equalled 16.8%.

11.3.1.6 Information on other methodological aspects

Despite efforts to make the reporting of KP LULUCF activities correspond to that under the Convention, there are some aspects that make direct comparison difficult. Specifically for FM, a direct comparison with the emission estimates of related category 4.A.1 under the Convention reporting will reveal some differences. There are several aspects to be considered when comparing the quantitative estimates of these categories, which relate to different treatment of land areas, i.e., differences in land-based and activity reporting (see Chapter 11.2.2 above).

11.3.1.7 The year of the onset of an activity, if after 2013

Not applicable.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are directly human-induced

The annually updated cadastral information from the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz) refers exclusively to intentional, i.e., human-induced interventions into land use. These interventions are thereby reflected in the corresponding records, including the time attribute, collected and summarized at the level of cadastral units and individual years.

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Since no remote sensing technology is directly involved in the Czech KP LULUCF emission inventory, there is no issue related to distinguishing harvesting or forest disturbance from deforestation. Harvesting and forest disturbance always occur on Forest Land, while deforestation is a permanent cadastral change of land use from Forest Land to other categories of land use.

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested.

Any deforestation in terms of land use change requires an official administrative decision. Hence, no permanent loss of forest cover may occur prior this approval, which is reflected in cadastral land use. The above also implies that there is no afforestation occurring on previously deforested land through an administrative decision. A temporary loss of forest cover up to an area of 1 ha may occur as part of forest management operations on Forest land (units of land subject to *FM*), which is, however, not qualified as deforestation in terms of Art. 3.3. KP LULUCF activity.

The cadastral information on forest land areas centrally administered by COSMC in combination with the information of mandatory forest planning administered centrally by FMI, Brandýs n.l. provides a clear distinction of two types of land under forest areas temporarily without forest cover, which are not classified as deforested. One type of unstocked forest land is that required for long-term forest activities, such as forest roads and nurseries, where the length of return to forest cover is unspecific but intended by designated land use. In 2016, such areas represented 2.39 % of forest land. The second type is clearcut area, which is a result of forest management operations as noted above and an inherent part of forest management evidence and planning. The clearcut area (CA) is also listed in Tab. 11-2 for individual years. In 2016, it represented 1.16 % of forest land. The mandatory period to regenerate/reforest clearcut areas is two years according to the Czech Forestry Act.

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 2016, with a maximum of 0.05% in 1998. The mean value for the entire reporting period was 0.03%, hence 99.97% 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 2016, the estimated removals from AR activities reached -636 Gg CO_2 eq. The estimated emissions from D equalled 219 Gg CO_2 eq. The details can be found in the corresponding CRF Tables of KP LULUCF.

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

The Czech Republic adopted the broad definition (FCCC/CP/2001/13/Add.1; IPCC 2014) of FM. It reads "Forest management is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner." This decision implies that the entire forest area in the country is subject to FM interventions, as guided by the Forestry Act (No. 289/1995 Coll.).

11.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

Not applicable for the Czech Republic.

11.5.3 Information relating to Forest Management

As noted in Section 11.5.1 above, the practice of *FM* is generally guided by the Forestry Act (No. 289/1995 Coll.).

11.5.3.1 Conversion of natural forest to planted forest

The extent of natural forest in the Czech Republic was 29.1 kha as of 2016 (MAF 2017), representing about 0.001% of the forest area in the country. The remnants of natural forest in the country are extremely valuable and under the most strict conservation and protection regime. Hence, no conversion of natural forest to planted forest is permitted and has not occurred under the conditions of the country during the reporting period since 1990.

11.5.3.2 Forest Management Reference Level (FMRL)

FMRL applicable for the Czech Republic was prepared by the Joint Research Centre of the European Commission (JRC), based on elaboration of the results of independent EU modeling groups, coordinated by the International Institute for Applied Systems Analysis (IIASA), assisted by the JRC and funded by the European Commission Directorate General of Climate Action (DG CLIM). The adopted value of FMRL with emissions/removals from HWP using the first order decay functions is 4 686 Gg CO_2 eq. A detailed description of the FMRL can be found on https://unfccc.int/bodies/awg-kp/items/5896.php (revised submission of the Czech Republic from 13 September 2011). At the link, the report of the technical assessment of FMRL submission of the Czech Republic is also available.

The approach adopted by JRC in constructing FMRL is based on using two models, namely G4M (Global Forestry Model) from IIASA and EFISCEN (European Forest Information Scenario Model) from the European Forest Institute (EFI). These tools were used to project annual estimates of emissions and removals for forest management until 2020 for the above- and below-ground biomass carbon pools. To estimate the FMRL, the emissions and removals estimated by the models for the time series 2000 to 2020 were calibrated/adjusted using historical data from the Party for the period 2000–2008 as reported in the NIR 2010 submission. The following pools and gases were in cluded in FMRL: above- and below-ground biomass pools, the HWP pool, CO_2 emissions from liming and GHG emissions from biomass burning. Deadwood, litter and soil organic matter were assumed in equilibrium. The HWP contribution as included in FMRL was estimated using the first-order decay function using equation 12.1 from the 2006 IPCC Gl. (IPCC 2006), annual production data as reported at FAO and the recommended (IPCC 2006) specific half lives for product types, including paper and paperboard (2 years), wood panels (25 years and sawnwood (35 years). Other details can be found in the revised submission and technical assessemt documents as referenced above.

11.5.3.3 Technical Corrections of FMRL

No technical correction has been applied to FMRL for the Czech Republic yet. The inventory team works on preparing the technical correction of FMRL for the next, i.e., NIR 2019 submission reflecting the activity data used and currently adopted accounting rules (e.g., exluding emissions from liming) as also communicated by the latest review (KL. 14 and 16). This will also include an information demonstrating consistency between FMRL and the FM reporting and related interpretation.

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 2nd Commitment period 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.

The estimation of HWP contribution was guided by IPCC (2014) methodologies and the principles of Decision 2/CMP.7. Hence, the method excludes the imported wood (being discerned discern at the source data from FAOSTAT (FAO database) as noted in in the NIR, under 6.10. The HWP in solid waste disposal sites is not included, assumed to be instantaneously oxidized. The input to HWP exclu des firewood (and woody residuals) as its carbon stock is accounted for using instantaneous oxidation. HWP originated from deforested land is excluded from the estimate assuming instantaneous oxidation.

With respect to the remaining information required under Decision 2/CMP.8, annex II, the following additional details (apart from the information already given above) are provided:

- Activity data used for HWP estimation (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. 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 used for the disaggregated HWP categories are those as in Table 2.8.1 (IPCC, 2014b). Exports and imports were treated according to Equations 2.8.1 (for industrial roundwood) and 2.8.2 (for wood pulp) of the IPCC KP Supplement (IPCC, 2014b). In 2006, the proportion of domestically consumed HWP (Eq. 2.8.1 of IPCC 2014) reached 0.76 and 0.67 for industrial roundwood (as well as wood-based panels) and pulp, respectively. The amounts of volume that are accounted for as input to the HWP pool exclude firewood as its carbon stock is accounted for using the instantaneous oxidation method.

- Estimation of HWP contribution using first order decay equation (Eq. 2.8.5, IPCC 2014b) include default half-life constants for the major HWP categories: 35 years for sawnwood, 25 years for wood-based panels and 2 years for paper and paperboard

- The FMRL of the Czech Republic is based on a projection representing "business as usual scenario", inherited emissions occurring during the second commitment period from HWP originating from forests prior to the start of the second commitment period are accounted for.

- All emissions from HWP already accounted for during the 1st Commitment period on the basis of instantaneous oxidation are excluded from accounting in the 2nd Commitment period: this requirement is met by including solely emissions from the non-firewood harvested wood product sub-categories (i.e., sawnwood, wood based panels, as well as paper and paperboard) during the 2nd Commitment period.

11.5.4 Information on estimated emissions and removals of Forest Management activity under Art. 3.4

For inventory 2016, the estimated removals from *FM* with (without) HWP contribution reached -4436 (-4 005) Gg CO_2 eq. The details can be found in the corresponding CRF Tables of KP LULUCF.

11.5.5 Information on methodology and estimated emission contribution from HWP

The activity and methodology data applicable to estimation of emission contribution from HWP are described in Chapter 6.10 of the current NIR submission. Estimation of the HWP contribution is treated identically under the Convention and KP LULUCF; therefore all details, including source category description, methodological issues, uncertainties and time series consistency, QA/QC and verification as described in Chapter 6.10 of NIR are also fully applicable for KP reporting. Other details can be found in the corresponding CRF tables.

In 2016, the estimated emission contribution from HWP reached -431 Gg CO_2 eq. The estimates for the entire reporting period since 1990 can be found in the corresponding CRF Tables of KP LULUCF.

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

As stated in CRF KP-LULUCF table "NIR-3", one key category was identified among the KP LULUCF activities, namely FM. Similarly to its associated LULUCF category 4.A.1 Forest land remaining Forest land, it was identified by level assessment. No other activity was identified as key in this NIR submission.

11.7 Information relating to Article 6

No LULUCF joint implementation project under Art. 6 concerns the Czech Republic.

12 Information on accounting of Kyoto units

12.1 Background information

The information from the national registry on the issue, acquisition, holding, transfer, cancellation, withdrawal and carryover of assigned amount units, removal units, emission reduction units and certified emission reductions in the period from 1st of January 2017 to 31st of December 2017 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 2017 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 2017.

No invalid units exist as at 31 December 2017.

No discrepant transactions occurred in 2017.

12.4 Publicly accessible information

Non-confidential information in accordance with decision 13/CMP.1, annex, chapter II.E, paragraphs 44–48, is provided in the Public Reports section of the registry website at:

https://ets-registry.webgate.ec.europa.eu/euregistry/CZ/public/reports/publicReports.xhtml

12.5 Calculation of the commitment period reserve (CPR)

The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8. For the purposes of the joint fulfilment, the commitment period reserve applies to the EU, its Member States and Iceland individually.

The calculations of the commitment period reserve for the Czech Republic are as follows.

Method 1: 90 % of assigned amount results in:

0.90 x 520,515,203 = 468,463,683 tonnes of CO_2eq.

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

8 x 130,348,689.520 = 1 042,789,516 tonnes CO_2 eq.

The commitment period reserve consequently amount to **468,463,683** 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:

- Risto Saarikivi 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.

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/2016/CZE the ERT reiterates the recommendation of the SIAR that the Party include a disaster recovery plan in line with document FCCC/SBI/2015/10. The disaster recovery plan is therefore submitted as Annex despite no changes were made to the docuemnt.

In September 2017, the Czech Republic was subject to in-country review in Prague. 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 review.

14.2 Changes to National Registry

The following changes to the national registry of the Czech Republic have therefore occurred in 2017:

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	None.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	The version of the EUCR released after 8.0.7 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 8.0.7 of the national registry are listed in Annex B. 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.

15 Information on Minimization of Adverse Impact in Accordance with Art. 3, para 14

The Czech Republic strives to implement its Kyoto commitments in a way, which minimizes adverse impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention. The impact of mitigation actions on overall objectives of sustainable development is also given due consideration. As there is no common methodology for reporting of possible adverse impacts on developing country Parties, the information provided is based on the expert judgment of the Ministry of the Environment of the Czech Republic. More information on EU wide policies is available in chapter 15 of the Annual European Union greenhouse gas inventory 1990–2014 and inventory report 2016 and will be updated in the European Union submission for the year 2017. The table below summarizes how the Party gives priority to selected actions, identified in paragraph 24 of the Annex to Decision 15/CMP.1.

Tab 15-1 Actions implementation by party as identified in paragraph 24 of the Annex to Decision 15/CMP.1

Action	Implementation by the Party
(a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities.	The ongoing liberalization of energy market is in line with EU policies and directives. No significant market distortions have been identified. Consumption taxes for electricity and fossil fuels were harmonized recently. The main instrument addressing externalities is the emission trading under the EU ETS. Introduction of new instruments is subject to economic modelling and regulatory impact assessment. The introduction of carbon tax was proposed and discussed but the government decided to wait for the outcome of proposal for EU wide harmonisation. The government has requested a feasibility and impact analysis to be submitted by the end of 2018.
(b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies.	No subsidies for environmentally unsound and unsafe technologies have been identified.
(c) Cooperating in the technological development of non-energy uses of fossil fuels and supporting developing country Parties to this end.	The Czech Republic does not take part in any such activity.
(d) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort.	There is currently no ongoing or CCS programme or demonstration project in the Czech Republic. On 31st March 2014 the first open call for applications to fund individual projects within the Programme CZ08 “Pilot Studies and Surveys on CCS Technology (Carbon Capture and Storage)” under the so called Norway Grants. In 2015 4 projects were approved in the first call of the the Programme CZ08. These projects focus on pilot CCS technologies for coal fired power plants, sharing of knowledge and experience, research of high temperature CO_2 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

	rural communities in Cambodia - Developing biogas digesters in Cuba - Supporting small enterprises in producing wood biomass fuel, developing geothermal energy and increasing energy efficiency of hospitals in Bosnia and Herzegovina - Modernization of a central district heating system with possible use of alternative heat source in Serbia Some of these projects build on projects successfully implemented in the period 2011 – 2014 described in the previous inventory report.

16 Other Information

No other information submitted in 2018.

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Abbreviations

AACLC	Aggregate areas of cadastral land categories
AD	Activity data
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
CRF	Common Reporting Format
CUEC	Charles University Environment Center
CULS	Czech University of Life Sciences
CzechTerra	Czech Landscape Inventory
CzSO	Czech Statistical Office
ČPS	Czech Gas Association (Český plynárenský svaz)
DOC	Degradable Organic Carbon
EEA	European Environmental Agency
EIG	Emission Inventory Guidebook
EMEO/EEA	European Monitoring and Evaluation Programme/Environmetal Protection Agency
ERT	Expert Review Team
ETS	Emission Trading Scheme
FAO	Food and Agriculture Organization
FMI	Forest Management Institute, Brandýs nad Labem
FMP	Forest Management Plans
FOD (model)	First Order Decay (model)
GHG	Greenhouse Gas
HDV	Heavy Duty Vehicle
HWP	Harwested Wood Products
CHMI	Czech Hydrometeorological Institute
IEA	International Energy Agency
IFER	Institute of Forest Ecosystem Research (Ústav pro výzkum lesních ekosystémů)
IGU	International Gas Union
IPCC	Intergovernmental Panel of Climate Change
IPR	Integrated Pollution Register
ISPOP	Integrated system of mandatory reporting (Integrovaný systém plnění ohlašovacích povinností)
KP LULUCF	LULUCF activities under Kyoto Protocol
ISOH/VISOH	Information system of waste management/Public information system of waste management
LDV	Light Duty Vehicle
LPG	Liquid Petroleum Gas
LPIS	Land Parcel Identification System,

LTO	Landing/Taking-off
LULUCF	Land Use, Land-Use Change and Forestry
MA	Ministry of Agriculture
MCF	Methane Correction Factor
MIT	Ministry of Industry and Trade
MoE	Ministry of Environment
MSW	Municipal Solid Waste
NACE	Nomenclature Classification of Economic Activities
NIR	National Inventory Report
NIS	National Inventory System (National system under Kyoto protocol, Art. 5)
OKD, a.s.	Ostrava – Karvina Mines (Ostravsko karvinské doly, a.s.)
OTE	Electricity Market Operator (Operátor trhu s elektřinou, a.s.)
PC	Passenger Car
QA/QC	Quality Assurance/Quality Control
RA	Reference Approach
REZZO	Register of Emissions and Sources of Air Pollution (Registr emisí a zdrojů znečišťování ovzduší)
SA	Sectoral Approach
SWDS	Solid Waste Disposal Sites
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nation Framework Convention on Climate Change
ÚVVP	Institute for Research and Use of Fuels (Ústav pro výzkum a využití paliv)
VŠCHT	University of Chemistry and Technology Prague (Vysoká škola chemicko technologická)
NEC	National Emission Ceilings

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Annexes to the National Inventory Report

Annex 1 Key Categories

Key Categories were estimated using IPCC 2006 Gl. approach 1 including and excluding LULUCF. Tables A1-1 till A1-4 followed the approach in Tables 4.2 and 4.3 of the IPCC 2006 Gl.

Tab. A1- 1 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2016 – 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.1 Energy industries - Solid Fuels	CO_2	50569.21	50569.21	36.44	36.44
1.A.3.b Transport - Road transportation	CO_2	17670.12	17670.12	12.73	49.17
1.A.4 Other sectors - Gaseous Fuels	CO_2	7473.04	7473.04	5.39	54.56
2.C.1 Iron and Steel Production	CO_2	7286.67	7286.67	5.25	59.81
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5268.87	5268.87	3.80	63.61
4.A.1 Forest Land remaining Forest Land	CO_2	-4186.42	4186.42	3.02	66.62
1.A.4 Other sectors - Solid Fuels	CO_2	3824.92	3824.92	2.76	69.38
5.B Biological treatment of solid waste	N_2O	3386.41	3386.41	2.44	71.82
5.A Solid Waste Disposal on Land	CH_4	3366.03	3366.03	2.43	74.25
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3301.92	3301.92	2.38	76.63
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	3270.08	3270.08	2.36	78.98
1.B.1.a Coal Mining and Handling	CH_4	3259.67	3259.67	2.35	81.33
3.A Enteric Fermentation	CH_4	2957.46	2957.46	2.13	83.46
1.A.1 Energy industries - Gaseous Fuels	CO_2	2954.74	2954.74	2.13	85.59
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	2757.19	2757.19	1.99	87.58
2.A.1 Cement Production	CO_2	1697.60	1697.60	1.22	88.80
1.A.4 Other sectors - Liquid Fuels	CO_2	1229.70	1229.70	0.89	89.69
5.D Wastewater treatment and discharge	CH_4	881.60	881.60	0.64	90.32
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	841.90	841.90	0.61	90.93
3.B Manure Management	N_2O	838.95	838.95	0.60	91.53
3.B Manure Management	CH_4	741.23	741.23	0.53	92.07
2.B.1 Ammonia Production	CO_2	685.72	685.72	0.49	92.56
5.B Biological treatment of solid waste	CH_4	675.08	675.08	0.49	93.05
2.A.2 Lime Production	CO_2	639.82	639.82	0.46	93.51
1.B.2.b Natural Gas	CH_4	571.24	571.24	0.41	93.92
1.A.4 Other sectors - Biomass	CH_4	568.85	568.85	0.41	94.33
4.A.2 Land converted to Forest Land	CO_2	-503.03	503.03	0.36	94.69
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	453.14	453.14	0.33	95.02
4.G Harvested wood products	CO_2	-430.67	430.67	0.31	95.33
1.A.1 Energy industries - Liquid Fuels	CO_2	389.04	389.04	0.28	95.61
1.A.3.b Transport - Road transportation	N_2O	363.18	363.18	0.26	95.87
2.A.4 Other process uses of carbonates	CO_2	340.59	340.59	0.25	96.12
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	309.88	309.88	0.22	96.34
2.B.8 Petrochemical and Carbon Black Production	CO_2	302.82	302.82	0.22	96.56
1.A.4 Other sectors - Solid Fuels	CH_4	296.39	296.39	0.21	96.77
2.B.2 Nitric Acid Production	N_2O	280.12	280.12	0.20	96.98
4.C.1 Grassland remaining Grassland	CO_2	-279.07	279.07	0.20	97.18
1.A.5.b Other mobile - Liquid Fuels	CO_2	277.11	277.11	0.20	97.38
1.A.3.c Transport - Railways	CO_2	273.75	273.75	0.20	97.57
1.A.1 Energy industries - Other Fossil Fuels	CO_2	249.61	249.61	0.18	97.75
2.B.10 Other chemical industry	CO_2	233.58	233.58	0.17	97.92
2.G.3 N_2O from product uses	N_2O	223.50	223.50	0.16	98.08
1.A.1 Energy industries - Solid Fuels	N_2O	221.27	221.27	0.16	98.24
3.H Urea application	CO_2	210.76	210.76	0.15	98.39

5.D Wastewater treatment and discharge	N_2O	197.57	197.57	0.14	98.54
4.C.2 Land converted to Grassland	CO_2	-182.76	182.76	0.13	98.67
3.G Liming	CO_2	168.01	168.01	0.12	98.79
1.B.1.a Coal Mining and Handling	CO_2	156.46	156.46	0.11	98.90
2.A.3 Glass Production	CO_2	138.06	138.06	0.10	99.00
5.C Incineration and open burning of waste	CO_2	126.33	126.33	0.09	99.09
4.E.2 Land converted to Settlements	CO_2	124.06	124.06	0.09	99.18
2.D.1 Lubricant Use	CO_2	114.95	114.95	0.08	99.27
1.A.4 Other sectors - Biomass	N_2O	90.26	90.26	0.07	99.33
4.B.1 Cropland remaining Cropland	CO_2	-87.06	87.06	0.06	99.39
4.B.2 Land converted to Cropland	CO_2	83.81	83.81	0.06	99.45
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	70.41	70.41	0.05	99.50
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	66.59	66.59	0.05	99.55
1.A.3.e Transport - Other Transportation	CO_2	60.98	60.98	0.04	99.60
1.A.2 Manufacturing industries and construction - Biomass	N_2O	35.06	35.06	0.03	99.62
4.A.1 Forest Land remaining Forest Land	CH_4	32.87	32.87	0.02	99.65
1.A.3.c Transport - Railways	N_2O	31.49	31.49	0.02	99.67
1.B.2.c Venting and Flaring	CH_4	29.26	29.26	0.02	99.69
1.A.3.b Transport - Road transportation	CH_4	26.91	26.91	0.02	99.71
1.A.1 Energy industries - Biomass	N_2O	26.60	26.60	0.02	99.73
4.A.1 Forest Land remaining Forest Land	N_2O	26.36	26.36	0.02	99.75
4.D.2. Land converted to Wetlands	CO_2	25.03	25.03	0.02	99.76
2.F.3 Fire Protection (CO_2 eq.)	HFC	23.74	23.74	0.02	99.78
1.A.2 Manufacturing industries and construction - Biomass	CH_4	22.17	22.17	0.02	99.80
2.B.8 Petrochemical and Carbon Black Production	CH_4	22.09	22.09	0.02	99.81
1.A.4 Other sectors - Liquid Fuels	N_2O	21.73	21.73	0.02	99.83
2.D.3 Other non-energy products from fuels and solvent use	CO_2	18.88	18.88	0.01	99.84
1.A.4 Other sectors - Solid Fuels	N_2O	18.11	18.11	0.01	99.86
1.A.4 Other sectors - Gaseous Fuels	CH_4	16.86	16.86	0.01	99.87
1.A.1 Energy industries - Biomass	CH_4	16.75	16.75	0.01	99.88
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	14.01	14.01	0.01	99.89
1.A.1 Energy industries - Solid Fuels	CH_4	13.01	13.01	0.01	99.90
1.A.3.d Transport - Domestic navigation	CO_2	12.73	12.73	0.01	99.91
2.C.1 Iron and Steel Production	CH_4	10.52	10.52	0.01	99.92
1.A.3.a Transport - Civil Aviation	CO_2	10.01	10.01	0.01	99.92
2.C.5 Lead Production	CO_2	9.28	9.28	0.01	99.93
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	7.87	7.87	0.01	99.94
1.A.5.b Other mobile - Liquid Fuels	N_2O	6.92	6.92	0.00	99.94
2.F.2 Foam Blowing (CO_2 eq.)	HFC	6.33	6.33	0.00	99.95
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	6.03	6.03	0.00	99.95
2.D.2 Paraffin Wax Use	CO_2	5.89	5.89	0.00	99.95
1.B.2.c Venting and Flaring	CO_2	4.81	4.81	0.00	99.96
1.B.2.a Oil	CH_4	4.79	4.79	0.00	99.96
4.B.2. Land converted to Cropland	N_2O	4.69	4.69	0.00	99.96
1.B.1.b Solid Fuel Transformation	CH_4	4.50	4.50	0.00	99.97
1.A.4 Other sectors - Gaseous Fuels	N_2O	4.02	4.02	0.00	99.97
2.C.2 Ferroalloys Production	CH_4	3.88	3.88	0.00	99.97
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	3.82	3.82	0.00	99.98
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	3.79	3.79	0.00	99.98
2.F.4 Aerosols (CO_2 eq.)	HFC	3.75	3.75	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3.24	3.24	0.00	99.98
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	3.19	3.19	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	2.83	2.83	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.38	2.38	0.00	99.99
1.A.4 Other sectors - Liquid Fuels	CH_4	2.34	2.34	0.00	99.99
5.C Incineration and open burning of waste	N_2O	2.29	2.29	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2.04	2.04	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	1.59	1.59	0.00	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	1.59	1.59	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1.33	1.33	0.00	100.00

2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.99	0.99	0.00	100.00
2.C.6 Zinc Production	CO_2	0.58	0.58	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.56	0.56	0.00	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	0.55	0.55	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.52	0.52	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0.41	0.41	0.00	100.00
1.A.3.c Transport - Railways	CH_4	0.38	0.38	0.00	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0.25	0.25	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0.24	0.24	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.10	0.10	0.00	100.00
1.B.2.b Natural Gas	CO_2	0.09	0.09	0.00	100.00
1.A.3.a Transport - Civil Aviation	N_2O	0.09	0.09	0.00	100.00
1.B.2.a Oil	CO_2	0.04	0.04	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.03	0.03	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.03	0.03	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.03	0.03	0.00	100.00
1.A.3.e Transport - Other Transportation	CH_4	0.03	0.03	0.00	100.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	0.00	100.00

Tab. A1- 2 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2016 – Trend Assessment including LULUCF

IPCC Source Categories	GHG	Base Year Estimate	Current Year Estimate	Trend Assessment	% contribution to Trend	Cumulative total of contribution to trend
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	3270.08	0.10	16.58	16.58
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	50569.21	0.08	13.21	29.79
1.A.3.b Transport - Road transportation	CO_2	6176.54	17670.12	0.07	11.44	41.24
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	3824.92	0.06	9.81	51.05
2.C.1 Iron and Steel Production	CO_2	9642.54	7286.67	0.05	8.07	59.12
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	9609.14	309.88	0.03	4.95	64.07
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.92	7473.04	0.03	3.99	68.07
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4192.21	2757.19	0.02	3.51	71.58
5.B Biological treatment of solid waste	N_2O	0.00	3386.41	0.02	2.84	74.41
5.A Solid Waste Disposal on Land	CH_4	1979.27	3366.03	0.02	2.82	77.23
1.B.1.a Coal Mining and Handling	CH_4	10322.40	3259.67	0.02	2.87	80.10
4.A.1 Forest Land remaining Forest Land	CO_2	-4817.86	-4186.42	0.01	1.95	82.05
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.04	2954.74	0.01	1.75	83.80
2.A.1 Cement Production	CO_2	2489.18	1697.60	0.01	1.42	85.22
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.66	5268.87	0.01	1.33	86.55
3.B Manure Management	N_2O	1619.93	838.95	0.01	1.36	87.90
1.A.4 Other sectors - Liquid Fuels	CO_2	4009.76	1229.70	0.01	1.14	89.05
1.B.2.b Natural Gas	CH_4	1044.93	571.24	0.01	0.87	89.92
5.D Wastewater treatment and discharge	CH_4	889.80	881.60	0.00	0.74	90.66
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	302.82	0.00	0.66	91.32
2.B.1 Ammonia Production	CO_2	990.80	685.72	0.00	0.57	91.90
3.A Enteric Fermentation	CH_4	5754.89	2957.46	0.00	0.64	92.54
5.B Biological treatment of solid waste	CH_4	0.00	675.08	0.00	0.57	93.11
2.A.2 Lime Production	CO_2	1336.65	639.82	0.00	0.54	93.64
1.A.1 Energy industries - Liquid Fuels	CO_2	1574.60	389.04	0.00	0.53	94.17
3.G Liming	CO_2	1187.63	168.01	0.00	0.50	94.67
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	296.39	0.00	0.47	95.15
4.A.2 Land converted to Forest Land	CO_2	-326.89	-503.03	0.00	0.42	95.57
4.G Harvested wood products	CO_2	-1712.97	-430.67	0.00	0.36	95.93
1.A.4 Other sectors - Biomass	CH_4	324.26	568.85	0.00	0.30	96.23
1.A.3.b Transport - Road transportation	N_2O	136.73	363.18	0.00	0.30	96.53
3.B Manure Management	CH_4	1716.01	741.23	0.00	0.31	96.84
2.A.4 Other process uses of carbonates	CO_2	117.94	340.59	0.00	0.29	97.13
2.B.2 Nitric Acid Production	N_2O	1050.29	280.12	0.00	0.23	97.36
4.C.1 Grassland remaining Grassland	CO_2	0.00	-279.07	0.00	0.23	97.60

1.A.3.c Transport - Railways	CO_2	653.86	273.75	0.00	0.23	97.83
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	249.61	0.00	0.20	98.02
2.G.3 N_2O from product uses	N_2O	206.22	223.50	0.00	0.19	98.21
5.D Wastewater treatment and discharge	N_2O	234.18	197.57	0.00	0.17	98.38
4.C.2 Land converted to Grassland	CO_2	-145.01	-182.76	0.00	0.15	98.53
3.H Urea application	CO_2	108.53	210.76	0.00	0.12	98.65
1.B.1.a Coal Mining and Handling	CO_2	456.24	156.46	0.00	0.12	98.76
5.C Incineration and open burning of waste	CO_2	23.15	126.33	0.00	0.11	98.87
4.E.2 Land converted to Settlements	CO_2	86.31	124.06	0.00	0.10	98.97
2.A.3 Glass Production	CO_2	123.66	138.06	0.00	0.10	99.08
4.B.1 Cropland remaining Cropland	CO_2	-2.28	-87.06	0.00	0.07	99.15
4.B.2 Land converted to Cropland	CO_2	114.15	83.81	0.00	0.07	99.22
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	14.01	0.00	0.07	99.29
1.A.3.a Transport - Civil Aviation	CO_2	139.44	10.01	0.00	0.07	99.36
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	221.27	0.00	0.06	99.41
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	66.59	0.00	0.06	99.47
1.A.3.e Transport - Other Transportation	CO_2	5.42	60.98	0.00	0.05	99.52
1.A.4 Other sectors - Biomass	N_2O	51.50	90.26	0.00	0.04	99.56
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	18.11	0.00	0.04	99.60
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	7.87	0.00	0.04	99.64
2.D.1 Lubricant Use	CO_2	116.13	114.95	0.00	0.03	99.67
1.A.3.c Transport - Railways	N_2O	75.21	31.49	0.00	0.03	99.70
1.B.2.c Venting and Flaring	CH_4	12.28	29.26	0.00	0.02	99.72
1.A.3.b Transport - Road transportation	CH_4	37.50	26.91	0.00	0.02	99.75
1.A.1 Energy industries - Biomass	N_2O	0.48	26.60	0.00	0.02	99.77
4.A.1 Forest Land remaining Forest Land	N_2O	38.02	26.36	0.00	0.02	99.79
4.D.2. Land converted to Wetlands	CO_2	21.48	25.03	0.00	0.02	99.81
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	35.06	0.00	0.02	99.83
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	22.09	0.00	0.02	99.85
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	70.41	0.00	0.01	99.86
1.A.1 Energy industries - Biomass	CH_4	0.30	16.75	0.00	0.01	99.88
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	22.17	0.00	0.01	99.89
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	22.75	0.55	0.00	0.01	99.90
1.A.3.d Transport - Domestic navigation	CO_2	56.61	12.73	0.00	0.01	99.91
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	16.86	0.00	0.01	99.92
1.B.2.a Oil	CH_4	22.69	4.79	0.00	0.01	99.93
1.A.4 Other sectors - Liquid Fuels	N_2O	22.47	21.73	0.00	0.01	99.94
2.C.5 Lead Production	CO_2	4.04	9.28	0.00	0.01	99.94
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	9.54	0.25	0.00	0.00	99.95
4.A.1 Forest Land remaining Forest Land	CH_4	44.15	32.87	0.00	0.00	99.95
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1325.22	841.90	0.00	0.01	99.96
1.B.2.c Venting and Flaring	CO_2	2.02	4.81	0.00	0.00	99.97
4.B.2. Land converted to Cropland	N_2O	8.91	4.69	0.00	0.00	99.97
1.A.4 Other sectors - Liquid Fuels	CH_4	10.56	2.34	0.00	0.00	99.98
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	13.01	0.00	0.00	99.98
2.C.2 Ferroalloys Production	CH_4	0.18	3.88	0.00	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	3.24	0.00	0.00	99.99
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	4.02	0.00	0.00	99.99
5.C Incineration and open burning of waste	N_2O	0.42	2.29	0.00	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	2.04	0.00	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	3.46	0.41	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	1.59	0.00	0.00	99.99
2.C.1 Iron and Steel Production	CH_4	14.84	10.52	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	1.33	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	2.83	0.00	0.00	100.00
1.B.1.b Solid Fuel Transformation	CH_4	0.75	4.50	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.38	0.00	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.48	0.24	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation	N_2O	1.19	0.09	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.56	0.00	0.00	100.00
1.A.3.c Transport - Railways	CH_4	0.92	0.38	0.00	0.00	100.00

1.A.3.d Transport - Domestic navigation	N_2O	0.46	0.10	0.00	0.00	100.00
1.B.2.b Natural Gas	CO_2	0.17	0.09	0.00	0.00	100.00
2.D.2 Paraffin Wax Use	CO_2	9.43	5.89	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.13	0.03	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.03	0.00	0.00	100.00
1.B.2.a Oil	CO_2	0.02	0.04	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.03	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0.02	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.00	453.14	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.00	3.79	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.00	6.03	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	277.11	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.00	0.52	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.00	6.92	0.00	0.00	100.00
2.B.10 Other chemical industry	CO_2	0.00	233.58	0.00	0.00	100.00
2.C.6 Zinc Production	CO_2	0.00	0.58	0.00	0.00	100.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	18.88	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.00	3.82	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.00	3301.92	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.00	0.99	0.00	0.00	100.00
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.00	6.33	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.00	23.74	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.00	0.03	0.00	0.00	100.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0.00	3.75	0.00	0.00	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	1.59	0.00	0.00	100.00
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	3.19	0.00	0.00	100.00

Tab. A1- 3 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2016 – 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.1 Energy industries - Solid Fuels	CO_2	50569.21	50569.21	38.08	38.08
1.A.3.b Transport - Road transportation	CO_2	17670.12	17670.12	13.31	51.38
1.A.4 Other sectors - Gaseous Fuels	CO_2	7473.04	7473.04	5.63	57.01
2.C.1 Iron and Steel Production	CO_2	7286.67	7286.67	5.49	62.50
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5268.87	5268.87	3.97	66.47
1.A.4 Other sectors - Solid Fuels	CO_2	3824.92	3824.92	2.88	69.35
5.B Biological treatment of solid waste	N_2O	3386.41	3386.41	2.55	71.90
5.A Solid Waste Disposal on Land	CH_4	3366.03	3366.03	2.53	74.43
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3301.92	3301.92	2.49	76.92
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	3270.08	3270.08	2.46	79.38
1.B.1.a Coal Mining and Handling	CH_4	3259.67	3259.67	2.45	81.83
3.A Enteric Fermentation	CH_4	2957.46	2957.46	2.23	84.06
1.A.1 Energy industries - Gaseous Fuels	CO_2	2954.74	2954.74	2.22	86.29
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	2757.19	2757.19	2.08	88.36
2.A.1 Cement Production	CO_2	1697.60	1697.60	1.28	89.64
1.A.4 Other sectors - Liquid Fuels	CO_2	1229.70	1229.70	0.93	90.57
5.D Wastewater treatment and discharge	CH_4	881.60	881.60	0.66	91.23
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	841.90	841.90	0.63	91.86
3.B Manure Management	N_2O	838.95	838.95	0.63	92.49
3.B Manure Management	CH_4	741.23	741.23	0.56	93.05
2.B.1 Ammonia Production	CO_2	685.72	685.72	0.52	93.57
5.B Biological treatment of solid waste	CH_4	675.08	675.08	0.51	94.08
2.A.2 Lime Production	CO_2	639.82	639.82	0.48	94.56
1.B.2.b Natural Gas	CH_4	571.24	571.24	0.43	94.99
1.A.4 Other sectors - Biomass	CH_4	568.85	568.85	0.43	95.42
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	453.14	453.14	0.34	95.76
1.A.1 Energy industries - Liquid Fuels	CO_2	389.04	389.04	0.29	96.05
1.A.3.b Transport - Road transportation	N_2O	363.18	363.18	0.27	96.33
2.A.4 Other process uses of carbonates	CO_2	340.59	340.59	0.26	96.58
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	309.88	309.88	0.23	96.82
2.B.8 Petrochemical and Carbon Black Production	CO_2	302.82	302.82	0.23	97.04
1.A.4 Other sectors - Solid Fuels	CH_4	296.39	296.39	0.22	97.27
2.B.2 Nitric Acid Production	N_2O	280.12	280.12	0.21	97.48
1.A.5.b Other mobile - Liquid Fuels	CO_2	277.11	277.11	0.21	97.69
1.A.3.c Transport - Railways	CO_2	273.75	273.75	0.21	97.89
1.A.1 Energy industries - Other Fossil Fuels	CO_2	249.61	249.61	0.19	98.08
2.B.10 Other chemical industry	CO_2	233.58	233.58	0.18	98.26
2.G.3 N_2O from product uses	N_2O	223.50	223.50	0.17	98.42
1.A.1 Energy industries - Solid Fuels	N_2O	221.27	221.27	0.17	98.59
3.H Urea application	CO_2	210.76	210.76	0.16	98.75
5.D Wastewater treatment and discharge	N_2O	197.57	197.57	0.15	98.90
3.G Liming	CO_2	168.01	168.01	0.13	99.03
1.B.1.a Coal Mining and Handling	CO_2	156.46	156.46	0.12	99.14
2.A.3 Glass Production	CO_2	138.06	138.06	0.10	99.25
5.C Incineration and open burning of waste	CO_2	126.33	126.33	0.10	99.34
2.D.1 Lubricant Use	CO_2	114.95	114.95	0.09	99.43
1.A.4 Other sectors - Biomass	N_2O	90.26	90.26	0.07	99.50
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	70.41	70.41	0.05	99.55
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	66.59	66.59	0.05	99.60
1.A.3.e Transport - Other Transportation	CO_2	60.98	60.98	0.05	99.65
1.A.2 Manufacturing industries and construction - Biomass	N_2O	35.06	35.06	0.03	99.67
1.A.3.c Transport - Railways	N_2O	31.49	31.49	0.02	99.70
1.B.2.c Venting and Flaring	CH_4	29.26	29.26	0.02	99.72
1.A.3.b Transport - Road transportation	CH_4	26.91	26.91	0.02	99.74
1.A.1 Energy industries - Biomass	N_2O	26.60	26.60	0.02	99.76
2.F.3 Fire Protection (CO_2 eq.)	HFC	23.74	23.74	0.02	99.78
1.A.2 Manufacturing industries and construction - Biomass	CH_4	22.17	22.17	0.02	99.79
2.B.8 Petrochemical and Carbon Black Production	CH_4	22.09	22.09	0.02	99.81

1.A.4 Other sectors - Liquid Fuels	N_2O	21.73	21.73	0.02	99.83
2.D.3 Other non-energy products from fuels and solvent use	CO_2	18.88	18.88	0.01	99.84
1.A.4 Other sectors - Solid Fuels	N_2O	18.11	18.11	0.01	99.85
1.A.4 Other sectors - Gaseous Fuels	CH_4	16.86	16.86	0.01	99.87
1.A.1 Energy industries - Biomass	CH_4	16.75	16.75	0.01	99.88
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	14.01	14.01	0.01	99.89
1.A.1 Energy industries - Solid Fuels	CH_4	13.01	13.01	0.01	99.90
1.A.3.d Transport - Domestic navigation	CO_2	12.73	12.73	0.01	99.91
2.C.1 Iron and Steel Production	CH_4	10.52	10.52	0.01	99.92
1.A.3.a Transport - Civil Aviation	CO_2	10.01	10.01	0.01	99.92
2.C.5 Lead Production	CO_2	9.28	9.28	0.01	99.93
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	7.87	7.87	0.01	99.94
1.A.5.b Other mobile - Liquid Fuels	N_2O	6.92	6.92	0.01	99.94
2.F.2 Foam Blowing (CO_2 eq.)	HFC	6.33	6.33	0.00	99.95
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	6.03	6.03	0.00	99.95
2.D.2 Paraffin Wax Use	CO_2	5.89	5.89	0.00	99.96
1.B.2.c Venting and Flaring	CO_2	4.81	4.81	0.00	99.96
1.B.2.a Oil	CH_4	4.79	4.79	0.00	99.96
1.B.1.b Solid Fuel Transformation	CH_4	4.50	4.50	0.00	99.97
1.A.4 Other sectors - Gaseous Fuels	N_2O	4.02	4.02	0.00	99.97
2.C.2 Ferroalloys Production	CH_4	3.88	3.88	0.00	99.97
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	3.82	3.82	0.00	99.98
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	3.79	3.79	0.00	99.98
2.F.4 Aerosols (CO_2 eq.)	HFC	3.75	3.75	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3.24	3.24	0.00	99.98
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	3.19	3.19	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	2.83	2.83	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.38	2.38	0.00	99.99
1.A.4 Other sectors - Liquid Fuels	CH_4	2.34	2.34	0.00	99.99
5.C Incineration and open burning of waste	N_2O	2.29	2.29	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2.04	2.04	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	1.59	1.59	0.00	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	1.59	1.59	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1.33	1.33	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.99	0.99	0.00	100.00
2.C.6 Zinc Production	CO_2	0.58	0.58	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.56	0.56	0.00	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	0.55	0.55	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.52	0.52	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0.41	0.41	0.00	100.00
1.A.3.c Transport - Railways	CH_4	0.38	0.38	0.00	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0.25	0.25	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0.24	0.24	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.10	0.10	0.00	100.00
1.B.2.b Natural Gas	CO_2	0.09	0.09	0.00	100.00
1.A.3.a Transport - Civil Aviation	N_2O	0.09	0.09	0.00	100.00
1.B.2.a Oil	CO_2	0.04	0.04	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.03	0.03	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.03	0.03	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.03	0.03	0.00	100.00
1.A.3.e Transport - Other Transportation	CH_4	0.03	0.03	0.00	100.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	0.00	100.00

Tab. A1- 4 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2016 – 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.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	3270.08	0.10	17.13	17.13
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	50569.21	0.08	13.43	30.56
1.A.3.b Transport - Road transportation	CO_2	6176.54	17670.12	0.07	11.74	42.30
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	3824.92	0.06	10.14	52.44
2.C.1 Iron and Steel Production	CO_2	9642.54	7286.67	0.05	8.29	60.73
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	9609.14	309.88	0.03	5.11	65.84
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.92	7473.04	0.02	4.09	69.94
1.B.1.a Coal Mining and Handling	CH_4	10322.40	3259.67	0.02	2.97	72.91
5.B Biological treatment of solid waste	N_2O	0.00	3386.41	0.02	2.91	75.82
5.A Solid Waste Disposal on Land	CH_4	1979.27	3366.03	0.02	2.89	78.72
3.A Enteric Fermentation	CH_4	5754.89	2957.46	0.01	2.54	81.26
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4192.21	2757.19	0.01	2.37	83.63
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.04	2954.74	0.01	1.79	85.42
2.A.1 Cement Production	CO_2	2489.18	1697.60	0.01	1.46	86.88
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.66	5268.87	0.01	1.35	88.23
1.A.4 Other sectors - Liquid Fuels	CO_2	4009.76	1229.70	0.01	1.19	89.42
1.B.2.b Natural Gas	CH_4	1044.93	571.24	0.01	0.90	90.32
5.D Wastewater treatment and discharge	CH_4	889.80	881.60	0.00	0.76	91.08
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1325.22	841.90	0.00	0.72	91.80
3.B Manure Management	N_2O	1619.93	838.95	0.00	0.72	92.52
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	302.82	0.00	0.68	93.20
3.B Manure Management	CH_4	1716.01	741.23	0.00	0.64	93.84
2.B.1 Ammonia Production	CO_2	990.80	685.72	0.00	0.59	94.43
5.B Biological treatment of solid waste	CH_4	0.00	675.08	0.00	0.58	95.01
2.A.2 Lime Production	CO_2	1336.65	639.82	0.00	0.55	95.56
1.A.1 Energy industries - Liquid Fuels	CO_2	1574.60	389.04	0.00	0.55	96.11
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	296.39	0.00	0.49	96.60
1.A.3.b Transport - Road transportation	N_2O	136.73	363.18	0.00	0.31	96.91
1.A.4 Other sectors - Biomass	CH_4	324.26	568.85	0.00	0.31	97.22
2.A.4 Other process uses of carbonates	CO_2	117.94	340.59	0.00	0.29	97.51
2.B.2 Nitric Acid Production	N_2O	1050.29	280.12	0.00	0.24	97.75
1.A.3.c Transport - Railways	CO_2	653.86	273.75	0.00	0.24	97.99
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	249.61	0.00	0.20	98.19
2.G.3 N_2O from product uses	N_2O	206.22	223.50	0.00	0.19	98.38
3.H Urea application	CO_2	108.53	210.76	0.00	0.18	98.56
5.D Wastewater treatment and discharge	N_2O	234.18	197.57	0.00	0.17	98.73
3.G Liming	CO_2	1187.63	168.01	0.00	0.14	98.88
1.B.1.a Coal Mining and Handling	CO_2	456.24	156.46	0.00	0.12	99.00
5.C Incineration and open burning of waste	CO_2	23.15	126.33	0.00	0.11	99.11
2.A.3 Glass Production	CO_2	123.66	138.06	0.00	0.11	99.21
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	14.01	0.00	0.07	99.29
1.A.3.a Transport - Civil Aviation	CO_2	139.44	10.01	0.00	0.07	99.36
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	70.41	0.00	0.06	99.42
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	66.59	0.00	0.06	99.47
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	221.27	0.00	0.06	99.53
1.A.3.e Transport - Other Transportation	CO_2	5.42	60.98	0.00	0.05	99.58
1.A.4 Other sectors - Biomass	N_2O	51.50	90.26	0.00	0.04	99.62
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	18.11	0.00	0.04	99.67
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	7.87	0.00	0.04	99.71
2.D.1 Lubricant Use	CO_2	116.13	114.95	0.00	0.03	99.74
1.A.3.c Transport - Railways	N_2O	75.21	31.49	0.00	0.03	99.77
1.B.2.c Venting and Flaring	CH_4	12.28	29.26	0.00	0.03	99.79
1.A.3.b Transport - Road transportation	CH_4	37.50	26.91	0.00	0.02	99.82
1.A.1 Energy industries - Biomass	N_2O	0.48	26.60	0.00	0.02	99.84
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	35.06	0.00	0.02	99.86
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	22.09	0.00	0.02	99.88
1.A.1 Energy industries - Biomass	CH_4	0.30	16.75	0.00	0.01	99.89
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	22.17	0.00	0.01	99.91
1.A.2 Manufacturing industries and construction - Liquid	N_2O	22.75	0.55	0.00	0.01	99.92

Fuels						
1.A.3.d Transport - Domestic navigation	CO_2	56.61	12.73	0.00	0.01	99.93
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	16.86	0.00	0.01	99.94
1.B.2.a Oil	CH_4	22.69	4.79	0.00	0.01	99.95
1.A.4 Other sectors - Liquid Fuels	N_2O	22.47	21.73	0.00	0.01	99.95
2.C.5 Lead Production	CO_2	4.04	9.28	0.00	0.01	99.96
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	9.54	0.25	0.00	0.01	99.96
1.B.2.c Venting and Flaring	CO_2	2.02	4.81	0.00	0.00	99.97
1.A.4 Other sectors - Liquid Fuels	CH_4	10.56	2.34	0.00	0.00	99.97
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	13.01	0.00	0.00	99.98
2.C.2 Ferroalloys Production	CH_4	0.18	3.88	0.00	0.00	99.98
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	3.19	0.00	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	3.24	0.00	0.00	99.98
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	4.02	0.00	0.00	99.99
5.C Incineration and open burning of waste	N_2O	0.42	2.29	0.00	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	2.04	0.00	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	3.46	0.41	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	1.59	0.00	0.00	99.99
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	1.59	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	1.33	0.00	0.00	99.99
2.C.1 Iron and Steel Production	CH_4	14.84	10.52	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	2.83	0.00	0.00	100.00
1.B.1.b Solid Fuel Transformation	CH_4	0.75	4.50	0.00	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.48	0.24	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.38	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation	N_2O	1.19	0.09	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.56	0.00	0.00	100.00
1.A.3.c Transport - Railways	CH_4	0.92	0.38	0.00	0.00	100.00
2.D.2 Paraffin Wax Use	CO_2	9.43	5.89	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.46	0.10	0.00	0.00	100.00
1.B.2.b Natural Gas	CO_2	0.17	0.09	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.13	0.03	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.03	0.00	0.00	100.00
1.B.2.a Oil	CO_2	0.02	0.04	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.03	0.00	0.00	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0.02	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	100.00	0.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	**CO_2**	453.14	0.00	0.00	100.00	453.14
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	3.79	0.00	0.00	100.00	3.79
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	6.03	0.00	0.00	100.00	6.03
1.A.5.b Other mobile - Liquid Fuels	CO_2	277.11	0.00	0.00	100.00	277.11
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.52	0.00	0.00	100.00	0.52
1.A.5.b Other mobile - Liquid Fuels	N_2O	6.92	0.00	0.00	100.00	6.92
2.B.10 Other chemical industry	CO_2	233.58	0.00	0.00	100.00	233.58
2.C.6 Zinc Production	CO_2	0.58	0.00	0.00	100.00	0.58
2.D.3 Other non-energy products from fuels and solvent use	CO_2	18.88	0.00	0.00	100.00	18.88
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	3.82	0.00	0.00	100.00	3.82
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	0.00	100.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3301.92	0.00	0.00	100.00	3301.92
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.99	0.00	0.00	100.00	0.99
2.F.2 Foam Blowing (CO_2 eq.)	HFC	6.33	0.00	0.00	100.00	6.33
2.F.3 Fire Protection (CO_2 eq.)	HFC	23.74	0.00	0.00	100.00	23.74
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.03	0.00	0.00	100.00	0.03
2.F.4 Aerosols (CO_2 eq.)	HFC	3.75	0.00	0.00	100.00	3.75

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.1 Energy industries - Solid Fuels	CO_2	53719.76	53719.76	26.23	26.23
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	35635.57	17.40	17.40
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	24005.03	11.72	55.36
1.B.1.a Coal Mining and Handling	CH_4	10322.40	10322.40	5.04	60.40
2.C.1 Iron and Steel Production	CO_2	9642.54	9642.54	4.71	65.11
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	9609.14	9609.14	4.69	69.80
1.A.3.b Transport - Road transportation	CO_2	6176.54	6176.54	3.02	72.82
3.A Enteric Fermentation	CH_4	5754.89	5754.89	2.81	75.63
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.66	5685.66	2.78	78.40
4.A.1 Forest Land remaining Forest Land	CO_2	-4817.86	4817.86	2.35	80.76
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4192.21	4192.21	2.05	82.80
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.92	4173.92	2.04	84.84
1.A.4 Other sectors - Liquid Fuels	CO_2	4009.76	4009.76	1.96	86.80
2.A.1 Cement Production	CO_2	2489.18	2489.18	1.22	88.01
5.A Solid Waste Disposal on Land	CH_4	1979.27	1979.27	0.97	88.98
3.B Manure Management	CH_4	1716.01	1716.01	0.84	89.82
4.G Harvested wood products	CO_2	-1712.97	1712.97	0.84	90.66
3.B Manure Management	N_2O	1619.93	1619.93	0.79	91.45
1.A.1 Energy industries - Liquid Fuels	CO_2	1574.60	1574.60	0.77	92.22
2.A.2 Lime Production	CO_2	1336.65	1336.65	0.65	92.87
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.04	1336.04	0.65	93.52
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	1331.86	0.65	94.17
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1325.22	1325.22	0.65	94.82
3.G Liming	CO_2	1187.63	1187.63	0.58	95.40
2.B.2 Nitric Acid Production	N_2O	1050.29	1050.29	0.51	95.91
1.B.2.b Natural Gas	CH_4	1044.93	1044.93	0.51	96.42
2.B.1 Ammonia Production	CO_2	990.80	990.80	0.48	96.91
5.D Wastewater treatment and discharge	CH_4	889.80	889.80	0.43	97.34
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	792.47	0.39	97.73
1.A.3.c Transport - Railways	CO_2	653.86	653.86	0.32	98.05
1.B.1.a Coal Mining and Handling	CO_2	456.24	456.24	0.22	98.27
4.A.2 Land converted to Forest Land	CO_2	-326.89	326.89	0.16	98.43
1.A.4 Other sectors - Biomass	CH_4	324.26	324.26	0.16	98.59
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	239.87	0.12	98.70
5.D Wastewater treatment and discharge	N_2O	234.18	234.18	0.11	98.82
2.G.3 N_2O from product uses	N_2O	206.22	206.22	0.10	98.92
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	152.87	0.07	98.99
4.C.2 Land converted to Grassland	CO_2	-145.01	145.01	0.07	99.06
1.A.3.a Transport - Civil Aviation	CO_2	139.44	139.44	0.07	99.13
1.A.3.b Transport - Road transportation	N_2O	136.73	136.73	0.07	99.20
2.A.3 Glass Production	CO_2	123.66	123.66	0.06	99.26
2.A.4 Other process uses of carbonates	CO_2	117.94	117.94	0.06	99.32
2.D.1 Lubricant Use	CO_2	116.13	116.13	0.06	99.37
4.B.2 Land converted to Cropland	CO_2	114.15	114.15	0.06	99.43
3.H Urea application	CO_2	108.53	108.53	0.05	99.48
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	103.30	0.05	99.53
4.E.2 Land converted to Settlements	CO_2	86.31	86.31	0.04	99.58
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	85.75	0.04	99.62
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	84.10	0.04	99.66
1.A.3.c Transport - Railways	N_2O	75.21	75.21	0.04	99.69
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	74.50	0.04	99.73
1.A.3.d Transport - Domestic navigation	CO_2	56.61	56.61	0.03	99.76
1.A.4 Other sectors - Biomass	N_2O	51.50	51.50	0.03	99.78
4.A.1 Forest Land remaining Forest Land	CH_4	44.15	44.15	0.02	99.81
4.A.1 Forest Land remaining Forest Land	N_2O	38.02	38.02	0.02	99.82
1.A.3.b Transport - Road transportation	CH_4	37.50	37.50	0.02	99.84
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	36.17	0.02	99.86
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	24.04	0.01	99.87
5.C Incineration and open burning of waste	CO_2	23.15	23.15	0.01	99.88
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	22.75	22.75	0.01	99.89
1.B.2.a Oil	CH_4	22.69	22.69	0.01	99.91
1.A.4 Other sectors - Liquid Fuels	N_2O	22.47	22.47	0.01	99.92
4.D.2. Land converted to Wetlands	CO_2	21.48	21.48	0.01	99.93
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	16.60	0.01	99.93

2.C.1 Iron and Steel Production	CH_4	14.84	14.84	0.01	99.94
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	14.03	0.01	99.95
1.B.2.c Venting and Flaring	CH_4	12.28	12.28	0.01	99.96
1.A.4 Other sectors - Liquid Fuels	CH_4	10.56	10.56	0.01	99.96
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	10.45	0.01	99.97
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	9.57	0.00	99.97
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	9.54	9.54	0.00	99.97
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	0.00	99.98
4.B.2. Land converted to Cropland	N_2O	8.91	8.91	0.00	99.98
1.A.3.e Transport - Other Transportation	CO_2	5.42	5.42	0.00	99.99
2.C.5 Lead Production	CO_2	4.04	4.04	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	3.46	3.46	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	3.11	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.61	0.00	99.99
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	2.28	0.00	99.99
4.B.1 Cropland remaining Cropland	CO_2	-2.28	2.28	0.00	99.99
1.B.2.c Venting and Flaring	CO_2	2.02	2.02	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.48	1.48	0.00	100.00
1.A.3.a Transport - Civil Aviation	N_2O	1.19	1.19	0.00	100.00
1.A.3.c Transport - Railways	CH_4	0.92	0.92	0.00	100.00
1.B.1.b Solid Fuel Transformation	CH_4	0.75	0.75	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	0.73	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	0.61	0.00	100.00
1.A.1 Energy industries - Biomass	N_2O	0.48	0.48	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.46	0.46	0.00	100.00
5.C Incineration and open burning of waste	N_2O	0.42	0.42	0.00	100.00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	0.31	0.00	100.00
1.A.1 Energy industries - Biomass	CH_4	0.30	0.30	0.00	100.00
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	0.20	0.00	100.00
2.C.2 Ferroalloys Production	CH_4	0.18	0.18	0.00	100.00
1.B.2.b Natural Gas	CO_2	0.17	0.17	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.13	0.13	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.03	0.00	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0.02	0.02	0.00	100.00
1.B.2.a Oil	CO_2	0.02	0.02	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.00	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.00	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.00	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.00	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.00	0.00	0.00	100.00
2.B.10 Other chemical industry	CO_2	0.00	0.00	0.00	100.00
2.C.6 Zinc Production	CO_2	0.00	0.00	0.00	100.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	0.00	0.00	100.00
4.C.1 Grassland remaining Grassland	CO_2	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	CH_4	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	N_2O	0.00	0.00	0.00	100.00

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)	Level Assessment	Cumulative Total (LA)
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	53719.76	27.21	27.21
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	35635.57	18.05	45.25
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	24005.03	12.16	57.41
1.B.1.a Coal Mining and Handling	CH_4	10322.40	10322.40	5.23	62.64
2.C.1 Iron and Steel Production	CO_2	9642.54	9642.54	4.88	67.52
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	9609.14	9609.14	4.87	72.39
1.A.3.b Transport - Road transportation	CO_2	6176.54	6176.54	3.13	75.51
3.A Enteric Fermentation	CH_4	5754.89	5754.89	2.91	78.43
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.66	5685.66	2.88	81.31
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4192.21	4192.21	2.12	83.43
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.92	4173.92	2.11	85.55
1.A.4 Other sectors - Liquid Fuels	CO_2	4009.76	4009.76	2.03	87.58
2.A.1 Cement Production	CO_2	2489.18	2489.18	1.26	88.84
5.A Solid Waste Disposal on Land	CH_4	1979.27	1979.27	1.00	89.84
3.B Manure Management	CH_4	1716.01	1716.01	0.87	90.71
3.B Manure Management	N_2O	1619.93	1619.93	0.82	91.53
1.A.1 Energy industries - Liquid Fuels	CO_2	1574.60	1574.60	0.80	92.33
2.A.2 Lime Production	CO_2	1336.65	1336.65	0.68	93.00
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.04	1336.04	0.68	93.68
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	1331.86	0.67	94.35
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1325.22	1325.22	0.67	95.02
3.G Liming	CO_2	1187.63	1187.63	0.60	95.63
2.B.2 Nitric Acid Production	N_2O	1050.29	1050.29	0.53	96.16
1.B.2.b Natural Gas	CH_4	1044.93	1044.93	0.53	96.69
2.B.1 Ammonia Production	CO_2	990.80	990.80	0.50	97.19
5.D Wastewater treatment and discharge	CH_4	889.80	889.80	0.45	97.64
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	792.47	0.40	98.04
1.A.3.c Transport - Railways	CO_2	653.86	653.86	0.33	98.37
1.B.1.a Coal Mining and Handling	CO_2	456.24	456.24	0.23	98.60
1.A.4 Other sectors - Biomass	CH_4	324.26	324.26	0.16	98.77
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	239.87	0.12	98.89
5.D Wastewater treatment and discharge	N_2O	234.18	234.18	0.12	99.01
2.G.3 N_2O from product uses	N_2O	206.22	206.22	0.10	99.11
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	152.87	0.08	99.19
1.A.3.a Transport - Civil Aviation	CO_2	139.44	139.44	0.07	99.26
1.A.3.b Transport - Road transportation	N_2O	136.73	136.73	0.07	99.33
2.A.3 Glass Production	CO_2	123.66	123.66	0.06	99.39
2.A.4 Other process uses of carbonates	CO_2	117.94	117.94	0.06	99.45
2.D.1 Lubricant Use	CO_2	116.13	116.13	0.06	99.51
3.H Urea application	CO_2	108.53	108.53	0.05	99.57
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	103.30	0.05	99.62
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	85.75	0.04	99.66
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	84.10	0.04	99.70
1.A.3.c Transport - Railways	N_2O	75.21	75.21	0.04	99.74
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	74.50	0.04	99.78
1.A.3.d Transport - Domestic navigation	CO_2	56.61	56.61	0.03	99.81
1.A.4 Other sectors - Biomass	N_2O	51.50	51.50	0.03	99.83
1.A.3.b Transport - Road transportation	CH_4	37.50	37.50	0.02	99.85
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	36.17	0.02	99.87
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	24.04	0.01	99.88
5.C Incineration and open burning of waste	CO_2	23.15	23.15	0.01	99.90
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	22.75	22.75	0.01	99.91
1.B.2.a Oil	CH_4	22.69	22.69	0.01	99.92
1.A.4 Other sectors - Liquid Fuels	N_2O	22.47	22.47	0.01	99.93
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	16.60	0.01	99.94
2.C.1 Iron and Steel Production	CH_4	14.84	14.84	0.01	99.95
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	14.03	0.01	99.95
1.B.2.c Venting and Flaring	CH_4	12.28	12.28	0.01	99.96
1.A.4 Other sectors - Liquid Fuels	CH_4	10.56	10.56	0.01	99.96
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	10.45	0.01	99.97
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	9.57	0.00	99.97
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	9.54	9.54	0.00	99.98
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	0.00	99.98
1.A.3.e Transport - Other Transportation	CO_2	5.42	5.42	0.00	99.99

2.C.5 Lead Production	CO_2	4.04	4.04	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	3.46	3.46	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	3.11	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.61	0.00	99.99
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	2.28	0.00	99.99
1.B.2.c Venting and Flaring	CO_2	2.02	2.02	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.48	1.48	0.00	100.00
1.A.3.a Transport - Civil Aviation	N_2O	1.19	1.19	0.00	100.00
1.A.3.c Transport - Railways	CH_4	0.92	0.92	0.00	100.00
1.B.1.b Solid Fuel Transformation	CH_4	0.75	0.75	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	0.73	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	0.61	0.00	100.00
1.A.1 Energy industries - Biomass	N_2O	0.48	0.48	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.46	0.46	0.00	100.00
5.C Incineration and open burning of waste	N_2O	0.42	0.42	0.00	100.00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	0.31	0.00	100.00
1.A.1 Energy industries - Biomass	CH_4	0.30	0.30	0.00	100.00
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	0.20	0.00	100.00
2.C.2 Ferroalloys Production	CH_4	0.18	0.18	0.00	100.00
1.B.2.b Natural Gas	CO_2	0.17	0.17	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.13	0.13	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.03	0.00	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0.02	0.02	0.00	100.00
1.B.2.a Oil	CO_2	0.02	0.02	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.00	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.00	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.00	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.00	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.00	0.00	0.00	100.00
2.B.10 Other chemical industry	CO_2	0.00	0.00	0.00	100.00
2.C.6 Zinc Production	CO_2	0.00	0.00	0.00	100.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	CH_4	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	N_2O	0.00	0.00	0.00	100.00

Tab. A1- 7 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2016 – 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.1 Energy industries - Solid Fuels	CO_2	50569.21	50569.21	5.00	37.33	2528.46	34.62	37.33	0.11	34.62
1.A.3.b Transport - Road transportation	CO_2	17670.12	17670.12	4.97	13.05	879.02	12.10	13.05	0.11	46.72
2.C.1 Iron and Steel Production	CO_2	7286.67	7286.67	12.21	5.38	889.45	5.33	5.38	0.27	52.05
1.A.4 Other sectors - Gaseous Fuels	CO_2	7473.04	7473.04	3.91	5.52	291.83	5.06	5.52	0.09	57.11
5.A Solid Waste Disposal on Land	CH_4	3671.11	3671.11	63.70	2.71	2338.47	3.92	2.71	1.41	61.03
4.A.1 Forest Land remaining Forest Land	CO_2	-4070.82	4070.82	41.63	3.01	1694.69	3.76	3.01	0.92	64.79
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5268.87	5268.87	3.91	3.89	205.76	3.57	3.89	0.09	68.36
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3086.10	3086.10	43.57	2.28	1344.49	2.89	2.28	0.97	71.25
1.A.4 Other sectors - Solid Fuels	CO_2	3824.92	3824.92	5.00	2.82	191.25	2.62	2.82	0.11	73.87
1.B.1.a Coal Mining and Handling	CH_4	3259.67	3259.67	13.60	2.41	443.36	2.41	2.41	0.30	76.28
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	3270.08	3270.08	5.00	2.41	163.50	2.24	2.41	0.11	78.52
3.A Enteric Fermentation	CH_4	2957.46	2957.46	15.81	2.18	467.62	2.23	2.18	0.35	80.76
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	2760.59	2760.59	20.62	2.04	569.11	2.17	2.04	0.46	82.93
1.A.1 Energy industries - Gaseous Fuels	CO_2	2954.74	2954.74	3.91	2.18	115.39	2.00	2.18	0.09	84.93
2.A.1 Cement Production	CO_2	1697.60	1697.60	2.83	1.25	48.02	1.14	1.25	0.06	86.07
5.D Wastewater treatment and discharge	CH_4	865	865	58	1	505	0.89	0.64	1.29	86.96
1.A.4 Other sectors - Liquid Fuels	CO_2	1230	1230	6	1	72	0.85	0.91	0.13	87.81
5.B Biological treatment of solid waste	CH_4	648	648	91	0	591	0.81	0.48	2.02	88.62
3.B Manure Management	N_2O	839	839	40	1	338	0.77	0.62	0.89	89.39
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	843	843	30	1	256	0.72	0.62	0.67	90.10
1.B.2.b Natural Gas	CH_4	571	571	75	0	430	0.65	0.42	1.67	90.76
3.B Manure Management	CH_4	741	741	22	1	166	0.59	0.55	0.50	91.35
1.A.4 Other sectors - Biomass	CH_4	569	569	51	0	288	0.56	0.42	1.12	91.91
1.A.3.b Transport - Road transportation	N_2O	363	363	134	0	486	0.55	0.27	2.97	92.46
2.B.1 Ammonia Production	CO_2	686	686	9	1	59	0.49	0.51	0.19	92.94
4.G Harvested wood products	CO_2	-431	431	62	0	267	0.45	0.32	1.37	93.40
4.C.1 Grassland remaining Grassland	CO_2	-479	479	45	0	217	0.45	0.35	1.01	93.85
4.A.2 Land converted to Forest Land	CO_2	-503	503	32	0	163	0.43	0.37	0.72	94.29
2.A.2 Lime Production	CO_2	640	640	3	0	18	0.43	0.47	0.06	94.72
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	453	453	18	0	82	0.35	0.33	0.40	95.07
1.A.4 Other sectors - Solid Fuels	CH_4	296	296	50	0	149	0.29	0.22	1.11	95.36
2.B.8 Petrochemical and Carbon Black Production	CO_2	303	303	40	0	122	0.28	0.22	0.89	95.63

1.A.1 Energy industries - Liquid Fuels	CO_2	389	389	6	0	23	0.27	0.29	0.13	95.90
2.A.4 Other process uses of carbonates	CO_2	341	341	11	0	38	0.25	0.25	0.25	96.15
1.A.1 Energy industries - Solid Fuels	N_2O	221	221	60	0	133	0.23	0.16	1.33	96.38
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	310	310	6	0	18	0.21	0.23	0.13	96.59
2.G.3 N_2O from product uses	N_2O	224	224	44	0	97	0.21	0.17	0.97	96.80
3.H Urea application	CO_2	211	211	52	0	110	0.21	0.16	1.16	97.01
1.A.1 Energy industries - Other Fossil Fuels	CO_2	250	250	28	0	71	0.21	0.18	0.63	97.22
5.D Wastewater treatment and discharge	N_2O	197	197	56	0	111	0.20	0.15	1.25	97.42
1.A.5.b Other mobile - Liquid Fuels	CO_2	277	277	6	0	16	0.19	0.20	0.13	97.61
1.A.3.c Transport - Railways	CO_2	274	274	5	0	14	0.19	0.20	0.12	97.80
4.E.2 Land converted to Settlements	CO_2	124	124	102	0	127	0.16	0.09	2.27	97.96
2.B.2 Nitric Acid Production	N_2O	216	216	16	0	34	0.16	0.16	0.34	98.13
2.B.10 Other chemical industry	CO_2	234	234	4	0	9	0.16	0.17	0.09	98.29
4.C.2 Land converted to Grassland	CO_2	-183	183	31	0	57	0.16	0.13	0.69	98.44
3.G Liming	CO_2	168	168	30	0	51	0.14	0.12	0.67	98.59
1.B.1.a Coal Mining and Handling	CO_2	156	156	25	0	40	0.13	0.12	0.56	98.71
2.D.1 Lubricant Use	CO_2	115	115	50	0	58	0.11	0.08	1.11	98.83
2.A.3 Glass Production	CO_2	138	138	5	0	7	0.09	0.10	0.12	98.92
1.A.4 Other sectors - Biomass	N_2O	90	90	61	0	55	0.09	0.07	1.34	99.02
5.C Incineration and open burning of waste	CO_2	114	114	16	0	18	0.09	0.08	0.35	99.10
4.B.2 Land converted to Cropland	CO_2	84	84	37	0	31	0.07	0.06	0.81	99.18
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	70	70	44	0	31	0.07	0.05	0.97	99.24
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	67	67	40	0	27	0.06	0.05	0.89	99.30
1.A.3.c Transport - Railways	N_2O	31	31	137	0	43	0.05	0.02	3.04	99.35
1.A.3.b Transport - Road transportation	CH_4	27	27	157	0	42	0.05	0.02	3.49	99.40
5.B Biological treatment of solid waste	N_2O	64	64	5	0	3	0.04	0.05	0.11	99.44
1.A.3.e Transport - Other Transportation	CO_2	61	61	5	0	3	0.04	0.05	0.11	99.48
1.A.2 Manufacturing industries and construction - Biomass	N_2O	35	35	61	0	21	0.04	0.03	1.34	99.52
4.A.1 Forest Land remaining Forest Land	CH_4	33	33	46	0	15	0.03	0.02	1.03	99.55
4.B.1 Cropland remaining Cropland	CO_2	36	36	29	0	11	0.03	0.03	0.65	99.58
1.B.2.c Venting and Flaring	CH_4	29	29	50	0	15	0.03	0.02	1.12	99.61
1.A.1 Energy industries - Biomass	N_2O	27	27	61	0	16	0.03	0.02	1.34	99.64
4.D.2. Land converted to Wetlands	CO_2	25	25	69	0	17	0.03	0.02	1.54	99.66
1.A.4 Other sectors - Liquid Fuels	N_2O	22	22	60	0	13	0.02	0.02	1.34	99.69
2.F.3 Fire Protection (CO_2 eq.)	HFC	24	24	42	0	10	0.02	0.02	0.93	99.71
1.A.2 Manufacturing industries and construction - Biomass	CH_4	22	22	51	0	11	0.02	0.02	1.12	99.73
4.A.1 Forest Land remaining Forest Land	N_2O	22	22	46	0	10	0.02	0.02	1.03	99.75
2.B.8 Petrochemical and Carbon Black Production	CH_4	22	22	40	0	9	0.02	0.02	0.89	99.77
1.A.4 Other sectors - Solid Fuels	N_2O	18	18	60	0	11	0.02	0.01	1.33	99.79

1.A.4 Other sectors - Gaseous Fuels	CH_4	17	17	50	0	8	0.02	0.01	1.11	99.81
1.A.1 Energy industries - Biomass	CH_4	17	17	51	0	8	0.02	0.01	1.12	99.82
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	14	14	60	0	8	0.01	0.01	1.33	99.84
2.D.3 Other non-energy products from fuels and solvent use	CO_2	19	19	7	0	1	0.01	0.01	0.16	99.85
1.A.1 Energy industries - Solid Fuels	CH_4	13	13	50	0	7	0.01	0.01	1.11	99.86
4.B.2. Land converted to Cropland	N_2O	5	5	282	0	13	0.01	0.00	6.26	99.88
2.C.5 Lead Production	CO_2	9	9	51	0	5	0.01	0.01	1.13	99.88
2.C.1 Iron and Steel Production	CH_4	11	11	31	0	3	0.01	0.01	0.68	99.89
1.A.3.d Transport - Domestic navigation	CO_2	13	13	5	0	1	0.01	0.01	0.12	99.90
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	8	8	50	0	4	0.01	0.01	1.11	99.91
1.A.5.b Other mobile - Liquid Fuels	N_2O	7	7	60	0	4	0.01	0.01	1.34	99.92
1.A.3.a Transport - Civil Aviation	CO_2	10	10	6	0	1	0.01	0.01	0.12	99.92
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	6	6	61	0	4	0.01	0.00	1.35	99.93
2.F.2 Foam Blowing (CO_2 eq.)	HFC	6	6	42	0	3	0.01	0.00	0.93	99.94
2.D.2 Paraffin Wax Use	CO_2	6	6	50	0	3	0.01	0.00	1.11	99.94
1.B.2.a Oil	CH_4	5	5	75	0	4	0.01	0.00	1.67	99.95
1.B.1.b Solid Fuel Transformation	CH_4	5	5	64	0	3	0.00	0.00	1.42	99.95
1.B.2.c Venting and Flaring	CO_2	5	5	50	0	2	0.00	0.00	1.12	99.96
1.A.4 Other sectors - Gaseous Fuels	N_2O	4	4	60	0	2	0.00	0.00	1.33	99.96
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	4	4	44	0	2	0.00	0.00	0.97	99.97
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	4	4	51	0	2	0.00	0.00	1.13	99.97
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3	3	73	0	2	0.00	0.00	1.61	99.97
2.F.4 Aerosols (CO_2 eq.)	HFC	4	4	42	0	2	0.00	0.00	0.93	99.98
2.C.2 Ferroalloys Production	CH_4	4	4	25	0	1	0.00	0.00	0.57	99.98
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3	3	60	0	2	0.00	0.00	1.33	99.98
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	4	4	15	0	1	0.00	0.00	0.34	99.99
5.C Incineration and open burning of waste	N_2O	2	2	73	0	2	0.00	0.00	1.61	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2	2	50	0	1	0.00	0.00	1.11	99.99
1.A.4 Other sectors - Liquid Fuels	CH_4	2	2	50	0	1	0.00	0.00	1.11	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2	2	54	0	1	0.00	0.00	1.19	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	2	2	60	0	1	0.00	0.00	1.33	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	2	2	42	0	1	0.00	0.00	0.93	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1	1	50	0	1	0.00	0.00	1.11	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	1	1	44	0	0	0.00	0.00	0.97	100.00
1.A.3.c Transport - Railways	CH_4	0	0	158	0	1	0.00	0.00	3.49	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	1	1	60	0	0	0.00	0.00	1.34	100.00
2.C.6 Zinc Production	CO_2	1	1	51	0	0	0.00	0.00	1.13	100.00
1.A.5.b Other mobile - Liquid	CH_4	1	1	50	0	0	0.00	0.00	1.11	100.00

Fuels										
2.C.2 Ferroalloys Production	CO_2	1	1	25	0	0	0.00	0.00	0.57	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0	0	60	0	0	0.00	0.00	1.34	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0	0	50	0	0	0.00	0.00	1.11	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0	0	50	0	0	0.00	0.00	1.11	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0	0	137	0	0	0.00	0.00	3.04	100.00
1.A.3.a Transport - Civil Aviation	N_2O	0	0	110	0	0	0.00	0.00	2.44	100.00
1.B.2.b Natural Gas	CO_2	0	0	75	0	0	0.00	0.00	1.67	100.00
1.B.2.a Oil	CO_2	0	0	75	0	0	0.00	0.00	1.67	100.00
1.A.3.e Transport - Other Transportation	N_2O	0	0	60	0	0	0.00	0.00	1.33	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0	0	42	0	0	0.00	0.00	0.93	100.00
1.A.3.e Transport - Other Transportation	CH_4	0	0	50	0	0	0.00	0.00	1.11	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0	0	5	0	0	0.00	0.00	0.12	100.00
5.C Incineration and open burning of waste	CH_4	0	0	82	0	0	0.00	0.00	1.83	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0	0	79	0	0	0.00	0.00	1.74	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0	0	15	0	0	0.00	0.00	0.34	100.00

Tab. A1- 8 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2016 – 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.1 Energy industries - Solid Fuels	CO_2	50569	50569	5	37	2528	37	39.06	0.14	36.68
1.A.3.b Transport - Road transportation	CO_2	17670	17670	5	13	879	13	13.65	0.14	49.50
2.C.1 Iron and Steel Production	CO_2	7287	7287	12	5	889	6	5.63	0.33	55.15
1.A.4 Other sectors - Gaseous Fuels	CO_2	7473	7473	4	6	292	5	5.77	0.11	60.51
5.A Solid Waste Disposal on Land	CH_4	3671	3671	64	3	2338	4	2.84	1.73	64.67
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5269	5269	4	4	206	4	4.07	0.11	68.45
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3086	3086	44	2	1344	3	2.38	1.18	71.51
1.A.4 Other sectors - Solid Fuels	CO_2	3825	3825	5	3	191	3	2.95	0.14	74.28
1.B.1.a Coal Mining and Handling	CH_4	3260	3260	14	2	443	3	2.52	0.37	76.84
5.B Biological treatment of solid waste	N_2O	64	64	5	0	3	0	0.05	0.14	76.89
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	3270	3270	5	2	164	2	2.53	0.14	79.26
3.A Enteric Fermentation	CH_4	2957	2957	16	2	468	2	2.28	0.43	81.63
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	2761	2761	21	2	569	2	2.13	0.56	83.93
1.A.1 Energy industries - Gaseous Fuels	CO_2	2955	2955	4	2	115	2	2.28	0.11	86.05
2.A.1 Cement Production	CO_2	1698	1698	3	1	48	1	1.31	0.08	87.25
5.D Wastewater treatment and discharge	CH_4	865	865	58	1	505	1	0.67	1.58	88.20
1.A.4 Other sectors - Liquid Fuels	CO_2	1230	1230	6	1	72	1	0.95	0.16	89.10
5.B Biological treatment of solid waste	CH_4	648	648	91	0	591	1	0.50	2.48	89.96
3.B Manure Management	N_2O	839	839	40	1	338	1	0.65	1.09	90.77
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	843	843	30	1	256	1	0.65	0.83	91.53
1.B.2.b Natural Gas	CH_4	571	571	75	0	430	1	0.44	2.04	92.22
3.B Manure Management	CH_4	741	741	22	1	166	1	0.57	0.61	92.85
1.A.3.b Transport - Road transportation	N_2O	363	363	134	0	486	1	0.28	3.63	93.43
1.A.4 Other sectors - Biomass	CH_4	569	569	51	0	288	1	0.44	1.37	94.03
2.B.1 Ammonia Production	CO_2	686	686	9	1	59	1	0.53	0.23	94.54
2.A.2 Lime Production	CO_2	640	640	3	0	18	0	0.49	0.08	95.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	453	453	18	0	82	0	0.35	0.49	95.37
1.A.4 Other sectors - Solid Fuels	CH_4	296	296	50	0	149	0	0.23	1.36	95.67
2.B.8 Petrochemical and Carbon Black Production	CO_2	303	303	40	0	122	0	0.23	1.09	95.97
1.A.1 Energy industries - Liquid Fuels	CO_2	389	389	6	0	23	0	0.30	0.16	96.25
2.A.4 Other process uses of carbonates	CO_2	341	341	11	0	38	0	0.26	0.30	96.51
1.A.1 Energy industries - Solid Fuels	N_2O	221	221	60	0	133	0	0.17	1.63	96.76
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	310	310	6	0	18	0	0.24	0.16	96.98
2.B.2 Nitric Acid Production	N_2O	216	216	16	0	34	0	0.17	0.42	97.16
2.G.3 N_2O from product uses	N_2O	224	224	44	0	97	0	0.17	1.18	97.38
3.H Urea application	CO_2	211	211	52	0	110	0	0.16	1.42	97.60
1.A.1 Energy industries - Other Fossil Fuels	CO_2	250	250	28	0	71	0	0.19	0.77	97.82
5.D Wastewater treatment and discharge	N_2O	197	197	56	0	111	0	0.15	1.53	98.03
1.A.5.b Other mobile - Liquid Fuels	CO_2	277	277	6	0	16	0	0.21	0.16	98.24
1.A.3.c Transport - Railways	CO_2	274	274	5	0	14	0	0.21	0.14	98.44
2.B.10 Other chemical industry	CO_2	234	234	4	0	9	0	0.18	0.11	98.60
3.G Liming	CO_2	168	168	30	0	51	0	0.13	0.83	98.76
1.B.1.a Coal Mining and Handling	CO_2	156	156	25	0	40	0	0.12	0.69	98.89
2.D.1 Lubricant Use	CO_2	115	115	50	0	58	0	0.09	1.36	99.01
5.C Incineration and open burning of waste	CO_2	114	114	16	0	18	0	0.09	0.43	99.10
2.A.3 Glass Production	CO_2	138	138	5	0	7	0	0.11	0.15	99.20

1.A.4 Other sectors - Biomass	N_2O	90	90	61	0	55	0	0.07	1.64	99.30
1.A.3.b Transport - Road transportation	CH_4	27	27	157	0	42	0	0.02	4.27	99.35
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	70	70	44	0	31	0	0.05	1.18	99.42
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	67	67	40	0	27	0	0.05	1.09	99.48
1.A.3.c Transport - Railways	N_2O	31	31	137	0	43	0	0.02	3.73	99.54
1.A.3.e Transport - Other Transportation	CO_2	61	61	5	0	3	0	0.05	0.14	99.58
1.A.2 Manufacturing industries and construction - Biomass	N_2O	35	35	61	0	21	0	0.03	1.64	99.62
1.B.2.c Venting and Flaring	CH_4	29	29	50	0	15	0	0.02	1.37	99.65
1.A.1 Energy industries - Biomass	N_2O	27	27	61	0	16	0	0.02	1.64	99.68
1.A.4 Other sectors - Liquid Fuels	N_2O	22	22	60	0	13	0	0.02	1.63	99.70
2.F.3 Fire Protection (CO_2 eq.)	HFC	24	24	42	0	10	0	0.02	1.14	99.73
1.A.2 Manufacturing industries and construction - Biomass	CH_4	22	22	51	0	11	0	0.02	1.37	99.75
2.B.8 Petrochemical and Carbon Black Production	CH_4	22	22	40	0	9	0	0.02	1.09	99.77
1.A.4 Other sectors - Solid Fuels	N_2O	18	18	60	0	11	0	0.01	1.63	99.79
1.A.4 Other sectors - Gaseous Fuels	CH_4	17	17	50	0	8	0	0.01	1.36	99.81
1.A.1 Energy industries - Biomass	CH_4	17	17	51	0	8	0	0.01	1.37	99.83
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	14	14	60	0	8	0	0.01	1.63	99.84
2.D.3 Other non-energy products from fuels and solvent use	CO_2	19	19	7	0	1	0	0.01	0.19	99.85
1.A.1 Energy industries - Solid Fuels	CH_4	13	13	50	0	7	0	0.01	1.36	99.87
2.C.5 Lead Production	CO_2	9	9	51	0	5	0	0.01	1.38	99.88
2.C.1 Iron and Steel Production	CH_4	11	11	31	0	3	0	0.01	0.84	99.89
1.A.3.d Transport - Domestic navigation	CO_2	13	13	5	0	1	0	0.01	0.14	99.90
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	8	8	50	0	4	0	0.01	1.36	99.90
1.A.5.b Other mobile - Liquid Fuels	N_2O	7	7	60	0	4	0	0.01	1.63	99.91
1.A.3.a Transport - Civil Aviation	CO_2	10	10	6	0	1	0	0.01	0.15	99.92
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	6	6	61	0	4	0	0.00	1.65	99.93
2.F.2 Foam Blowing (CO_2 eq.)	HFC	6	6	42	0	3	0	0.00	1.14	99.93
2.D.2 Paraffin Wax Use	CO_2	6	6	50	0	3	0	0.00	1.36	99.94
1.B.2.a Oil	CH_4	5	5	75	0	4	0	0.00	2.04	99.94
1.B.1.b Solid Fuel Transformation	CH_4	5	5	64	0	3	0	0.00	1.74	99.95
1.B.2.c Venting and Flaring	CO_2	5	5	50	0	2	0	0.00	1.37	99.95
1.A.4 Other sectors - Gaseous Fuels	N_2O	4	4	60	0	2	0	0.00	1.63	99.96
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	4	4	51	0	2	0	0.00	1.38	99.96
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3	3	73	0	2	0	0.00	1.98	99.97
2.F.4 Aerosols (CO_2 eq.)	HFC	4	4	42	0	2	0	0.00	1.14	99.97
2.C.2 Ferroalloys Production	CH_4	4	4	25	0	1	0	0.00	0.69	99.97
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	4	4	44	0	2	0	0.00	1.18	99.98
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3	3	60	0	2	0	0.00	1.63	99.98
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	4	4	15	0	1	0	0.00	0.42	99.98
5.C Incineration and open burning of waste	N_2O	2	2	73	0	2	0	0.00	1.98	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2	2	50	0	1	0	0.00	1.36	99.99
1.A.4 Other sectors - Liquid Fuels	CH_4	2	2	50	0	1	0	0.00	1.36	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2	2	54	0	1	0	0.00	1.46	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	2	2	60	0	1	0	0.00	1.63	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	2	2	42	0	1	0	0.00	1.14	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1	1	50	0	1	0	0.00	1.36	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	1	1	44	0	0	0	0.00	1.18	100.00
1.A.3.c Transport - Railways	CH_4	0	0	158	0	1	0	0.00	4.28	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	1	1	60	0	0	0	0.00	1.63	100.00
2.C.6 Zinc Production	CO_2	1	1	51	0	0	0	0.00	1.38	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	1	1	50	0	0	0	0.00	1.36	100.00
2.C.2 Ferroalloys Production	CO_2	1	1	25	0	0	0	0.00	0.69	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0	0	60	0	0	0	0.00	1.63	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0	0	50	0	0	0	0.00	1.36	100.00

1.A.1 Energy industries - Liquid Fuels	CH_4	0	0	50	0	0	0	0.00	1.36	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0	0	137	0	0	0	0.00	3.73	100.00
1.A.3.a Transport - Civil Aviation	N_2O	0	0	110	0	0	0	0.00	2.99	100.00
1.B.2.b Natural Gas	CO_2	0	0	75	0	0	0	0.00	2.04	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0	0	5	0	0	0	0.00	0.14	100.00
1.B.2.a Oil	CO_2	0	0	75	0	0	0	0.00	2.04	100.00
1.A.3.e Transport - Other Transportation	N_2O	0	0	60	0	0	0	0.00	1.63	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0	0	42	0	0	0	0.00	1.14	100.00
1.A.3.e Transport - Other Transportation	CH_4	0	0	50	0	0	0	0.00	1.36	100.00
5.C Incineration and open burning of waste	CH_4	0	0	82	0	0	0	0.00	2.24	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0	0	79	0	0	0	0.00	2.13	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0	0	15	0	0	0	0.00	0.42	0.00

Tab. A1- 9 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2016 – Trend Assessment including LULUCF

IPCC Source Categories	GHG	Base Year Estimate (Abs)	Current Year Estimate (Abs)	Combined Uncertainty	TA_A1	Uncertain ammount BY	Uncertain ammount CY	BY uncertain total	CY uncertain total	Level A 2 assessment	Trend A2 Assessment	% contribution to Trend	Cumulative fraction of uncertainty (BY)	Cumulative Total (TA)
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35636	3270	5	17	1782	164	37417	3434	2	23	19	1.24	19.01
1.A.1 Energy industries - Solid Fuels	CO_2	53720	50569	5	13	2686	2528	56406	53098	38	16	14	20.37	32.60
1.A.3.b Transport - Road transportation	CO_2	6177	17670	5	11	307	879	6484	18549	13	15	13	27.02	45.13
1.A.4 Other sectors - Solid Fuels	CO_2	24005	3825	5	10	1200	191	25205	4016	3	14	11	28.46	56.43
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	9609	310	6	5	560	18	10169	328	0	7	6	28.60	62.13
1.A.4 Other sectors - Gaseous Fuels	CO_2	4174	7473	4	4	163	292	4337	7765	6	5	4	30.81	66.42
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0	3302	44	0	0	1439	0	4740	3	5	4	41.69	70.60
1.B.1.a Coal Mining and Handling	CH_4	10322	3260	14	3	1404	443	11726	3703	3	4	4	45.05	74.24
5.B Biological treatment of solid waste	N_2O	0	3386	5	3	0	171	0	3557	3	4	3	46.34	77.38
5.A Solid Waste Disposal on Land	CH_4	1979	3366	64	3	1261	2144	3240	5510	4	4	3	62.56	80.32
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336	2955	4	2	52	115	1388	3070	2	2	2	63.43	82.21
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5686	5269	4	1	222	206	5908	5475	4	2	1	64.99	83.56
4.A.1 Forest Land remaining Forest Land	CO_2	-4818	-4186	42	2	-2006	-1743	-6824	-5929	-4	1	1	51.80	84.77
1.A.4 Other sectors - Liquid Fuels	CO_2	4010	1230	6	1	234	72	4244	1301	1	2	1	52.34	86.12
2.C.1 Iron and Steel Production	CO_2	9643	7287	12	8	1177	889	10820	8176	6	1	1	59.07	86.96
5.B Biological treatment of solid waste	CH_4	0	675	91	1	0	616	0	1291	1	1	1	63.74	88.09
4.G Harvested wood products	CO_2	-1713	-431	62	0	-1062	-267	-2775	-698	0	1	1	61.72	89.11
1.A.4 Other sectors - Solid Fuels	CH_4	1332	296	50	0	668	149	2000	445	0	1	1	62.84	89.90
3.A Enteric Fermentation	CH_4	5755	2957	16	1	910	468	6665	3425	2	1	1	66.38	90.80
3.G Liming	CO_2	1188	168	30	1	361	51	1549	219	0	1	1	66.77	91.52
1.A.3.b Transport - Road transportation	N_2O	137	363	134	0	183	486	320	849	1	1	1	70.44	92.08
1.A.1 Energy industries - Liquid Fuels	CO_2	1575	389	6	1	92	23	1666	412	0	1	1	70.61	92.70
1.A.4 Other	CH_4	324	569	51	0	164	288	488	857	1	1	0	72.79	93.17

sectors - Biomass													
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0	453	18	0	0	82	0	535	0	1	0	73.41	93.64
5.D Wastewater treatment and discharge	CH_4	890	882	58	1	519	515	1409	1396	1	0	0	77.30	94.04
2.B.2 Nitric Acid Production	N_2O	1050	280	16	0	163	43	1213	324	0	1	0	77.63	94.47
3.B Manure Management	CH_4	1716	741	22	0	384	166	2100	907	1	1	0	78.89	94.91
4.C.1 Grassland remaining Grassland	CO_2	0	-279	45	0	0	-127	0	-406	0	0	0	77.93	95.27
4.A.2 Land converted to Forest Land	CO_2	-327	-503	32	0	-106	-163	-433	-666	0	0	0	76.70	95.60
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24	250	28	0	7	71	31	320	0	0	0	77.23	95.86
2.A.4 Other process uses of carbonates	CO_2	118	341	11	0	13	38	131	379	0	0	0	77.52	96.12
1.A.5.b Other mobile - Liquid Fuels	CO_2	0	277	6	0	0	16	0	293	0	0	0	77.64	96.38
2.B.8 Petrochemical and Carbon Black Production	CO_2	792	303	40	1	319	122	1112	425	0	0	0	78.56	96.66
3.B Manure Management	N_2O	1620	839	40	1	653	338	2273	1177	1	0	0	81.12	96.96
2.B.10 Other chemical industry	CO_2	0	234	4	0	0	9	0	243	0	0	0	81.19	97.17
3.H Urea application	CO_2	109	211	52	0	57	110	165	321	0	0	0	82.02	97.36
2.A.2 Lime Production	CO_2	1337	640	3	1	38	18	1374	658	0	0	0	82.16	97.59
1.B.1.a Coal Mining and Handling	CO_2	456	156	25	0	116	40	572	196	0	0	0	82.46	97.75
1.B.2.b Natural Gas	CH_4	1045	571	75	1	787	430	1832	1002	1	0	0	85.72	97.95
1.A.3.c Transport - Railways	CO_2	654	274	5	0	34	14	688	288	0	0	0	85.82	98.10
4.E.2 Land converted to Settlements	CO_2	86	124	102	0	88	127	175	251	0	0	0	86.78	98.22
2.G.3 N_2O from product uses	N_2O	206	224	44	0	90	97	296	321	0	0	0	87.52	98.32
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	153	14	60	0	92	8	245	22	0	0	0	87.58	98.45
5.C Incineration and open burning of waste	CO_2	23	126	16	0	4	20	27	146	0	0	0	87.74	98.56
2.A.1 Cement Production	CO_2	2489	1698	3	1	70	48	2560	1746	1	0	0	88.10	98.59
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4192	2757	21	4	864	568	5056	3326	2	0	0	92.40	98.64
4.C.2 Land converted to Grassland	CO_2	-145	-183	31	0	-45	-57	-190	-240	0	0	0	91.97	98.74
1.A.1 Energy industries - Solid Fuels	N_2O	240	221	60	0	144	133	384	354	0	0	0	92.97	98.83
4.B.1 Cropland remaining Cropland	CO_2	-2	-87	29	0	-1	-26	-3	-113	0	0	0	92.78	98.92
1.A.4 Other sectors - Biomass	N_2O	51	90	61	0	31	55	83	145	0	0	0	93.19	99.00
1.A.3.a Transport - Civil Aviation	CO_2	139	10	6	0	8	1	147	11	0	0	0	93.20	99.08
5.D Wastewater treatment and discharge	N_2O	234	198	56	0	132	111	366	309	0	0	0	94.04	99.14

1.A.4 Other sectors - Solid Fuels	N_2O	103	18	60	0	62	11	165	29	0	0	0	94.12	99.21
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	86	8	50	0	43	4	129	12	0	0	0	94.15	99.27
2.B.1 Ammonia Production	CO_2	991	686	9	1	85	59	1076	745	1	0	0	94.60	99.30
2.A.3 Glass Production	CO_2	124	138	5	0	7	7	130	145	0	0	0	94.65	99.35
2.D.1 Lubricant Use	CO_2	116	115	50	0	58	58	174	173	0	0	0	95.09	99.40
1.A.3.e Transport - Other Transportation	CO_2	5	61	5	0	0	3	6	64	0	0	0	95.11	99.45
1.A.1 Energy industries - Biomass	N_2O	0	27	61	0	0	16	1	43	0	0	0	95.24	99.49
1.A.2 Manufacturing industries and construction - Biomass	N_2O	17	35	61	0	10	21	27	56	0	0	0	95.40	99.52
1.A.3.c Transport - Railways	N_2O	75	31	137	0	103	43	178	75	0	0	0	95.72	99.56
2.F.3 Fire Protection (CO_2 eq.)	HFC	0	24	42	0	0	10	0	34	0	0	0	95.80	99.59
1.B.2.c Venting and Flaring	CH_4	12	29	50	0	6	15	18	44	0	0	0	95.91	99.62
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	75	67	40	0	30	27	105	93	0	0	0	96.11	99.64
1.A.1 Energy industries - Biomass	CH_4	0	17	51	0	0	8	0	25	0	0	0	96.18	99.66
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84	70	44	0	37	31	121	101	0	0	0	96.41	99.68
1.A.3.d Transport - Domestic navigation	CO_2	57	13	5	0	3	1	60	13	0	0	0	96.42	99.70
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10	22	51	0	5	11	16	33	0	0	0	96.50	99.72
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	23	1	60	0	14	0	36	1	0	0	0	96.50	99.74
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0	19	7	0	0	1	0	20	0	0	0	96.51	99.76
4.D.2. Land converted to Wetlands	CO_2	21	25	69	0	15	17	36	42	0	0	0	96.64	99.78
1.B.2.a Oil	CH_4	23	5	75	0	17	4	40	8	0	0	0	96.67	99.79
1.A.4 Other sectors - Gaseous Fuels	CH_4	10	17	50	0	5	8	14	25	0	0	0	96.74	99.81
4.B.2 Land converted to Cropland	CO_2	114	84	37	0	42	31	156	115	0	0	0	96.97	99.82
1.A.4 Other sectors - Liquid Fuels	N_2O	22	22	60	0	14	13	36	35	0	0	0	97.07	99.83
1.A.5.b Other mobile - Liquid Fuels	N_2O	0	7	60	0	0	4	0	11	0	0	0	97.10	99.84
2.C.5 Lead Production	CO_2	4	9	51	0	2	5	6	14	0	0	0	97.13	99.84
1.A.2 Manufacturing industries and construction -	N_2O	0	6	61	0	0	4	0	10	0	0	0	97.16	99.85

Other Fossil Fuels													
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0	6	42	0	0	3	0	9	0	0	0	97.18	99.86
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	10	0	50	0	5	0	14	0	0	0	0	97.18	99.87
1.A.3.b Transport - Road transportation	CH_4	38	27	157	0	59	42	97	69	0	0	0	97.50	99.87
4.A.1 Forest Land remaining Forest Land	CH_4	44	33	46	0	20	15	65	48	0	0	0	97.62	99.88
1.B.1.b Solid Fuel Transformation	CH_4	1	5	64	0	0	3	1	7	0	0	0	97.64	99.88
1.A.4 Other sectors - Liquid Fuels	CH_4	11	2	50	0	5	1	16	4	0	0	0	97.65	99.89
1.A.1 Energy industries - Solid Fuels	CH_4	14	13	50	0	7	7	21	20	0	0	0	97.70	99.89
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0	4	51	0	0	2	0	6	0	0	0	97.71	99.90
2.F.4 Aerosols (CO_2 eq.)	HFC	0	4	42	0	0	2	0	5	0	0	0	97.72	99.90
1.B.2.c Venting and Flaring	CO_2	2	5	50	0	1	2	3	7	0	0	0	97.74	99.91
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0	3	73	0	0	2	1	6	0	0	0	97.76	99.91
2.C.2 Ferroalloys Production	CH_4	0	4	25	0	0	1	0	5	0	0	0	97.77	99.92
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0	3	44	0	0	1	0	5	0	0	0	97.78	99.92
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0	4	15	0	0	1	0	4	0	0	0	97.78	99.92
1.A.4 Other sectors - Gaseous Fuels	N_2O	2	4	60	0	1	2	4	6	0	0	0	97.80	99.93
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1325	842	30	0	403	256	1728	1098	1	0	0	99.74	99.98
4.B.2. Land converted to Cropland	N_2O	9	5	282	0	25	13	34	18	0	0	0	99.84	99.98
5.C Incineration and open burning of waste	N_2O	0	2	73	0	0	2	1	4	0	0	0	99.85	99.99
4.A.1 Forest Land remaining Forest Land	N_2O	38	26	46	0	18	12	56	39	0	0	0	99.94	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0	2	54	0	0	1	0	3	0	0	0	99.95	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	3	0	60	0	2	0	6	1	0	0	0	99.95	99.99
2.F.5 Solvents (CO_2 eq.)	HFC	0	2	42	0	0	1	0	2	0	0	0	99.96	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	1	2	60	0	0	1	1	3	0	0	0	99.97	100.00
2.C.1 Iron and Steel Production	CH_4	15	11	31	0	5	3	19	14	0	0	0	99.99	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0	1	44	0	0	0	0	1	0	0	0	99.99	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1	1	50	0	0	1	1	2	0	0	0	100	100
1.A.3.a Transport	N_2O	1	0	110	0	1	0	2	0	0	0	0	100	100

- Civil Aviation														
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3	3	60	0	2	2	5	5	0	0	0	100	100
2.B.8 Petrochemical and Carbon Black Production	CH_4	36	22	40	0	15	9	51	31	0	0	0	100	100
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	3	2	50	0	1	1	4	4	0	0	0	100	100
1.A.1 Energy industries - Liquid Fuels	CH_4	1	0	50	0	1	0	2	0	0	0	0	100	100
2.C.6 Zinc Production	CO_2	0	1	51	0	0	0	0	1	0	0	0	100	100
1.A.5.b Other mobile - Liquid Fuels	CH_4	0	1	50	0	0	0	0	1	0	0	0	100	100
2.C.2 Ferroalloys Production	CO_2	0	1	25	0	0	0	0	1	0	0	0	100	100
1.A.3.c Transport - Railways	CH_4	1	0	158	0	1	1	2	1	0	0	0	100	100
1.A.3.d Transport - Domestic navigation	N_2O	0	0	137	0	1	0	1	0	0	0	0	100	100
2.D.2 Paraffin Wax Use	CO_2	9	6	50	0	5	3	14	9	0	0	0	100	100
1.A.3.d Transport - Domestic navigation	CH_4	0	0	5	0	0	0	0	0	0	0	0	100	100
1.A.3.e Transport - Other Transportation	N_2O	0	0	60	0	0	0	0	0	0	0	0	100	100
1.B.2.a Oil	CO_2	0	0	75	0	0	0	0	0	0	0	0	100	100
2.F.3 Fire Protection (CO_2 eq.)	PFC	0	0	42	0	0	0	0	0	0	0	0	100	100
1.A.3.e Transport - Other Transportation	CH_4	0	0	50	0	0	0	0	0	0	0	0	100	100
1.B.2.b Natural Gas	CO_2	0	0	75	0	0	0	0	0	0	0	0	100	100
1.A.3.a Transport - Civil Aviation	CH_4	0	0	79	0	0	0	0	0	0	0	0	100	100
5.C Incineration and open burning of waste	CH_4	0	0	82	0	0	0	0	0	0	0	0	100	100
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0	0	15	0	0	0	0	0	0	0	0	100	100

Tab. A1- 10 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2016 – Trend Assessment excluding LULUCF

IPCC Source Categories	GHG	Base Year Estimate (Abs)	Current Year Estimate (Abs)	Combined Uncertainty	TA_A1	Uncertain ammount BY	Uncertain ammount CY	BY uncertain total	CY uncertain total	Level A 2 assessment	Trend A2 Assessment	% contribution to Trend	Cumulative fraction of uncertainty (BY)	Cumulative Total (TA)
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.6	3270.1	5.0	16.6	1781.8	163.5	37417.3	3433.6	2.3	21.8	19.8	1.1	19.8
1.A.1 Energy industries - Solid Fuels	CO_2	53719.8	50569.2	5.0	13.2	2686.0	2528.5	56405.7	53097.7	35.8	15.2	13.8	17.5	33.6
1.A.3.b Transport - Road transportation	CO_2	6176.5	17670.1	5.0	11.4	307.3	879.0	6483.8	18549.1	12.5	14.2	12.9	23.2	46.5
1.A.4 Other sectors - Solid Fuels	CO_2	24005.0	3824.9	5.0	9.8	1200.3	191.2	25205.3	4016.2	2.7	13.0	11.8	24.4	58.3
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	9609.1	309.9	5.8	5.0	560.3	18.1	10169.4	327.9	0.2	6.5	5.9	24.5	64.2
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.9	7473.0	3.9	4.0	163.0	291.8	4336.9	7764.9	5.2	4.9	4.4	26.4	68.7
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.0	3301.9	43.6	0.0	0.0	1438.5	0.0	4740.4	3.2	4.8	4.3	35.8	73.0
1.B.1.a Coal Mining and Handling	CH_4	10322.4	3259.7	13.6	2.9	1404.0	443.4	11726.4	3703.0	2.5	4.2	3.8	38.7	76.8
5.B Biological treatment of solid waste	N_2O	0.0	3386.4	5.0	2.8	0.0	170.5	0.0	3556.9	2.4	3.6	3.2	39.8	80.0
5.A Solid Waste Disposal on Land	CH_4	1979.3	3366.0	63.7	2.8	1260.8	2144.1	3240.1	5510.2	3.7	3.3	3.0	53.7	83.1
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.0	2954.7	3.9	1.7	52.2	115.4	1388.2	3070.1	2.1	2.1	1.9	54.4	85.0
1.A.4 Other sectors - Liquid Fuels	CO_2	4009.8	1229.7	5.8	1.1	233.8	71.7	4243.6	1301.4	0.9	1.6	1.4	54.9	86.4
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.7	5268.9	3.9	1.3	222.0	205.8	5907.7	5474.6	3.7	1.5	1.4	56.2	87.8
5.B Biological treatment of solid waste	CH_4	0.0	675.1	91.3	0.6	0.0	616.3	0.0	1291.3	0.9	1.3	1.2	60.2	89.0
3.A Enteric Fermentation	CH_4	5754.9	2957.5	15.8	0.6	909.9	467.6	6664.8	3425.1	2.3	1.1	1.0	63.3	89.9
1.A.4 Other sectors - Solid Fuels	CH_4	1331.9	296.4	50.2	0.5	668.1	148.7	1999.9	445.1	0.3	0.9	0.8	64.2	90.7
2.C.1 Iron and Steel Production	CO_2	9642.5	7286.7	12.2	8.1	1177.0	889.5	10819.6	8176.1	5.5	0.9	0.8	70.0	91.6
3.G Liming	CO_2	1187.6	168.0	30.4	0.5	361.2	51.1	1548.8	219.1	0.1	0.8	0.7	70.4	92.3
1.A.1 Energy industries - Liquid Fuels	CO_2	1574.6	389.0	5.8	0.5	91.8	22.7	1666.4	411.7	0.3	0.7	0.6	70.5	93.0
1.A.3.b Transport - Road transportation	N_2O	136.7	363.2	133.8	0.3	182.9	485.9	319.6	849.1	0.6	0.6	0.6	73.7	93.5
1.A.2	CO_2	0.0	453.1	18.0	0.0	0.0	81.7	0.0	534.8	0.4	0.5	0.5	74.2	94.0

Manufacturing industries and construction - Other Fossil Fuels													
1.A.4 Other sectors - Biomass	CH_4	324.3	568.9	50.6	0.3	164.2	288.0	488.4	856.9	0.6	0.5	0.5	76.1	94.5
3.B Manure Management	CH_4	1716.0	741.2	22.4	0.3	383.7	165.7	2099.7	907.0	0.6	0.5	0.5	77.1	95.0
2.B.2 Nitric Acid Production	N_2O	1050.3	280.1	15.5	0.2	163.0	43.5	1213.3	323.6	0.2	0.5	0.4	77.4	95.4
5.D Wastewater treatment and discharge	CH_4	889.8	881.6	58.4	0.7	519.5	514.7	1409.3	1396.3	0.9	0.4	0.4	80.8	95.8
3.B Manure Management	N_2O	1619.9	838.9	40.3	1.4	653.0	338.2	2272.9	1177.1	0.8	0.4	0.3	83.0	96.1
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.5	302.8	40.3	0.7	319.5	122.1	1111.9	424.9	0.3	0.3	0.3	83.7	96.4
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.0	249.6	28.3	0.2	6.8	70.6	30.8	320.2	0.2	0.3	0.3	84.2	96.7
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.0	277.1	5.8	0.0	0.0	16.2	0.0	293.3	0.2	0.3	0.3	84.3	97.0
2.A.4 Other process uses of carbonates	CO_2	117.9	340.6	11.2	0.3	13.2	38.1	131.1	378.7	0.3	0.3	0.3	84.6	97.2
2.A.2 Lime Production	CO_2	1336.6	639.8	2.8	0.5	37.8	18.1	1374.5	657.9	0.4	0.3	0.2	84.7	97.5
2.B.10 Other chemical industry	CO_2	0.0	233.6	3.9	0.0	0.0	9.1	0.0	242.7	0.2	0.2	0.2	84.7	97.7
1.B.2.b Natural Gas	CH_4	1044.9	571.2	75.3	0.9	787.1	430.3	1832.0	1001.5	0.7	0.2	0.2	87.5	97.9
3.H Urea application	CO_2	108.5	210.8	52.2	0.1	56.7	110.0	165.2	320.8	0.2	0.2	0.2	88.2	98.1
1.B.1.a Coal Mining and Handling	CO_2	456.2	156.5	25.3	0.1	115.5	39.6	571.8	196.1	0.1	0.2	0.2	88.5	98.3
1.A.3.c Transport - Railways	CO_2	653.9	273.7	5.2	0.2	34.1	14.3	688.0	288.0	0.2	0.2	0.2	88.6	98.4
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.9	14.0	60.1	0.1	91.9	8.4	244.8	22.4	0.0	0.1	0.1	88.6	98.6
5.C Incineration and open burning of waste	CO_2	23.1	126.3	15.8	0.1	3.7	20.0	26.8	146.3	0.1	0.1	0.1	88.8	98.7
2.G.3 N_2O from product uses	N_2O	206.2	223.5	43.6	0.2	89.8	97.4	296.1	320.9	0.2	0.1	0.1	89.4	98.8
1.A.1 Energy industries - Solid Fuels	N_2O	239.9	221.3	60.1	0.1	144.2	133.1	384.1	354.3	0.2	0.1	0.1	90.3	98.9
1.A.4 Other sectors - Biomass	N_2O	51.5	90.3	60.5	0.0	31.2	54.6	82.7	144.9	0.1	0.1	0.1	90.6	99.0
1.A.3.a Transport - Civil Aviation	CO_2	139.4	10.0	5.6	0.1	7.8	0.6	147.3	10.6	0.0	0.1	0.1	90.6	99.0
1.A.4 Other sectors - Solid Fuels	N_2O	103.3	18.1	60.1	0.0	62.1	10.9	165.4	29.0	0.0	0.1	0.1	90.7	99.1
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4192.2	2757.2	20.6	3.5	864.2	568.4	5056.5	3325.6	2.2	0.1	0.1	94.4	99.2
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.7	7.9	50.2	0.0	43.0	3.9	128.8	11.8	0.0	0.1	0.1	94.4	99.3

3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1325.2	841.9	30.4	0.0	403.0	256.1	1728.3	1098.0	0.7	0.1	0.1	96.1	99.3
5.D Wastewater treatment and discharge	N_2O	234.2	197.6	56.4	0.2	132.0	111.3	366.2	308.9	0.2	0.1	0.1	96.8	99.4
1.A.3.e Transport - Other Transportation	CO_2	5.4	61.0	5.0	0.0	0.3	3.0	5.7	64.0	0.0	0.1	0.1	96.8	99.4
2.A.3 Glass Production	CO_2	123.7	138.1	5.4	0.1	6.7	7.4	130.3	145.5	0.1	0.1	0.1	96.9	99.5
2.D.1 Lubricant Use	CO_2	116.1	115.0	50.2	0.0	58.4	57.8	174.5	172.7	0.1	0.1	0.1	97.2	99.5
1.A.3.c Transport - Railways	N_2O	75.2	31.5	137.3	0.0	103.2	43.2	178.4	74.7	0.1	0.0	0.0	97.5	99.6
1.A.1 Energy industries - Biomass	N_2O	0.5	26.6	60.5	0.0	0.3	16.1	0.8	42.7	0.0	0.0	0.0	97.6	99.6
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.6	35.1	60.5	0.0	10.1	21.2	26.7	56.3	0.0	0.0	0.0	97.8	99.6
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.0	23.7	41.9	0.0	0.0	9.9	0.0	33.7	0.0	0.0	0.0	97.8	99.7
1.B.2.c Venting and Flaring	CH_4	12.3	29.3	50.5	0.0	6.2	14.8	18.5	44.0	0.0	0.0	0.0	97.9	99.7
1.A.3.d Transport - Domestic navigation	CO_2	56.6	12.7	5.2	0.0	3.0	0.7	59.6	13.4	0.0	0.0	0.0	97.9	99.7
1.A.1 Energy industries - Biomass	CH_4	0.3	16.7	50.6	0.0	0.2	8.5	0.5	25.2	0.0	0.0	0.0	98.0	99.8
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	22.7	0.6	60.2	0.0	13.7	0.3	36.4	0.9	0.0	0.0	0.0	98.0	99.8
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.4	22.2	50.6	0.0	5.3	11.2	15.7	33.4	0.0	0.0	0.0	98.1	99.8
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.0	18.9	7.1	0.0	0.0	1.3	0.0	20.2	0.0	0.0	0.0	98.1	99.8
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.1	70.4	43.6	0.0	36.6	30.7	120.7	101.1	0.1	0.0	0.0	98.3	99.8
1.B.2.a Oil	CH_4	22.7	4.8	75.3	0.0	17.1	3.6	39.8	8.4	0.0	0.0	0.0	98.3	99.8
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.6	16.9	50.1	0.0	4.8	8.4	14.4	25.3	0.0	0.0	0.0	98.3	99.9
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.0	6.9	60.2	0.0	0.0	4.2	0.0	11.1	0.0	0.0	0.0	98.4	99.9
1.A.4 Other sectors - Liquid Fuels	N_2O	22.5	21.7	60.2	0.0	13.5	13.1	36.0	34.8	0.0	0.0	0.0	98.5	99.9
2.C.5 Lead Production	CO_2	4.0	9.3	51.0	0.0	2.1	4.7	6.1	14.0	0.0	0.0	0.0	98.5	99.9
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.0	6.0	60.8	0.0	0.0	3.7	0.0	9.7	0.0	0.0	0.0	98.5	99.9
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	9.5	0.2	50.2	0.0	4.8	0.1	14.3	0.4	0.0	0.0	0.0	98.5	99.9
2.F.2 Foam Blowing (CO_2	HFC	0.0	6.3	41.9	0.0	0.0	2.7	0.0	9.0	0.0	0.0	0.0	98.5	99.9

eq.)														
1.A.4 Other sectors - Liquid Fuels	CH_4	10.6	2.3	50.2	0.0	5.3	1.2	15.9	3.5	0.0	0.0	0.0	98.5	99.9
1.A.3.b Transport - Road transportation	CH_4	37.5	26.9	157.5	0.0	59.1	42.4	96.6	69.3	0.0	0.0	0.0	98.8	99.9
1.B.1.b Solid Fuel Transformation	CH_4	0.8	4.5	64.0	0.0	0.5	2.9	1.2	7.4	0.0	0.0	0.0	98.8	99.9
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.0	3.8	51.0	0.0	0.0	1.9	0.0	5.7	0.0	0.0	0.0	98.8	99.9
1.A.1 Energy industries - Solid Fuels	CH_4	14.0	13.0	50.2	0.0	7.0	6.5	21.1	19.5	0.0	0.0	0.0	98.9	99.9
2.F.4 Aerosols (CO_2 eq.)	HFC	0.0	3.8	41.9	0.0	0.0	1.6	0.0	5.3	0.0	0.0	0.0	98.9	99.9
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.3	3.2	72.8	0.0	0.2	2.4	0.5	5.6	0.0	0.0	0.0	98.9	100.0
1.B.2.c Venting and Flaring	CO_2	2.0	4.8	50.5	0.0	1.0	2.4	3.0	7.2	0.0	0.0	0.0	98.9	100.0
2.C.2 Ferroalloys Production	CH_4	0.2	3.9	25.5	0.0	0.0	1.0	0.2	4.9	0.0	0.0	0.0	98.9	100.0
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.0	3.2	43.6	0.0	0.0	1.4	0.0	4.6	0.0	0.0	0.0	98.9	100.0
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.0	3.8	15.3	0.0	0.0	0.6	0.0	4.4	0.0	0.0	0.0	98.9	100.0
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.3	4.0	60.1	0.0	1.4	2.4	3.7	6.4	0.0	0.0	0.0	99.0	100.0
5.C Incineration and open burning of waste	N_2O	0.4	2.3	72.8	0.0	0.3	1.7	0.7	4.0	0.0	0.0	0.0	99.0	100.0
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.2	22.1	40.3	0.0	14.6	8.9	50.7	31.0	0.0	0.0	0.0	99.0	100.0
1.A.1 Energy industries - Liquid Fuels	N_2O	3.5	0.4	60.2	0.0	2.1	0.2	5.5	0.7	0.0	0.0	0.0	99.0	100.0
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.2	2.0	53.9	0.0	0.1	1.1	0.3	3.1	0.0	0.0	0.0	99.0	100.0
2.F.5 Solvents (CO_2 eq.)	HFC	0.0	1.6	41.9	0.0	0.0	0.7	0.0	2.3	0.0	0.0	0.0	99.0	100.0
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.7	1.6	60.1	0.0	0.4	1.0	1.2	2.5	0.0	0.0	0.0	99.1	100.0
1.A.3.a Transport - Civil Aviation	N_2O	1.2	0.1	110.1	0.0	1.3	0.1	2.5	0.2	0.0	0.0	0.0	99.1	100.0
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.0	1.0	43.6	0.0	0.0	0.4	0.0	1.4	0.0	0.0	0.0	99.1	100.0
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.6	1.3	50.1	0.0	0.3	0.7	0.9	2.0	0.0	0.0	0.0	99.1	100.0
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.1	2.8	60.1	0.0	1.9	1.7	5.0	4.5	0.0	0.0	0.0	99.1	100.0

1.A.1 Energy industries - Liquid Fuels	CH_4	1.5	0.2	50.2	0.0	0.7	0.1	2.2	0.4	0.0	0.0	0.0	99.1	100.0
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.6	2.4	50.1	0.0	1.3	1.2	3.9	3.6	0.0	0.0	0.0	99.1	100.0
2.C.6 Zinc Production	CO_2	0.0	0.6	51.0	0.0	0.0	0.3	0.0	0.9	0.0	0.0	0.0	99.1	100.0
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.0	0.5	50.2	0.0	0.0	0.3	0.0	0.8	0.0	0.0	0.0	99.1	100.0
2.C.1 Iron and Steel Production	CH_4	14.8	10.5	30.8	0.0	4.6	3.2	19.4	13.8	0.0	0.0	0.0	99.1	100.0
2.C.2 Ferroalloys Production	CO_2	0.0	0.6	25.5	0.0	0.0	0.1	0.0	0.7	0.0	0.0	0.0	99.1	100.0
2.D.2 Paraffin Wax Use	CO_2	9.4	5.9	50.2	0.0	4.7	3.0	14.2	8.9	0.0	0.0	0.0	99.1	100.0
1.A.3.c Transport - Railways	CH_4	0.9	0.4	157.5	0.0	1.4	0.6	2.4	1.0	0.0	0.0	0.0	99.1	100.0
1.A.3.d Transport - Domestic navigation	N_2O	0.5	0.1	137.3	0.0	0.6	0.1	1.1	0.2	0.0	0.0	0.0	99.1	100.0
1.A.3.d Transport - Domestic navigation	CH_4	0.1	0.0	5.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	99.1	100.0
1.A.3.e Transport - Other Transportation	N_2O	0.0	0.0	60.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	99.1	100.0
1.B.2.a Oil	CO_2	0.0	0.0	75.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	99.1	100.0
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.0	0.0	41.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.1	100.0
1.A.3.e Transport - Other Transportation	CH_4	0.0	0.0	50.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.1	100.0
1.B.2.b Natural Gas	CO_2	0.2	0.1	75.3	0.0	0.1	0.1	0.3	0.2	0.0	0.0	0.0	99.1	100.0
1.A.3.a Transport - Civil Aviation	CH_4	0.0	0.0	78.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.1	100.0
5.C Incineration and open burning of waste	CH_4	0.0	0.0	82.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.1	100.0
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.0	0.0	15.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.1	100.0
2.A.1 Cement Production	CO_2	2489.2	1697.6	2.8	1.4	70.4	48.0	2559.6	1745.6	1.2	0.0	0.0	99.4	100.0
2.B.1 Ammonia Production	CO_2	990.8	685.7	8.6	0.6	85.2	59.0	1076.0	744.7	0.5	0.0	0.0	99.8	100.0
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.5	66.6	40.3	0.1	30.0	26.8	104.5	93.4	0.1	0.0	0.0	100.0	100.0

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.1 Energy industries - Solid Fuels	CO_2	53719.76	50569.21	4.00	4.00
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	13.01	4.00	4.00
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	221.27	4.00	4.00
1.A.1 Energy industries - Liquid Fuels	CO_2	1574.60	389.04	5.00	5.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.48	0.24	5.00	5.00
1.A.1 Energy industries - Liquid Fuels	N_2O	3.46	0.41	5.00	5.00
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.04	2954.74	3.00	3.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	1.33	3.00	3.00
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	1.59	3.00	3.00
1.A.1 Energy industries - Biomass	CH_4	0.30	16.75	8.00	8.00
1.A.1 Energy industries - Biomass	N_2O	0.48	26.60	8.00	8.00
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	249.61	20.00	20.00
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	2.04	20.00	20.00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	3.24	20.00	20.00
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	3270.08	4.00	4.00
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	7.87	4.00	4.00
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	14.01	4.00	4.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	9609.14	309.88	5.00	5.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	9.54	0.25	5.00	5.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	22.75	0.55	5.00	5.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.66	5268.87	3.00	3.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.38	3.00	3.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	2.83	3.00	3.00
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	22.17	8.00	8.00
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	35.06	8.00	8.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.00	453.14	10.00	10.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.00	3.79	10.00	10.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.00	6.03	10.00	10.00
1.A.3.a Transport - Civil Aviation	CO_2	139.44	10.01	4.00	4.00
1.A.3.a Transport - Civil Aviation	CH_4	0.02	0.00	4.00	4.00
1.A.3.a Transport - Civil Aviation	N_2O	1.19	0.09	4.00	4.00
1.A.3.b Transport - Road transportation	CO_2	6176.54	17670.12	3.00	3.00
1.A.3.b Transport - Road transportation	CH_4	37.50	26.91	3.00	3.00
1.A.3.b Transport - Road transportation	N_2O	136.73	363.18	3.00	3.00
1.A.3.c Transport - Railways	CO_2	653.86	273.75	5.00	5.00
1.A.3.c Transport - Railways	CH_4	0.92	0.38	5.00	5.00
1.A.3.c Transport - Railways	N_2O	75.21	31.49	5.00	5.00
1.A.3.d Transport - Domestic navigation	CO_2	56.61	12.73	5.00	5.00
1.A.3.d Transport - Domestic navigation	CH_4	0.13	0.03	5.00	5.00

1.A.3.d Transport - Domestic navigation	N_2O	0.46	0.10	5.00	5.00
1.A.3.e Transport - Other Transportation	CO_2	5.42	60.98	4.00	4.00
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.03	4.00	4.00
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.03	4.00	4.00
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	3824.92	4.00	4.00
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	296.39	4.00	4.00
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	18.11	4.00	4.00
1.A.4 Other sectors - Liquid Fuels	CO_2	4009.76	1229.70	5.00	5.00
1.A.4 Other sectors - Liquid Fuels	CH_4	10.56	2.34	5.00	5.00
1.A.4 Other sectors - Liquid Fuels	N_2O	22.47	21.73	5.00	5.00
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.92	7473.04	3.00	3.00
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	16.86	3.00	3.00
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	4.02	3.00	3.00
1.A.4 Other sectors - Biomass	CH_4	324.26	568.85	8.00	8.00
1.A.4 Other sectors - Biomass	N_2O	51.50	90.26	8.00	8.00
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	277.11	5.00	5.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.00	0.52	5.00	5.00
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.00	6.92	5.00	5.00
1.B.1.a Coal Mining and Handling	CO_2	456.24	156.46	4.00	4.00
1.B.1.a Coal Mining and Handling	CH_4	10322.40	3259.67	4.00	4.00
1.B.1.b Solid Fuel Transformation	CH_4	0.75	4.50	40.00	40.00
1.B.2.a Oil	CO_2	0.02	0.04	7.00	7.00
1.B.2.a Oil	CH_4	22.69	4.79	7.00	7.00
1.B.2.b Natural Gas	CO_2	0.17	0.09	7.00	7.00
1.B.2.b Natural Gas	CH_4	1044.93	571.24	7.00	7.00
1.B.2.c Venting and Flaring	CO_2	2.02	4.81	7.00	7.00
1.B.2.c Venting and Flaring	CH_4	12.28	29.26	7.00	7.00
2.A.1 Cement Production	CO_2	2489.18	1697.60	2.00	2.00
2.A.2 Lime Production	CO_2	1336.65	639.82	2.00	2.00
2.A.3 Glass Production	CO_2	142.75	138.06	5.00	5.00
2.A.4 Other process uses of carbonates	CO_2	113.86	340.59	5.00	5.00
2.B.1 Ammonia Production	CO_2	990.80	685.72	5.00	5.00
2.B.2 Nitric Acid Production	N_2O	1050.29	216.44	4.00	4.00
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	66.59	5.00	5.00
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	302.82	5.00	5.00
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	22.09	5.00	5.00
2.B.10 Other chemical industry	CO_2	0.00	233.58	3.00	3.00
2.C.1 Iron and Steel Production	CO_2	9642.54	7286.67	7.00	7.00
2.C.1 Iron and Steel Production	CH_4	14.84	10.52	7.00	7.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.56	5.00	5.00
2.C.2 Ferroalloys Production	CH_4	0.18	3.88	5.00	5.00
2.C.5 Lead Production	CO_2	4.04	9.28	10.00	10.00
2.C.6 Zinc Production	CO_2	0.00	0.58	10.00	10.00
2.D.1 Lubricant Use	CO_2	116.13	114.95	5.00	5.00
2.D.2 Paraffin Wax Use	CO_2	9.43	5.89	5.00	5.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	18.88	5.00	5.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.00	3.82	3.00	3.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	3.00	3.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.00	3086.10	37.00	37.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.00	0.99	37.00	37.00
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.00	6.33	35.00	35.00
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.00	23.74	35.00	35.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.00	0.03	35.00	35.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0.00	3.75	35.00	35.00
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	1.59	35.00	35.00
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	70.41	37.00	37.00
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	4.40	37.00	37.00
2.G.3 N_2O from product uses	N_2O	206.22	223.50	37.00	37.00
3.A Enteric Fermentation	CH_4	5754.89	2957.46	5.00	5.00
3.B Manure Management	CH_4	1695.43	741.23	10.00	10.00
3.B Manure Management	N_2O	1619.93	838.95	5.00	5.00
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4203.87	2760.59	5.00	5.00
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1327.84	842.67	5.00	5.00
3.G Liming	CO_2	1187.63	168.01	5.00	5.00
3.H Urea application	CO_2	108.53	210.76	15.00	15.00
4.A.1 Forest Land remaining Forest Land	CO_2	-4822.40	-4070.82	20.00	20.00

4.A.1 Forest Land remaining Forest Land	CH_4	44.15	32.87	20.00	20.00
4.A.1 Forest Land remaining Forest Land	N_2O	29.11	21.67	20.00	20.00
4.A.2 Land converted to Forest Land	CO_2	-326.89	-503.03	0.00	0.00
4.B.1 Cropland remaining Cropland	CO_2	90.16	35.87	0.00	0.00
4.B.2 Land converted to Cropland	CO_2	114.15	83.81	0.00	0.00
4.B.2. Land converted to Cropland	N_2O	8.91	4.69	0.00	0.00
4.C.1 Grassland remaining Grassland	CO_2	48.18	-478.90	0.00	0.00
4.C.2 Land converted to Grassland	CO_2	-145.01	-182.76	0.00	0.00
4.D.2. Land converted to Wetlands	CO_2	21.48	25.03	0.00	0.00
4.E.2 Land converted to Settlements	CO_2	86.31	124.06	0.00	0.00
4.G Harvested wood products	CO_2	-1712.97	-430.67	0.00	0.00
5.A Solid Waste Disposal on Land	CH_4	1979.27	3671.11	0.00	0.00
5.B Biological treatment of solid waste	CH_4	0.00	647.76	5.00	5.00
5.B Biological treatment of solid waste	N_2O	0.00	63.60	5.00	5.00
5.C Incineration and open burning of waste	CO_2	20.83	113.69	15.00	15.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	20.00	20.00
5.C Incineration and open burning of waste	N_2O	0.42	2.29	20.00	20.00
5.D Wastewater treatment and discharge	CH_4	889.80	865.35	30.14	30.14
5.D Wastewater treatment and discharge	N_2O	234.18	197.45	26.00	26.00

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 ammount**	**Combined uncertainty as % of total national emissions in year t**
1.A.1 Energy industries - Solid Fuels	CO_2	5.00	2528.46	2.1095
1.A.1 Energy industries - Solid Fuels	CH_4	50.16	6.53	0.0054
1.A.1 Energy industries - Solid Fuels	N_2O	60.13	133.06	0.1110
1.A.1 Energy industries - Liquid Fuels	CO_2	5.83	22.68	0.0189
1.A.1 Energy industries - Liquid Fuels	CH_4	50.25	0.12	0.0001
1.A.1 Energy industries - Liquid Fuels	N_2O	60.21	0.25	0.0002
1.A.1 Energy industries - Gaseous Fuels	CO_2	3.91	115.39	0.0963
1.A.1 Energy industries - Gaseous Fuels	CH_4	50.09	0.67	0.0006
1.A.1 Energy industries - Gaseous Fuels	N_2O	60.07	0.95	0.0008
1.A.1 Energy industries - Biomass	CH_4	50.64	8.48	0.0071
1.A.1 Energy industries - Biomass	N_2O	60.53	16.10	0.0134
1.A.1 Energy industries - Other Fossil Fuels	CO_2	28.28	70.60	0.0589
1.A.1 Energy industries - Other Fossil Fuels	CH_4	53.85	1.10	0.0009
1.A.1 Energy industries - Other Fossil Fuels	N_2O	72.80	2.36	0.0020
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	5.00	163.50	0.1364
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	50.16	3.95	0.0033
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	60.13	8.43	0.0070
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5.83	18.07	0.0151
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	50.25	0.12	0.0001
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	60.21	0.33	0.0003
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	3.91	205.76	0.1717
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	50.09	1.19	0.0010
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	60.07	1.70	0.0014
1.A.2 Manufacturing industries and construction - Biomass	CH_4	50.64	11.23	0.0094
1.A.2 Manufacturing industries and construction - Biomass	N_2O	60.53	21.22	0.0177
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	18.03	81.69	0.0682
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	50.99	1.93	0.0016

1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	60.83	3.67	0.0031
1.A.3.a Transport - Civil Aviation	CO_2	5.61	0.56	0.0005
1.A.3.a Transport - Civil Aviation	CH_4	78.60	0.00	0.0000
1.A.3.a Transport - Civil Aviation	N_2O	110.07	0.09	0.0001
1.A.3.b Transport - Road transportation	CO_2	4.97	879.02	0.7334
1.A.3.b Transport - Road transportation	CH_4	157.48	42.37	0.0354
1.A.3.b Transport - Road transportation	N_2O	133.78	485.87	0.4054
1.A.3.c Transport - Railways	CO_2	5.22	14.28	0.0119
1.A.3.c Transport - Railways	CH_4	157.53	0.60	0.0005
1.A.3.c Transport - Railways	N_2O	137.27	43.22	0.0361
1.A.3.d Transport - Domestic navigation	CO_2	5.22	0.66	0.0006
1.A.3.d Transport - Domestic navigation	CH_4	5.22	0.00	0.0000
1.A.3.d Transport - Domestic navigation	N_2O	137.27	0.14	0.0001
1.A.3.e Transport - Other Transportation	CO_2	5.00	3.05	0.0025
1.A.3.e Transport - Other Transportation	CH_4	50.16	0.01	0.0000
1.A.3.e Transport - Other Transportation	N_2O	60.13	0.02	0.0000
1.A.4 Other sectors - Solid Fuels	CO_2	5.00	191.25	0.1596
1.A.4 Other sectors - Solid Fuels	CH_4	50.16	148.67	0.1240
1.A.4 Other sectors - Solid Fuels	N_2O	60.13	10.89	0.0091
1.A.4 Other sectors - Liquid Fuels	CO_2	5.83	71.70	0.0598
1.A.4 Other sectors - Liquid Fuels	CH_4	50.25	1.18	0.0010
1.A.4 Other sectors - Liquid Fuels	N_2O	60.21	13.08	0.0109
1.A.4 Other sectors - Gaseous Fuels	CO_2	3.91	291.83	0.2435
1.A.4 Other sectors - Gaseous Fuels	CH_4	50.09	8.45	0.0070
1.A.4 Other sectors - Gaseous Fuels	N_2O	60.07	2.41	0.0020
1.A.4 Other sectors - Biomass	CH_4	50.64	288.04	0.2403
1.A.4 Other sectors - Biomass	N_2O	60.53	54.64	0.0456
1.A.5.b Other mobile - Liquid Fuels	CO_2	5.83	16.16	0.0135
1.A.5.b Other mobile - Liquid Fuels	CH_4	50.25	0.26	0.0002
1.A.5.b Other mobile - Liquid Fuels	N_2O	60.21	4.17	0.0035
1.B.1.a Coal Mining and Handling	CO_2	25.32	39.61	0.0331
1.B.1.a Coal Mining and Handling	CH_4	13.60	443.36	0.3699
1.B.1.b Solid Fuel Transformation	CH_4	64.03	2.88	0.0024
1.B.2.a Oil	CO_2	75.33	0.03	0.0000
1.B.2.a Oil	CH_4	75.33	3.61	0.0030
1.B.2.b Natural Gas	CO_2	75.33	0.07	0.0001
1.B.2.b Natural Gas	CH_4	75.33	430.29	0.3590
1.B.2.c Venting and Flaring	CO_2	50.49	2.43	0.0020
1.B.2.c Venting and Flaring	CH_4	50.49	14.77	0.0123
2.A.1 Cement Production	CO_2	2.83	48.02	0.0401
2.A.2 Lime Production	CO_2	2.83	18.10	0.0151
2.A.3 Glass Production	CO_2	5.39	7.43	0.0062
2.A.4 Other process uses of carbonates	CO_2	11.18	38.08	0.0318
2.B.1 Ammonia Production	CO_2	8.60	58.99	0.0492
2.B.2 Nitric Acid Production	N_2O	15.52	33.60	0.0280

2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	40.31	26.84	0.0224
2.B.8 Petrochemical and Carbon Black Production	CO_2	40.31	122.07	0.1018
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.31	8.90	0.0074
2.B.10 Other chemical industry	CO_2	3.91	9.12	0.0076
2.C.1 Iron and Steel Production	CO_2	12.21	889.45	0.7421
2.C.1 Iron and Steel Production	CH_4	30.81	3.24	0.0027
2.C.2 Ferroalloys Production	CO_2	25.50	0.14	0.0001
2.C.2 Ferroalloys Production	CH_4	25.50	0.99	0.0008
2.C.5 Lead Production	CO_2	50.99	4.73	0.0039
2.C.6 Zinc Production	CO_2	50.99	0.29	0.0002
2.D.1 Lubricant Use	CO_2	50.25	57.76	0.0482
2.D.2 Paraffin Wax Use	CO_2	50.25	2.96	0.0025
2.D.3 Other non-energy products from fuels and solvent use	CO_2	7.07	1.34	0.0011
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	15.30	0.58	0.0005
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	15.30	0.00	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	43.57	1344.49	1.1217
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	43.57	0.43	0.0004
2.F.2 Foam Blowing (CO_2 eq.)	HFC	41.88	2.65	0.0022
2.F.3 Fire Protection (CO_2 eq.)	HFC	41.88	9.94	0.0083
2.F.3 Fire Protection (CO_2 eq.)	PFC	41.88	0.01	0.0000
2.F.4 Aerosols (CO_2 eq.)	HFC	41.88	1.57	0.0013
2.F.5 Solvents (CO_2 eq.)	HFC	41.88	0.66	0.0006
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	43.57	30.67	0.0256
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	43.57	1.92	0.0016
2.G.3 N_2O from product uses	N_2O	43.57	97.37	0.0812
3.A Enteric Fermentation	CH_4	15.81	467.62	0.3901
3.B Manure Management	CH_4	22.36	165.74	0.1383
3.B Manure Management	N_2O	40.31	338.19	0.2822
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	20.62	569.11	0.4748
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	30.41	256.29	0.2138
3.G Liming	CO_2	30.41	51.10	0.0426
3.H Urea application	CO_2	52.20	110.02	0.0918
4.A.1 Forest Land remaining Forest Land	CO_2	41.63	-1694.69	-1.4139
4.A.1 Forest Land remaining Forest Land	CH_4	46.24	15.20	0.0127
4.A.1 Forest Land remaining Forest Land	N_2O	46.24	10.02	0.0084
4.A.2 Land converted to Forest Land	CO_2	32.39	-162.92	-0.1359
4.B.1 Cropland remaining Cropland	CO_2	29.4662	10.5682	0.0088
4.B.2 Land converted to Cropland	CO_2	36.66	30.72	0.03
4.B.2. Land converted to Cropland	N_2O	282.36	13.24	0.01
4.C.1 Grassland remaining Grassland	CO_2	45.40	-217.43	-0.18
4.C.2 Land converted to Grassland	CO_2	31.28	-57.17	-0.05
4.D.2. Land converted to Wetlands	CO_2	69.28	17.34	0.01
4.E.2 Land converted to Settlements	CO_2	102.32	126.94	0.11
4.G Harvested wood products	CO_2	62.00	-267.02	-0.22
5.A Solid Waste Disposal on Land	CH_4	63.70	2338.47	1.95
5.B Biological treatment of solid waste	CH_4	91.29	591.32	0.49

5.B Biological treatment of solid waste	N_2O	5.04	3.20	0.00
5.C Incineration and open burning of waste	CO_2	15.81	17.98	0.01
5.C Incineration and open burning of waste	CH_4	82.46	0.00	0.00
5.C Incineration and open burning of waste	N_2O	72.80	1.67	0.00
5.D Wastewater treatment and discharge	CH_4	58.38	505.22	0.42
5.D Wastewater treatment and discharge	N_2O	56.36	111.27	0.0928
		Level uncertainty =	**10040.19**	**3.7927**

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.1 Energy industries - Solid Fuels	CO_2	0.0873	0.2668	0.26	1.5091	1.5316
1.A.1 Energy industries - Solid Fuels	CH_4	0.0000	0.0001	0.00	0.0004	0.0012
1.A.1 Energy industries - Solid Fuels	N_2O	0.0004	0.0012	0.02	0.0066	0.0230
1.A.1 Energy industries - Liquid Fuels	CO_2	-0.0032	0.0021	-0.01	0.0145	0.0174
1.A.1 Energy industries - Liquid Fuels	CH_4	0.0000	0.0000	0.00	0.0000	0.0002
1.A.1 Energy industries - Liquid Fuels	N_2O	0.0000	0.0000	0.00	0.0000	0.0006
1.A.1 Energy industries - Gaseous Fuels	CO_2	0.0111	0.0156	0.03	0.0661	0.0717
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.0000	0.0000	0.00	0.0000	0.0003
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.0000	0.0000	0.00	0.0000	0.0004
1.A.1 Energy industries - Biomass	CH_4	0.0001	0.0001	0.00	0.0010	0.0045
1.A.1 Energy industries - Biomass	N_2O	0.0001	0.0001	0.01	0.0016	0.0085
1.A.1 Energy industries - Other Fossil Fuels	CO_2	0.0012	0.0013	0.02	0.0372	0.0447
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.0000	0.0000	0.00	0.0003	0.0006
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.0000	0.0000	0.00	0.0005	0.0012
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	-0.1014	0.0173	-0.30	0.0976	0.3195
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	-0.0002	0.0000	-0.01	0.0002	0.0122
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	-0.0004	0.0001	-0.03	0.0004	0.0262
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	-0.0304	0.0016	-0.09	0.0116	0.0919
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0.0000	0.0000	0.00	0.0000	0.0015
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	-0.0001	0.0000	0.00	0.0000	0.0044
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	0.0088	0.0278	0.02	0.1179	0.1200
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	0.0000	0.0000	0.00	0.0001	0.0002
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	0.0000	0.0000	0.00	0.0001	0.0003
1.A.2 Manufacturing industries and construction - Biomass	CH_4	0.0001	0.0001	0.00	0.0013	0.0043
1.A.2 Manufacturing industries and construction - Biomass	N_2O	0.0001	0.0002	0.01	0.0021	0.0081
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.0024	0.0024	0.04	0.0338	0.0493
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.0000	0.0000	0.00	0.0003	0.0010
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.0000	0.0000	0.00	0.0004	0.0020
1.A.3.a Transport - Civil Aviation	CO_2	-0.0004	0.0001	0.00	0.0003	0.0016
1.A.3.a Transport - Civil Aviation	CH_4	0.0000	0.0000	0.00	0.0000	0.0000
1.A.3.a Transport - Civil Aviation	N_2O	0.0000	0.0000	0.00	0.0000	0.0004
1.A.3.b Transport - Road transportation	CO_2	0.0726	0.0932	0.29	0.3955	0.4893
1.A.3.b Transport - Road transportation	CH_4	0.0000	0.0001	0.00	0.0006	0.0027
1.A.3.b Transport - Road transportation	N_2O	0.0015	0.0019	0.20	0.0081	0.1954
1.A.3.c Transport - Railways	CO_2	-0.0007	0.0014	0.00	0.0102	0.0103
1.A.3.c Transport - Railways	CH_4	0.0000	0.0000	0.00	0.0000	0.0002
1.A.3.c Transport - Railways	N_2O	-0.0001	0.0002	-0.01	0.0012	0.0117
1.A.3.d Transport - Domestic navigation	CO_2	-0.0001	0.0001	0.00	0.0005	0.0005
1.A.3.d Transport - Domestic navigation	CH_4	0.0000	0.0000	0.00	0.0000	0.0000
1.A.3.d Transport - Domestic navigation	N_2O	0.0000	0.0000	0.00	0.0000	0.0001
1.A.3.e Transport - Other Transportation	CO_2	0.0003	0.0003	0.00	0.0018	0.0020
1.A.3.e Transport - Other Transportation	CH_4	0.0000	0.0000	0.00	0.0000	0.0000
1.A.3.e Transport - Other Transportation	N_2O	0.0000	0.0000	0.00	0.0000	0.0000
1.A.4 Other sectors - Solid Fuels	CO_2	-0.0598	0.0202	-0.18	0.1141	0.2127
1.A.4 Other sectors - Solid Fuels	CH_4	-0.0029	0.0016	-0.14	0.0088	0.1442
1.A.4 Other sectors - Solid Fuels	N_2O	-0.0002	0.0001	-0.01	0.0005	0.0149
1.A.4 Other sectors - Liquid Fuels	CO_2	-0.0069	0.0065	-0.02	0.0459	0.0503

1.A.4 Other sectors - Liquid Fuels	CH_4	0.0000	0.0000	0.00	0.0001	0.0011
1.A.4 Other sectors - Liquid Fuels	N_2O	0.0000	0.0001	0.00	0.0008	0.0025
1.A.4 Other sectors - Gaseous Fuels	CO_2	0.0255	0.0394	0.06	0.1673	0.1790
1.A.4 Other sectors - Gaseous Fuels	CH_4	0.0001	0.0001	0.00	0.0004	0.0029
1.A.4 Other sectors - Gaseous Fuels	N_2O	0.0000	0.0000	0.00	0.0001	0.0008
1.A.4 Other sectors - Biomass	CH_4	0.0019	0.0030	0.10	0.0340	0.1018
1.A.4 Other sectors - Biomass	N_2O	0.0003	0.0005	0.02	0.0054	0.0190
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.0015	0.0015	0.00	0.0103	0.0112
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.0000	0.0000	0.00	0.0000	0.0001
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.0000	0.0000	0.00	0.0003	0.0022
1.B.1.a Coal Mining and Handling	CO_2	-0.0007	0.0008	-0.02	0.0047	0.0180
1.B.1.a Coal Mining and Handling	CH_4	-0.0172	0.0172	-0.22	0.0973	0.2441
1.B.1.b Solid Fuel Transformation	CH_4	0.0000	0.0000	0.00	0.0013	0.0017
1.B.2.a Oil	CO_2	0.0000	0.0000	0.00	0.0000	0.0000
1.B.2.a Oil	CH_4	-0.0001	0.0000	0.00	0.0003	0.0038
1.B.2.b Natural Gas	CO_2	0.0000	0.0000	0.00	0.0000	0.0000
1.B.2.b Natural Gas	CH_4	-0.0005	0.0030	-0.04	0.0298	0.0463
1.B.2.c Venting and Flaring	CO_2	0.0000	0.0000	0.00	0.0003	0.0010
1.B.2.c Venting and Flaring	CH_4	0.0001	0.0002	0.01	0.0015	0.0059
2.A.1 Cement Production	CO_2	0.0007	0.0090	0.00	0.0253	0.0254
2.A.2 Lime Production	CO_2	-0.0011	0.0034	0.00	0.0095	0.0098
2.A.3 Glass Production	CO_2	0.0003	0.0007	0.00	0.0051	0.0052
2.A.4 Other process uses of carbonates	CO_2	0.0014	0.0018	0.01	0.0127	0.0190
2.B.1 Ammonia Production	CO_2	0.0003	0.0036	0.00	0.0256	0.0257
2.B.2 Nitric Acid Production	N_2O	-0.0024	0.0011	-0.04	0.0065	0.0360
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	0.0001	0.0004	0.00	0.0025	0.0048
2.B.8 Petrochemical and Carbon Black Production	CO_2	-0.0010	0.0016	-0.04	0.0113	0.0433
2.B.8 Petrochemical and Carbon Black Production	CH_4	0.0000	0.0001	0.00	0.0008	0.0008
2.B.10 Other chemical industry	CO_2	0.0012	0.0012	0.00	0.0052	0.0061
2.C.1 Iron and Steel Production	CO_2	0.0063	0.0384	0.06	0.3805	0.3857
2.C.1 Iron and Steel Production	CH_4	0.0000	0.0001	0.00	0.0005	0.0006
2.C.2 Ferroalloys Production	CO_2	0.0000	0.0000	0.00	0.0000	0.0001
2.C.2 Ferroalloys Production	CH_4	0.0000	0.0000	0.00	0.0001	0.0005
2.C.5 Lead Production	CO_2	0.0000	0.0000	0.00	0.0007	0.0019
2.C.6 Zinc Production	CO_2	0.0000	0.0000	0.00	0.0000	0.0002
2.D.1 Lubricant Use	CO_2	0.0002	0.0006	0.01	0.0043	0.0118
2.D.2 Paraffin Wax Use	CO_2	0.0000	0.0000	0.00	0.0002	0.0002
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.0001	0.0001	0.00	0.0007	0.0009
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.0000	0.0000	0.00	0.0001	0.0003
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.0000	0.0000	0.00	0.0000	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.0163	0.0163	0.37	0.8519	0.9305
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.0000	0.0000	0.00	0.0003	0.0003
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.0000	0.0000	0.00	0.0017	0.0018
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.0001	0.0001	0.00	0.0062	0.0068
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.0000	0.0000	0.00	0.0000	0.0000
2.F.4 Aerosols (CO_2 eq.)	HFC	0.0000	0.0000	0.00	0.0010	0.0011
2.F.5 Solvents (CO_2 eq.)	HFC	0.0000	0.0000	0.00	0.0004	0.0005
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	0.0001	0.0004	0.00	0.0194	0.0195
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.0000	0.0000	0.00	0.0012	0.0013
2.G.3 N_2O from product uses	N_2O	0.0005	0.0012	0.01	0.0617	0.0627
3.A Enteric Fermentation	CH_4	-0.0036	0.0156	-0.05	0.1103	0.1228
3.B Manure Management	CH_4	-0.0017	0.0039	-0.03	0.0553	0.0654
3.B Manure Management	N_2O	-0.0010	0.0044	-0.04	0.0313	0.0501
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	0.0005	0.0146	0.01	0.1030	0.1035
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	0.0000	0.0044	0.00	0.0314	0.0314
3.G Liming	CO_2	-0.0031	0.0009	-0.09	0.0063	0.0925
3.H Urea application	CO_2	0.0007	0.0011	0.04	0.0236	0.0443
4.A.1 Forest Land remaining Forest Land	CO_2	-0.0054	-0.0215	-0.20	-0.6074	0.6385
4.A.1 Forest Land remaining Forest Land	CH_4	0.0000	0.0002	0.00	0.0049	0.0050
4.A.1 Forest Land remaining Forest Land	N_2O	0.0000	0.0001	0.00	0.0032	0.0033
4.A.2 Land converted to Forest Land	CO_2	-0.0016	-0.0027	-0.05	0.0000	0.0506

4.B.1 Cropland remaining Cropland	CO_2	-0.0001	0.0002	0.00	0.0000	0.0033
4.B.2 Land converted to Cropland	CO_2	0.0001	0.0004	0.00	0.00	0.00
4.B.2. Land converted to Cropland	N_2O	0.00	0.00	0.00	0.00	0.00
4.C.1 Grassland remaining Grassland	CO_2	0.00	0.00	-0.12	0.00	0.12
4.C.2 Land converted to Grassland	CO_2	0.00	0.00	-0.02	0.00	0.02
4.D.2. Land converted to Wetlands	CO_2	0.00	0.00	0.00	0.00	0.00
4.E.2 Land converted to Settlements	CO_2	0.00	0.00	0.04	0.00	0.04
4.G Harvested wood products	CO_2	0.00	0.00	0.21	0.00	0.21
5.A Solid Waste Disposal on Land	CH_4	0.01	0.02	0.81	0.00	0.81
5.B Biological treatment of solid waste	CH_4	0.00	0.00	0.31	0.02	0.31
5.B Biological treatment of solid waste	N_2O	0.00	0.00	0.00	0.00	0.00
5.C Incineration and open burning of waste	CO_2	0.00	0.00	0.00	0.01	0.01
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	0.00	0.00
5.C Incineration and open burning of waste	N_2O	0.00	0.00	0.00	0.00	0.00
5.D Wastewater treatment and discharge	CH_4	0.00	0.00	0.08	0.19	0.21
5.D Wastewater treatment and discharge	N_2O	0.00	0.00	0.01	0.04	0.04
					Trend uncertainty =	**2.2976**

Tab. A2 - 4 Uncertainty analysis (Tier 1), first part of Table 3.3 of IPCC 2006 Gl. excl. LULUCF

Input DATA					
IPCC Source Category	**Gas**	**Base year emissions (1990) abs**	**Year t emissions (2015) abs**	**Activity data uncertainty**	**Emission factor uncertainty**
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	50569.21	4	3
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	13.01	4	50
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	221.27	4	60
1.A.1 Energy industries - Liquid Fuels	CO_2	1574.60	389.04	5	3
1.A.1 Energy industries - Liquid Fuels	CH_4	1.48	0.24	5	50
1.A.1 Energy industries - Liquid Fuels	N_2O	3.46	0.41	5	60
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.04	2954.74	3	3
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	1.33	3	50
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	1.59	3	60
1.A.1 Energy industries - Biomass	CH_4	0.30	16.75	8	50
1.A.1 Energy industries - Biomass	N_2O	0.48	26.60	8	60
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	249.61	20	20
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	2.04	20	50
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	3.24	20	70
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	3270.08	4	3
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	7.87	4	50
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	14.01	4	60
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	9609.14	309.88	5	3
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	9.54	0.25	5	50
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	22.75	0.55	5	60
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.66	5268.87	3	3
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.38	3	50
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	2.83	3	60
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	22.17	8	50
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	35.06	8	60
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.00	453.14	10	15
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.00	3.79	10	50
1.A.2 Manufacturing industries and construction - Other	N_2O	0.00	6.03	10	60

Fossil Fuels					
1.A.3.a Transport - Civil Aviation	CO_2	139.44	10.01	4	4
1.A.3.a Transport - Civil Aviation	CH_4	0.02	0.00	4	79
1.A.3.a Transport - Civil Aviation	N_2O	1.19	0.09	4	110
1.A.3.b Transport - Road transportation	CO_2	6176.54	17670.12	3	4
1.A.3.b Transport - Road transportation	CH_4	37.50	26.91	3	157
1.A.3.b Transport - Road transportation	N_2O	136.73	363.18	3	134
1.A.3.c Transport - Railways	CO_2	653.86	273.75	5	1
1.A.3.c Transport - Railways	CH_4	0.92	0.38	5	157
1.A.3.c Transport - Railways	N_2O	75.21	31.49	5	137
1.A.3.d Transport - Domestic navigation	CO_2	56.61	12.73	5	1
1.A.3.d Transport - Domestic navigation	CH_4	0.13	0.03	5	1
1.A.3.d Transport - Domestic navigation	N_2O	0.46	0.10	5	137
1.A.3.e Transport - Other Transportation	CO_2	5.42	60.98	4	3
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.03	4	50
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.03	4	60
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	3824.92	4	3
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	296.39	4	50
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	18.11	4	60
1.A.4 Other sectors - Liquid Fuels	CO_2	4009.76	1229.70	5	3
1.A.4 Other sectors - Liquid Fuels	CH_4	10.56	2.34	5	50
1.A.4 Other sectors - Liquid Fuels	N_2O	22.47	21.73	5	60
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.92	7473.04	3	3
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	16.86	3	50
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	4.02	3	60
1.A.4 Other sectors - Biomass	CH_4	324.26	568.85	8	50
1.A.4 Other sectors - Biomass	N_2O	51.50	90.26	8	60
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	277.11	5	3
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.00	0.52	5	50
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.00	6.92	5	60
1.B.1.a Coal Mining and Handling	CO_2	456.24	156.46	4	25
1.B.1.a Coal Mining and Handling	CH_4	10322.40	3259.67	4	13
1.B.1.b Solid Fuel Transformation	CH_4	0.75	4.50	40	50
1.B.2.a Oil	CO_2	0.02	0.04	7	75
1.B.2.a Oil	CH_4	22.69	4.79	7	75
1.B.2.b Natural Gas	CO_2	0.17	0.09	7	75
1.B.2.b Natural Gas	CH_4	1044.93	571.24	7	75
1.B.2.c Venting and Flaring	CO_2	2.02	4.81	7	50
1.B.2.c Venting and Flaring	CH_4	12.28	29.26	7	50
2.A.1 Cement Production	CO_2	2489.18	1697.60	2	2
2.A.2 Lime Production	CO_2	1336.65	639.82	2	2
2.A.3 Glass Production	CO_2	142.75	138.06	5	2
2.A.4 Other process uses of carbonates	CO_2	113.86	340.59	5	10
2.B.1 Ammonia Production	CO_2	990.80	685.72	5	7
2.B.2 Nitric Acid Production	N_2O	1050.29	216.44	4	15
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	66.59	5	40
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	302.82	5	40
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	22.09	5	40
2.B.10 Other chemical industry	CO_2	0.00	233.58	3	3
2.C.1 Iron and Steel Production	CO_2	9642.54	7286.67	7	10
2.C.1 Iron and Steel Production	CH_4	14.84	10.52	7	30
2.C.2 Ferroalloys Production	CO_2	0.03	0.56	5	25
2.C.2 Ferroalloys Production	CH_4	0.18	3.88	5	25
2.C.5 Lead Production	CO_2	4.04	9.28	10	50
2.C.6 Zinc Production	CO_2	0.00	0.58	10	50
2.D.1 Lubricant Use	CO_2	116.13	114.95	5	50
2.D.2 Paraffin Wax Use	CO_2	9.43	5.89	5	50
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	18.88	5	5
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.00	3.82	3	15
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	3	15
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.00	3086.10	37	23
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.00	0.99	37	23
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.00	6.33	35	23
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.00	23.74	35	23
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.00	0.03	35	23
2.F.4 Aerosols (CO_2 eq.)	HFC	0.00	3.75	35	23

2.F.5 Solvents (CO_2 eq.)	HFC	0.00	1.59	35	23
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	70.41	37	23
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	4.40	37	23
2.G.3 N_2O from product uses	N_2O	206.22	223.50	37	23
3.A Enteric Fermentation	CH_4	5754.89	2957.46	5	15
3.B Manure Management	CH_4	1695.43	741.23	10	20
3.B Manure Management	N_2O	1619.93	838.95	5	40
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4203.87	2760.59	5	20
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1327.84	842.67	5	30
3.G Liming	CO_2	1187.63	168.01	5	30
3.H Urea application	CO_2	108.53	210.76	15	50
5.A Solid Waste Disposal on Land	CH_4	1979.27	3671.11	0	64
5.B Biological treatment of solid waste	CH_4	0.00	647.76	5	91
5.B Biological treatment of solid waste	N_2O	0.00	63.60	5	1
5.C Incineration and open burning of waste	CO_2	20.83	113.69	15	5
5.C Incineration and open burning of waste	CH_4	0.00	0.00	20	80
5.C Incineration and open burning of waste	N_2O	0.42	2.29	20	70
5.D Wastewater treatment and discharge	CH_4	889.80	865.35	30	50
5.D Wastewater treatment and discharge	N_2O	234.18	197.45	26	50

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

		Uncertainty of Emissions		
IPCC Source Category	**Gas**	**Combined uncertainty**	**Uncertain ammount**	**Combined uncertainty as % of total national emissions in year t**
1.A.1 Energy industries - Solid Fuels	CO_2	5.00	2528.46	2.1972
1.A.1 Energy industries - Solid Fuels	CH_4	50.16	6.53	0.0057
1.A.1 Energy industries - Solid Fuels	N_2O	60.13	133.06	0.1156
1.A.1 Energy industries - Liquid Fuels	CO_2	5.83	22.68	0.0197
1.A.1 Energy industries - Liquid Fuels	CH_4	50.25	0.12	0.0001
1.A.1 Energy industries - Liquid Fuels	N_2O	60.21	0.25	0.0002
1.A.1 Energy industries - Gaseous Fuels	CO_2	3.91	115.39	0.1003
1.A.1 Energy industries - Gaseous Fuels	CH_4	50.09	0.67	0.0006
1.A.1 Energy industries - Gaseous Fuels	N_2O	60.07	0.95	0.0008
1.A.1 Energy industries - Biomass	CH_4	50.64	8.48	0.0074
1.A.1 Energy industries - Biomass	N_2O	60.53	16.10	0.0140
1.A.1 Energy industries - Other Fossil Fuels	CO_2	28.28	70.60	0.0614
1.A.1 Energy industries - Other Fossil Fuels	CH_4	53.85	1.10	0.0010
1.A.1 Energy industries - Other Fossil Fuels	N_2O	72.80	2.36	0.0021
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	5.00	163.50	0.1421
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	50.16	3.95	0.0034
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	60.13	8.43	0.0073
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5.83	18.07	0.0157
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	50.25	0.12	0.0001
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	60.21	0.33	0.0003
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	3.91	205.76	0.1788
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	50.09	1.19	0.0010
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	60.07	1.70	0.0015
1.A.2 Manufacturing industries and construction - Biomass	CH_4	50.64	11.23	0.0098
1.A.2 Manufacturing industries and construction - Biomass	N_2O	60.53	21.22	0.0184
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	18.03	81.69	0.0710

1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	50.99	1.93	0.0017
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	60.83	3.67	0.0032
1.A.3.a Transport - Civil Aviation	CO_2	5.61	0.56	0.0005
1.A.3.a Transport - Civil Aviation	CH_4	78.60	0.00	0.0000
1.A.3.a Transport - Civil Aviation	N_2O	110.07	0.09	0.0001
1.A.3.b Transport - Road transportation	CO_2	4.97	879.02	0.7639
1.A.3.b Transport - Road transportation	CH_4	157.48	42.37	0.0368
1.A.3.b Transport - Road transportation	N_2O	133.78	485.87	0.4222
1.A.3.c Transport - Railways	CO_2	5.22	14.28	0.0124
1.A.3.c Transport - Railways	CH_4	157.53	0.60	0.0005
1.A.3.c Transport - Railways	N_2O	137.27	43.22	0.0376
1.A.3.d Transport - Domestic navigation	CO_2	5.22	0.66	0.0006
1.A.3.d Transport - Domestic navigation	CH_4	5.22	0.00	0.0000
1.A.3.d Transport - Domestic navigation	N_2O	137.27	0.14	0.0001
1.A.3.e Transport - Other Transportation	CO_2	5.00	3.05	0.0026
1.A.3.e Transport - Other Transportation	CH_4	50.16	0.01	0.0000
1.A.3.e Transport - Other Transportation	N_2O	60.13	0.02	0.0000
1.A.4 Other sectors - Solid Fuels	CO_2	5.00	191.25	0.1662
1.A.4 Other sectors - Solid Fuels	CH_4	50.16	148.67	0.1292
1.A.4 Other sectors - Solid Fuels	N_2O	60.13	10.89	0.0095
1.A.4 Other sectors - Liquid Fuels	CO_2	5.83	71.70	0.0623
1.A.4 Other sectors - Liquid Fuels	CH_4	50.25	1.18	0.0010
1.A.4 Other sectors - Liquid Fuels	N_2O	60.21	13.08	0.0114
1.A.4 Other sectors - Gaseous Fuels	CO_2	3.91	291.83	0.2536
1.A.4 Other sectors - Gaseous Fuels	CH_4	50.09	8.45	0.0073
1.A.4 Other sectors - Gaseous Fuels	N_2O	60.07	2.41	0.0021
1.A.4 Other sectors - Biomass	CH_4	50.64	288.04	0.2503
1.A.4 Other sectors - Biomass	N_2O	60.53	54.64	0.0475
1.A.5.b Other mobile - Liquid Fuels	CO_2	5.83	16.16	0.0140
1.A.5.b Other mobile - Liquid Fuels	CH_4	50.25	0.26	0.0002
1.A.5.b Other mobile - Liquid Fuels	N_2O	60.21	4.17	0.0036
1.B.1.a Coal Mining and Handling	CO_2	25.32	39.61	0.0344
1.B.1.a Coal Mining and Handling	CH_4	13.60	443.36	0.3853
1.B.1.b Solid Fuel Transformation	CH_4	64.03	2.88	0.0025
1.B.2.a Oil	CO_2	75.33	0.03	0.0000
1.B.2.a Oil	CH_4	75.33	3.61	0.0031
1.B.2.b Natural Gas	CO_2	75.33	0.07	0.0001
1.B.2.b Natural Gas	CH_4	75.33	430.29	0.3739
1.B.2.c Venting and Flaring	CO_2	50.49	2.43	0.0021
1.B.2.c Venting and Flaring	CH_4	50.49	14.77	0.0128
2.A.1 Cement Production	CO_2	2.83	48.02	0.0417
2.A.2 Lime Production	CO_2	2.83	18.10	0.0157
2.A.3 Glass Production	CO_2	5.39	7.43	0.0065
2.A.4 Other process uses of carbonates	CO_2	11.18	38.08	0.0331
2.B.1 Ammonia Production	CO_2	8.60	58.99	0.0513
2.B.2 Nitric Acid Production	N_2O	15.52	33.60	0.0292

2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	40.31	26.84	0.0233
2.B.8 Petrochemical and Carbon Black Production	CO_2	40.31	122.07	0.1061
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.31	8.90	0.0077
2.B.10 Other chemical industry	CO_2	3.91	9.12	0.0079
2.C.1 Iron and Steel Production	CO_2	12.21	889.45	0.7729
2.C.1 Iron and Steel Production	CH_4	30.81	3.24	0.0028
2.C.2 Ferroalloys Production	CO_2	25.50	0.14	0.0001
2.C.2 Ferroalloys Production	CH_4	25.50	0.99	0.0009
2.C.5 Lead Production	CO_2	50.99	4.73	0.0041
2.C.6 Zinc Production	CO_2	50.99	0.29	0.0003
2.D.1 Lubricant Use	CO_2	50.25	57.76	0.0502
2.D.2 Paraffin Wax Use	CO_2	50.25	2.96	0.0026
2.D.3 Other non-energy products from fuels and solvent use	CO_2	7.07	1.34	0.0012
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	15.30	0.58	0.0005
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	15.30	0.00	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	43.57	1344.49	1.1683
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	43.57	0.43	0.0004
2.F.2 Foam Blowing (CO_2 eq.)	HFC	41.88	2.65	0.0023
2.F.3 Fire Protection (CO_2 eq.)	HFC	41.88	9.94	0.0086
2.F.3 Fire Protection (CO_2 eq.)	PFC	41.88	0.01	0.0000
2.F.4 Aerosols (CO_2 eq.)	HFC	41.88	1.57	0.0014
2.F.5 Solvents (CO_2 eq.)	HFC	41.88	0.66	0.0006
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	43.57	30.67	0.0267
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	43.5660	1.9172	0.0017
2.G.3 N_2O from product uses	N_2O	43.5660	97.3701	0.0846
3.A Enteric Fermentation	CH_4	15.8114	467.6159	0.4064
3.B Manure Management	CH_4	22.3607	165.7447	0.1440
3.B Manure Management	N_2O	40.3113	338.1915	0.2939
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	20.6155	569.1102	0.4945
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	30.4138	256.2878	0.2227
3.G Liming	CO_2	30.4138	51.0985	0.0444
3.H Urea application	CO_2	52.2015	110.0208	0.0956
5.A Solid Waste Disposal on Land	CH_4	63.6993	2338.4702	2.0321
5.B Biological treatment of solid waste	CH_4	91.2874	591.3188	0.5138
5.B Biological treatment of solid waste	N_2O	5.0359	3.2029	0.0028
5.C Incineration and open burning of waste	CO_2	15.8114	17.9767	0.0156
5.C Incineration and open burning of waste	CH_4	82.4621	0.0017	0.0000
5.C Incineration and open burning of waste	N_2O	72.8011	1.6693	0.0015
5.D Wastewater treatment and discharge	CH_4	58.3835	505.2226	0.4390
5.D Wastewater treatment and discharge	N_2O	56.3560	111.2742	0.0967
		Level uncertainty =	**9630.9895**	**3.65**

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

		Uncertainty of Trend				
IPCC Source Category	**Gas**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by EF uncertainty**	**Uncertainty in trend in national emissions introduced by AD uncertainty**	**Uncertainty introduced into the trend in total national emissions**
1.A.1 Energy industries - Solid Fuels	CO_2	0.0888	0.2839	0.2664	1.6057	1.6277
1.A.1 Energy industries - Solid Fuels	CH_4	0.0000	0.0001	0.0011	0.0004	0.0012
1.A.1 Energy industries - Solid Fuels	N_2O	0.0004	0.0012	0.0223	0.0070	0.0234
1.A.1 Energy industries - Liquid Fuels	CO_2	-0.0035	0.0022	-0.0106	0.0154	0.0187
1.A.1 Energy industries - Liquid Fuels	CH_4	0.0000	0.0000	-0.0002	0.0000	0.0002
1.A.1 Energy industries - Liquid Fuels	N_2O	0.0000	0.0000	-0.0006	0.0000	0.0006
1.A.1 Energy industries - Gaseous Fuels	CO_2	0.0117	0.0166	0.0294	0.0704	0.0762
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.0000	0.0000	0.0003	0.0000	0.0003
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.0000	0.0000	0.0004	0.0000	0.0004
1.A.1 Energy industries - Biomass	CH_4	0.0001	0.0001	0.0046	0.0011	0.0048
1.A.1 Energy industries - Biomass	N_2O	0.0001	0.0001	0.0089	0.0017	0.0090
1.A.1 Energy industries - Other Fossil Fuels	CO_2	0.0013	0.0014	0.0263	0.0396	0.0475
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.0000	0.0000	0.0005	0.0003	0.0006
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.0000	0.0000	0.0012	0.0005	0.0013
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	-0.1106	0.0184	-0.3319	0.1038	0.3477
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	-0.0003	0.0000	-0.0133	0.0003	0.0133
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	-0.0005	0.0001	-0.0285	0.0004	0.0285
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	-0.0331	0.0017	-0.0992	0.0123	0.1000
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0.0000	0.0000	-0.0017	0.0000	0.0017
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	-0.0001	0.0000	-0.0048	0.0000	0.0048
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	0.0090	0.0296	0.0224	0.1255	0.1275
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	0.0000	0.0000	0.0002	0.0001	0.0002
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	0.0000	0.0000	0.0003	0.0001	0.0003
1.A.2 Manufacturing industries and construction - Biomass	CH_4	0.0001	0.0001	0.0043	0.0014	0.0046
1.A.2 Manufacturing industries and construction - Biomass	N_2O	0.0001	0.0002	0.0082	0.0022	0.0085
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.0025	0.0025	0.0382	0.0360	0.0524
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.0000	0.0000	0.0011	0.0003	0.0011
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.0000	0.0000	0.0020	0.0005	0.0021
1.A.3.a Transport - Civil Aviation	CO_2	-0.0004	0.0001	-0.0018	0.0003	0.0018
1.A.3.a Transport - Civil Aviation	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport - Civil Aviation	N_2O	0.0000	0.0000	-0.0004	0.0000	0.0004
1.A.3.b Transport - Road transportation	CO_2	0.0768	0.0992	0.3046	0.4208	0.5195
1.A.3.b Transport - Road transportation	CH_4	0.0000	0.0002	0.0024	0.0006	0.0025
1.A.3.b Transport - Road transportation	N_2O	0.0015	0.0020	0.2064	0.0086	0.2065
1.A.3.c Transport - Railways	CO_2	-0.0008	0.0015	-0.0012	0.0109	0.0109
1.A.3.c Transport - Railways	CH_4	0.0000	0.0000	-0.0002	0.0000	0.0002
1.A.3.c Transport - Railways	N_2O	-0.0001	0.0002	-0.0132	0.0012	0.0132
1.A.3.d Transport - Domestic navigation	CO_2	-0.0001	0.0001	-0.0002	0.0005	0.0005
1.A.3.d Transport - Domestic navigation	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.d Transport - Domestic navigation	N_2O	0.0000	0.0000	-0.0001	0.0000	0.0001
1.A.3.e Transport - Other Transportation	CO_2	0.0003	0.0003	0.0010	0.0019	0.0022
1.A.3.e Transport - Other Transportation	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport - Other Transportation	N_2O	0.0000	0.0000	0.0000	0.0000	0.0000

1.A.4 Other sectors - Solid Fuels	CO_2	-0.0655	0.0215	-0.1964	0.1215	0.2309
1.A.4 Other sectors - Solid Fuels	CH_4	-0.0032	0.0017	-0.1583	0.0094	0.1585
1.A.4 Other sectors - Solid Fuels	N_2O	-0.0003	0.0001	-0.0164	0.0006	0.0164
1.A.4 Other sectors - Liquid Fuels	CO_2	-0.0076	0.0069	-0.0229	0.0488	0.0539
1.A.4 Other sectors - Liquid Fuels	CH_4	0.0000	0.0000	-0.0013	0.0001	0.0013
1.A.4 Other sectors - Liquid Fuels	N_2O	0.0000	0.0001	0.0024	0.0009	0.0026
1.A.4 Other sectors - Gaseous Fuels	CO_2	0.0268	0.0419	0.0670	0.1780	0.1902
1.A.4 Other sectors - Gaseous Fuels	CH_4	0.0001	0.0001	0.0030	0.0004	0.0030
1.A.4 Other sectors - Gaseous Fuels	N_2O	0.0000	0.0000	0.0009	0.0001	0.0009
1.A.4 Other sectors - Biomass	CH_4	0.0020	0.0032	0.1009	0.0361	0.1071
1.A.4 Other sectors - Biomass	N_2O	0.0003	0.0005	0.0192	0.0057	0.0200
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.0016	0.0016	0.0047	0.0110	0.0119
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.0000	0.0000	0.0001	0.0000	0.0001
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.0000	0.0000	0.0023	0.0003	0.0023
1.B.1.a Coal Mining and Handling	CO_2	-0.0008	0.0009	-0.0194	0.0050	0.0200
1.B.1.a Coal Mining and Handling	CH_4	-0.0191	0.0183	-0.2485	0.1035	0.2692
1.B.1.b Solid Fuel Transformation	CH_4	0.0000	0.0000	0.0011	0.0014	0.0018
1.B.2.a Oil	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a Oil	CH_4	-0.0001	0.0000	-0.0042	0.0003	0.0042
1.B.2.b Natural Gas	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Natural Gas	CH_4	-0.0006	0.0032	-0.0437	0.0317	0.0540
1.B.2.c Venting and Flaring	CO_2	0.0000	0.0000	0.0010	0.0003	0.0010
1.B.2.c Venting and Flaring	CH_4	0.0001	0.0002	0.0060	0.0016	0.0062
2.A.1 Cement Production	CO_2	0.0005	0.0095	0.0010	0.0270	0.0270
2.A.2 Lime Production	CO_2	-0.0013	0.0036	-0.0025	0.0102	0.0105
2.A.3 Glass Production	CO_2	0.0003	0.0008	0.0005	0.0055	0.0055
2.A.4 Other process uses of carbonates	CO_2	0.0015	0.0019	0.0150	0.0135	0.0202
2.B.1 Ammonia Production	CO_2	0.0003	0.0038	0.0018	0.0272	0.0273
2.B.2 Nitric Acid Production	N_2O	-0.0026	0.0012	-0.0389	0.0069	0.0395
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	0.0001	0.0004	0.0041	0.0026	0.0049
2.B.8 Petrochemical and Carbon Black Production	CO_2	-0.0012	0.0017	-0.0469	0.0120	0.0485
2.B.8 Petrochemical and Carbon Black Production	CH_4	0.0000	0.0001	-0.0003	0.0009	0.0009
2.B.10 Other chemical industry	CO_2	0.0013	0.0013	0.0033	0.0056	0.0065
2.C.1 Iron and Steel Production	CO_2	0.0059	0.0409	0.0594	0.4049	0.4092
2.C.1 Iron and Steel Production	CH_4	0.0000	0.0001	0.0002	0.0006	0.0006
2.C.2 Ferroalloys Production	CO_2	0.0000	0.0000	0.0001	0.0000	0.0001
2.C.2 Ferroalloys Production	CH_4	0.0000	0.0000	0.0005	0.0002	0.0005
2.C.5 Lead Production	CO_2	0.0000	0.0001	0.0019	0.0007	0.0020
2.C.6 Zinc Production	CO_2	0.0000	0.0000	0.0002	0.0000	0.0002
2.D.1 Lubricant Use	CO_2	0.0002	0.0006	0.0112	0.0046	0.0121
2.D.2 Paraffin Wax Use	CO_2	0.0000	0.0000	-0.0001	0.0002	0.0002
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.0001	0.0001	0.0005	0.0007	0.0009
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.0000	0.0000	0.0003	0.0001	0.0003
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.0173	0.0173	0.3984	0.9064	0.9901
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.0000	0.0000	0.0001	0.0003	0.0003
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.0000	0.0000	0.0008	0.0018	0.0019
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.0001	0.0001	0.0031	0.0066	0.0073
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.4 Aerosols (CO_2 eq.)	HFC	0.0000	0.0000	0.0005	0.0010	0.0012
2.F.5 Solvents (CO_2 eq.)	HFC	0.0000	0.0000	0.0002	0.0004	0.0005
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	0.0001	0.0004	0.0021	0.0207	0.0208
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.0000	0.0000	0.0006	0.0013	0.0014
2.G.3 N_2O from product uses	N_2O	0.0005	0.0013	0.0117	0.0656	0.0667
3.A Enteric Fermentation	CH_4	-0.0043	0.0166	-0.0640	0.1174	0.1337
3.B Manure Management	CH_4	-0.0020	0.0042	-0.0397	0.0588	0.0710
3.B Manure Management	N_2O	-0.0012	0.0047	-0.0466	0.0333	0.0572
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	0.0003	0.0155	0.0051	0.1096	0.1097
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	-0.0001	0.0047	-0.0025	0.0334	0.0335

3.G Liming	CO_2	-0.0034	0.0009	-0.1009	0.0067	0.1011
3.H Urea application	CO_2	0.0008	0.0012	0.0395	0.0251	0.0468
5.A Solid Waste Disposal on Land	CH_4	0.0134	0.0206	0.8554	0.0000	0.8554
5.B Biological treatment of solid waste	CH_4	0.0036	0.0036	0.3314	0.0257	0.3324
5.B Biological treatment of solid waste	N_2O	0.0004	0.0004	0.0002	0.0025	0.0025
5.C Incineration and open burning of waste	CO_2	0.0006	0.0006	0.0028	0.0135	0.0138
5.C Incineration and open burning of waste	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and open burning of waste	N_2O	0.0000	0.0000	0.0008	0.0004	0.0009
5.D Wastewater treatment and discharge	CH_4	0.0016	0.0049	0.0816	0.2071	0.2225
5.D Wastewater treatment and discharge	N_2O	0.0003	0.0011	0.0130	0.0408	0.0428
					Trend uncertainty =	**2.3307**

Annex 3 Detailed methodological descriptions for individual sources or sink categories

A3. 1 Updates of the country specific emission and oxidation factors for determination of CO_2 emissions from combustion of bituminous coal and lignite (brown coal) in the Czech Republic

1. Introduction

Emissions of CO_2, produced during the combustion of solid fuels, have in the Czech Republic a very significant contribution to the overall emissions of greenhouse gases. Emissions of CO_2 are according to the IPCC methodology determined as a product of the consumption of fuels, expressed as amount of energy contained in the fuels determined on the basis of net calorific value (TJ), emission factor for CO_2 (t CO_2/TJ) and oxidation factor. In the met

hodology for GHG inventory, IPCC provides default emission factors for CO_2, for the individual types of fuels (IPCC,1997 and 2006).

The default emission factors, tabulated in IPCC methodology were determined as middle values on the basis of many calorimetric and analytical tests of individual types of fuels. It is necessary to remember that the used data for determination of this emission factors has predominantly American origin and further comes from the 80s. For the needs of current national inventory, where the nature of the various types of fuels may be different, the default emission factors are not necessary sufficiently satisfactory.

Hence, the new versions of the IPCC methodology (IPCC, 2000 and 2006) recommends to all countries, where emissions of CO_2 from combustion of solid fuels is a so called key category, to check and update the emission factors of CO_2 for calculation of emissions of CO_2 on the basis of national data. In the Czech Republic, where the main part of the CO_2 emissions from solid fuels comes from the combustion of lignite (brown coal) and bituminous coal, it is significant to determine country specific emission factors for these two types of fuels.

The default emission factors for lignite (brown coal) and bituminous coal, provided in the older and newer version of the IPCC methodology, practically do not differ. In the recommended values for oxidation factor, however a substantial change appeared: while the older version (IPCC, 1997) reported default value of oxidation factor 0.98, new version (IPCC 2006) provides default value of 1, which is the maximum possible and considering the solid fuels, in practice unreachable. In the IPCC methodology this change was introduced, because the authors of the new version were aware that these values are for solid fuels so geographically and technologically specific, that it could be difficult to generalize them. Default value of 1 was chosen as a conservative estimate, preventing possible underestimation of emission determination. Therefore a country, which wants to prevent possible overestimation of the emissions of CO_2 from combustion of solid fuels, has to determine representative country specific values of oxidation factor for individual types of solid fuels, on the basis of local data.

For determination of the country specific emission factors it is necessary to obtain data about the carbon content in given type of fuel and its net calorific value.

The factor for the carbon content (CC) is for the individual types of solid fuels defined as the ratio of weight of the carbon and the amount of energy in this fuel of the mass m

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

where wc is the fraction of mass of carbon in the fuel and Q_i is its net calorific value. It is important to notice, that all variables in the equation (A3-1) are related to the fuel (carbon) with its current water content in the supplied fuel, i.e. in the state, when it is determined the quantity (i.e. mass): raw - index ^{r} .

As the calorific value is expressed in MJ/kg (=TJ/kt), carbon content in% mass (C^r = 100*w_C) and CC in t C/TJ, it is possible to rewrite the previous equation to:

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

The emission factor for CO_2 (t CO_2/TJ) is obtained by multiplying by the ratio of the molar weight of carbon dioxide and carbon

$$EF(CO_2) = CC \cdot 3.664 \qquad \text{(A3-3)}$$

IPCC methodology provides the following default factors for carbon content CC:

Lignite (brown coal): 27.6 (t C/TJ)

Bituminous coal: 25.8 (t C/TJ)

In the Czech national inventory these emission factors were used until 2006. On the basis of the recommendation of international expert review team (ERT) of UNFCCC, during the review conducted in February 2007, it was decided to use for lignite (brown coal) and bituminous coal factors for CC values 25.43 and 27.27 (t C/TJ), which can be found in the national study from 1999 (Fott, 1999) and are pertaining to the state of the coal in the Czech Republic in the 90s. For determination of the oxidation factor the necessary data was not available, therefore for all solid fuels was used the default value of 0.98 from 1996 Guidelines, for the whole time series from 1990 to 2012 (2006 Guidelines come into force from the current year 2013).

In the last years related to the implementation of the emission trading within EU ETS, the operators of the bigger plants combusting coal began to systematically address the laboratory determined emission factors for different types of coal, combusted in these plants according to the prescribed requirements of the European Directive 82/2003 EC including the relevant guidelines, regarding the methodology of monitoring. Some operators gradually extended this assessment also by the determination of oxidation factors, whose values depend not only on the type of coal, but also on the nature of the combustion source.

Data from the coal analysis from 1999 naturally was not so extensive. Further the coal base in the beginning of the 90s in the Czech Republic largely changed - production in less efficient mines have been gradually phased out and the in the existing mines now often is extracted on different places for example, in deeper coal layers. For these reasons, the research team of the Czech national inventory decided in the frame of its improvement plan to revise the emission factors, used until now and to determine new oxidation factors. Detailed description of the used approach, input data and discussion of the reached results, can be found in the study of authors E. Krtková, P. Fott and V. Neužil, prepared for publication in scientific journal. In the further text of this Annex clarification of the principle of the used method is reported and the reached results from the above mentioned paper are presented.

2. Revision and updating of nationally specific emission factors

In the last years, lignite (brown coal) is extracted mostly in the North Bohemia (Mostecko), where is the most significant brown coal area in the Czech Republic, and to a lesser extent in the West Bohemian region (Sokolovsko). Bituminous coal is currently quarried only in Ostrava-Karvina district, in the large coalfield, whose greater part is situated in the neighboring country Poland. Lignite (brown coal) is in the Czech Republic extracted from the surface mines, while bituminous coal is extracted from the underground mines.

Overview of data sets for updating emission factors

Set “ČEZ“

The most extensive collection of data with the results of chemical analyzes, including calorific values, gained the national inventory team from the company ČEZ, which operates most of the coal-fired power plants in CR, burning in particular energy (pulverized) lignite (brown coal). The set contains 29 samples of bituminous energy (pulverized) coal and 146 samples of lignite (brown coal), mainly energy one and to a lesser extent also sorted one - 25 samples and this is mostly from North Bohemian region, and in to a lesser extent from West Bohemian region.

Set “Dalkia”

Except from the company ČEZ, the research team received extended set of relevant coal data from the company Dalkia, which operates particularly power and heat plants, combusting mostly bituminous energy coal in the east part of the Czech Republic and with a lesser extent lignite (brown coal). The set “Dalkia” contains analyzes mostly of bituminous coal (143 samples) and 36 samples of lignite (brown coal).

Combined set of aggregated data

In order to evaluate the parameters, required for determining of country specific emission factors, the primary data was aggregated as it follows: aggregated items from the above mentioned sets (“ČEZ” and “Dalkia”) were acquired as average of calorific value and the percentage of carbon content from six to twelve analyzed samples (i.e. analysis of monthly collected samples).

Combined set was extended by 3 aggregated items (yearly average for 2012) by lignite (brown coal) from West Bohemian region (Sokolovská uhelná).

The combined set included three major operators of combustion sources in the Czech Republic and contains of 37 aggregated items altogether, from which 19 from the set “ČEZ”, 15 from set “Dalkia”, three were obtained as described in the previous paragraph. This set contains 23 aggregated items of lignite (brown coal) (from which 4 from set “Dalkia”) and 14 for bituminous coal (3 items come from the set “ČEZ”, the rest 11 items are from the set “Dalkia”). 18 aggregated items for lignite (brown coal) come from a larger North Bohemian region, 5 items of lignite (brown coal) – from smaller West Bohemian region.

The range of the net calorific value for lignite (brown coal) is, from this set, between 9.9 and 18.5 MJ/kg, while the range of the net calorific value for black coal is between (16.2 and 26.4 MJ/kg).

Set “ETS”

The set contains data from the ETS database created in CHMI, to which have been saved certified forms, filled by the operators of energy installations in the Czech Republic under the ETS. These forms, containing data for 2011, were provided to CHMI from the Ministry of Environment. For the processing there were taken into account only those installations whose annual emissions exceeded 50 kt CO_2 and which, in accordance with monitoring guidelines of EU, determined emission factors from the laboratory data. In this way there were processed 34 sources, combusting lignite (brown coal) and 13 – combusting bituminous coal.

The range of net calorific value for lignite (brown coal) was in this case between 10.4 and 18.8 MJ/kg, while for bituminous coal - was between 17.1 and 26.8 MJ/kg.

The procedure for evaluating of the emission factors

In the above mentioned article from 1999 (Fott, 1999) it was demonstrated linear correlation between the carbon content C^r [%] in the coal and its calorific value Q_i^r [MJ/kg].

$$C^r = a \cdot Q_i^r + b \qquad \text{(A3-4)}$$

with a correlation coefficient r^2 higher than 0.99. This correlation equation fits for bituminous and lignite (brown coal), therefore both types of coal can be described by one equation (i.e. a single pair of parameters a, b).

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

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

In this way a country specific parameters a, b were evaluated in equation (A3-4), (A3-5) instead of two separate values of country specific factor for lignite (brown coal) and for bituminous coal.

This procedure was applied also on current data. For the process there were used the two most representative sets: combined set of aggregated data, hereinafter referred as “Comb” and “ETS”.

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

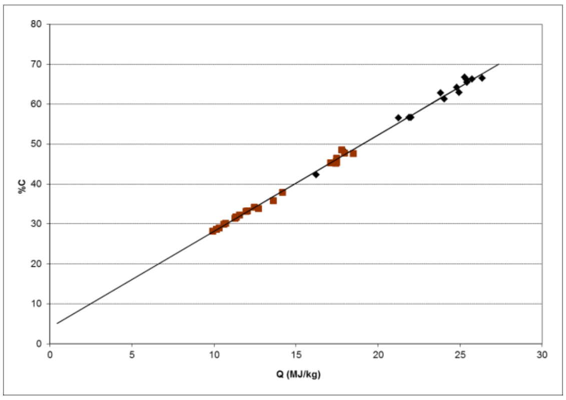


Fig. A3 1 Combined set of aggregated data “Comb”. Correlation between carbon content (%C) and net calorific value for lignite (brown coal) (indicated with brown squares) and bituminous coal (indicated with black squares)

In terms of the uncertainty of emission determination, it is necessary to assess the extent to which the carbon content factor values differ from the values determined by the curve (5). This is graphically illustrated on Fig. A3 2. Numerically, the difference between the individual points from the calculated curve can be characterized with the mean relative error, which is 1.14% for lignite (brown coal) and 1.30% for bituminous coal. Nevertheless, the mean relative error of any kind of coal does not exceed 3%. Therefore, the uncertainty of the carbon content factors and thus the uncertainty of CO_2 emission factors can be considered as acceptable.

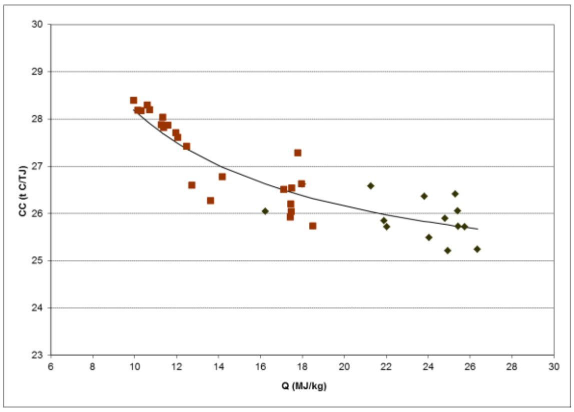


Fig. A3 2 Combined set of aggregated data “Comb”. Correlation between the factor of carbon content CC and net calorific value for brown coal (indicated as brown squares) and black coal (indicated as black squares), found through the eq. A3-5.

In the set “ETS” values Q_i^r and factors for CC were available, but the carbon content in percentages was not given. Therefore the parameters a, b were assessed with non-liner regression, using the equation (A3-5). In this way the parameters a = 2.4211 and b = 3.9539 were determined. In this case the mean relative error for lignite (brown coal) was equal to 1.59% and for bituminous coal was equal to 1.73%.

The parameters a, b, evaluated from the both sets are very similar. However, statistical indicators characterizing uncertainty are in the case of set "ETS" somewhat higher, than for the combined set.

3. Determination of country specific oxidation factors

Formula for calculation of oxidation factor from analytical data

Oxidation factor from analytical data is calculated using the following formula.

$$OF = 1 - \frac{A}{C \cdot \left(\frac{1}{C,out - 1}\right)} = 1 - \frac{A \cdot C,out}{C \cdot (1 - C,out)}$$

where OF is oxidation factor (with value somewhat lower than 1), A is the mass fraction of ash, C is the mass fraction of carbon and C,out is the mass fraction of carbon on the exit of the combustion device (the mass fractions are values in the interval between 0 and 1, e.g. 40% corresponds to mass fraction of 0.4). In case, that on the exit both forms of ash are present (slag and dry ash), C,out is calculated as weighted average of the fraction of non-combusted carbon in both forms of ash.

Sets of data used for determination of oxidation factors and their processing

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_2 (t CO_2/TJ) and oxidation factor. CzSO provides annual fuel consumption for each category of sources, both in weight units and in energy units determined using the net calorific value. The national inventory research team uses this data as an input activity data.

For determination of the CO_2 emission factor it is necessary to define appropriate emission and oxidation factor for individual categories and for the whole time series. Regarding the updating of the country specific emission factors, the research team decided to determine them as an average of two values: emission factor, calculated using the eq. A3-5, using the parameters **a = 2.4142** and **b = 4.0291**, determined from the combined file "Comb" and emission factor calculated using the parameters **a =2.4211** and **b = 3.9539**, calculated from the file "ETS". The reason for this decision is the very good correspondence of the relevant curves calculated from equation (A3-5) of these two representative sets.

In the case of the oxidation factors the research team decided to use till 2010 so far used oxidation factor of 0.98 and from year 2011 the newly determined country specific oxidation factor presented in section 3. The reason for this decision is the fact that the current values were determined, based on data recorded between 2011 and 2012, while the data for the previous years was not available. However, the newly established oxidation factors suggest that so far used value 0.98 corresponds better to reality than the default value of 1 pursuant to 2006 Guidelines.

Examples of setting of CO_2 emission factors, 2013

a) Lignite (brown coal)

In tab. 3-11, chapter "Energy" is provided average calorific value of 13.409 MJ/kg, CC factor is calculated as:

$$\frac{10 \cdot \left(\frac{2.4142 + 4.0291}{13.409}\right) + 10 \cdot \left(\frac{2.4211 + 3.9539}{13.409}\right)}{2} = \frac{27.147 + 27.160}{2} = 27.153 \ \frac{t\ C}{TJ}$$

To this corresponds emission factor for CO_2

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

27.153 • 3.664= 99.489 t CO_2/TJ. Resultant emission factor for CO_2 including the oxidation factor has a value of.

$$99.489 \cdot 0.9846 = 97.957 \frac{t\ CO_2}{TJ}$$

b) Bituminous coal

In tab. 3-11, chapter "Energy" is provided average calorific value of 25.502 MJ/kg, CC factor is calculated as:

$$\frac{10 \cdot \left(\frac{2.4142 + 4.0291}{25.502}\right) + 10 \cdot \left(\frac{2.4211 + 3.9539}{25.502}\right)}{2} = \frac{25.722 + 25.761}{2} = 25.742 \ \frac{t\ C}{TJ}$$

To this corresponds emission factor for CO_2

$$25.742 \cdot 3.664 = 94.317 \frac{t\,CO_2}{TJ}$$

Resultant emission factor for CO_2 including the oxidation factor has a value of

$$94.317 \cdot 0.9707 = 91.554 \frac{t\,CO_2}{TJ}$$

A3. 2 Country specific CO_2 emission factor for LPG

In order to enhance the accuracy of emission estimates from Energy sector the research with aim to develop country specific emission factor for LPG was carried out last year. LPG is the mixture of propane and butane and other C2 – C5 hydrocarbons and is available in two versions – summer and winter mixture. The basic qualitative parameters are available in the official Czech Standard ČSN EN ISO 4256. These parameters are given in Tab. A3 - 1.

Tab. A3 - 1 Qualitative parameters of LPG – summer and winter mixture

PARAMETER*)	summer mixture	winter mixture
C2-hydrocarbons and inerts -%, max.	7	7
C3- hydrocarbons -%, min.	30	55
C4- hydrocarbons -%	30 - 60	15 - 40
C5-and higher hydrocarbons -%, max.	3	2
Unsaturated hydrocarbons -%, max.	60	65
Hydrogen sulfide - $mg.kg^{-1}$, max.	0.2	0.2
Content of sulphur - $mg.kg^{-1}$, max.	200	200

**)% in the table mean mass percents*

For the determination of country specific emission factor is necessary to obtain data about composition of LPG, which is distributed in the territory of the Czech Republic. These data were obtained from the Česká rafinérská, a.s., which is the major distributor of the LPG in the CR. The quality of distributed LPG is based on the above mentioned official standard (ČSN EN ISO 4256) and so also the data provided by Česká rafinérská, a.s. are in line with this standard. The specific composition is listed in Tab. A3 - 2.

Tab. A3 - 2 Composition of LPG distributed in the Czech Republic (in mass percents)

Composition	summer mixture	winter mixture
C2+inerts	0.2	0.1
propane	38.5	58.7
propylene	7.2	4.5
iso-butane	25.6	27.9
n-butane	15.7	5.9
sum of butens	12.2	2.8
C5 and higher	0.6	0.1
Ratio of the production of summer : winter mixture = circa 1 : 1.1		

This elementary composition of LPG (given in Tab. A2-2) was used for the calculations of country specific emission factor (based on the carbon content in each component). At first carbon emission factors related to the mass of LPG (kg C/kg LPG) were computed. For the summer mixture is the carbon emission factor equal to 0.8287 kg C/kg; for winter mixture 0.8232 kg C/kg. Final value computed using weighted average taking in consideration the summer : winter mixture ratio is equal to 0.8258 kg C/kg.

The net calorific value related to the mass (MJ/kg) was computed using equation A2-2. For the summer mixture is net calorific value equal to 45.853 MJ/kg; for the winter mixture to 46.029 MJ/kg. Final value computed using weighted average taking in consideration the summer : winter mixture ratio is equal to 45.945 MJ/kg. This net calorific value was also used for the conversion of activity data from kilotons to TJ.

Final emission factor was determined using equation A3-7

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

This value is in very good agreement with the value 17.9 t C/TJ determined in Harmelen and Koch (2002); corresponded net calorific value is 45.5 MJ/kg (Harmelen and Koch, 2002), which is also in a good agreement with the value determined as Czech country specific.

Tab. A3 – 3 indicates comparison of the newly developed country specific CO_2 emission factor and the default one provided either in Revised 1996 Guidelines (IPCC, 1997) or in 2006 Guidelines (IPCC 2006). It is necessary to keep in mind, that 2006 Guidelines states the range of default emission factors, which for LPG is 16.8 – 17.9 t C/TJ. It is apparent that default emission factors slightly underestimate the emission estimates. The country specific emission factor does not fit into the default interval, which also supports this conclusion. Since country specific emission factor was evaluated based on the specific composition of LPG distributed in the Czech Republic, the newly developed emission factor will evaluate the emission estimates more accurate than the default emission factor.

Tab. A3 - 3 Comparison of country specific CO_2 and default emission factors for LPG

	[t C/TJ]	[t CO_2/TJ]
Revised 1996 Guidelines	17.2	63.07
2006 Guidelines	17.2	63.1
CO_2 country specific emission factor for CR	17.97	65.90

Based on the composition of LPG was also net calorific value computed, which agreed better to the specific conditions of CR then the net calorific value presented in CzSO questionnaire. The updated net calorific value was used for the computation of fuel consumption in TJ; the value 45 945 kJ/kg was used (conversion from kt to TJ).

A3. 3 Country specific CO_2 emission factor for Refinery Gas

Another improvement concerning emission factor from combustion of Refinery Gas was accomplished in 2013. Refinery gas is defined as non-condensable gas obtained during distillation of crude oil or treatment id oil products in refineries. It consists mainly of hydrogen, methane, ethane and olefins (IPCC 2006).

Refinery Gas in CR is also used mainly by Česká rafinérská, a.s. This company is also included in the EU ETS and in terms of this obligation also carries out the analyses of molar composition of Refinery Gas. These analyses were provided to the inventory team for the purposes of the development of country specific CO_2 emission factor from combustion of Refinery Gas. These analyses obtain the information about content of hydrogen, content of CO_2, content of CO, content of methane, ethane, propane, iso-butane, n-butane, butenes, iso-pentanes, n-pentanes, ethylene, propylene, C6 and higher hydrocarbons, content of oxygen, nitrogen, hydrogen sulphide and water in the Refinery Gas. The analyses are available for the 2008 – 2012 in the time step 3 – 4 days.

It is apparent that the available analyses are sufficiently detailed, so it allowed the inventory to team to develop country specific emission factor for the Czech Republic. The approach of 'carbon content in the fuel', which was fully attested in case of determination of country specific emission factor from combustion of Natural Gas (Krtková et al., 2014), was also used for determination of Refinery Gas emission factor. Based on the molar composition of the gas mixture the country specific emission factors for years 2008 – 2012 were determined. For the years before the average value of the 2008 – 2012 values was used. The table below shows the used values.

Tab. A3 - 4 Country specific carbon emission factors from combustion of Refinery Gas (t C/TJ)

1990 - 2007	2008	2009	2010	2011	2012
15.03	15.06	14.93	14.58	15.24	15.34

All values in the table lies within the default range 13.1 – 18.8 t C/TJ specified in the 2006 Guidelines and further more are close to the default value 15.7 t C/TJ (IPCC 2006). However, the previously used default value provided by the 1996 Guidelines (IPCC, 1997) was somewhat higher, 18. 2 t C/TJ.

Also net calorific value of Refinery Gas was computed based on the available analyses of the molar composition. CzSO has updated this value based on the request of the inventory team. The updated value is 46.023 MJ/kg. This value was used for the whole time series.

A3. 4 Country specific CO_2 emission factor for Natural Gas combustion

Extensive research was carried out in 2012 with aim to develop the country-specific emission factor for Natural Gas combustion (CHMI, 2012b). This research was part of a project of The Technical Assistance of the Green Savings programme. Final evaluation of the CO_2 emission factor for Natural Gas combustion is based on its correlation with the net calorific value. Detailed description of the research is given in the following paragraphs.

Complete description of this research will be published in Greenhouse Gas Measurement & Management journal, the manuscript is entitled Carbon dioxide emissions from natural gas combustion – country specific emission factors for the Czech Republic (Krtková et al., 2014).

The net calorific value of Natural Gas can be computed on the basis of the molar composition according to:

$$Qm = \sum wi \bullet Qmi \quad \text{(A3-8)}$$

$$Qv = Qm \bullet d \quad \text{(A3-9)}$$

where Q_m [MJ/kg] is the net calorific value of Natural Gas related to its mass, w [kg/kg] is the mass fraction, Q_{mi} [MJ/kg] is the net calorific value of different components of Natural Gas related to their mass, Q_v [MJ/m^3] is the net calorific values of Natural Gas related to its volume and d [kg/m^3] is its density.

Tab. A3 - 5 lists the net calorific values of the basic components of Natural Gas.

Tab. A3 - 5 Net calorific values of the basic components of Natural Gas (ČSN EN ISO 6976, 2006)

Net calorific values of basic components of Natural Gas [MJ/kg]	
methane	50.035
ethane	47.52
propane	46.34
iso-butane	45.57
n-butane	45.72
iso-pentane	45.25
n-pentane	45.35
sum C>6 (like heptane)	44.93

The carbon emission factor for Natural Gas related to its energy content (CEF_{TJ} [t C/TJ]) is computed according to

$$CEFTJ = CEF_m/Q_m \quad \text{(A3-10)}$$

where CEF_m is carbon emission factor related to the mass.

Carbon dioxide emission factor (EF (CO_2) [t CO_2/TJ]) is then calculated

$$EF\ (CO_2) = CEFTJ \bullet M_{CO2}/M_C \quad \text{(A3-11)}$$

where M_{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_2) and Q_v for 10 characteristic samples of Natural Gas was used in the article (Čapla and Havlát, 2006). Samples 1 – 4 were chosen based on their place of origin: sample 1 – Natural Gas from Russian gas fields distributed in Czech Republic in 2001; sample 2 – Natural Gas from Norwegian gas fields in the North Sea; sample 3 – Natural Gas coming from Dutch gas fields; sample 4 – Natural Gas mined in Southern Moravia. Samples 5 – 10 represented the composition of the Natural Gas distributed in the Czech Republic in 2005 – 2006.

This rather representative dataset was used to determine the regression curve, which was similar to the line

$$EF (CO_2) = 0.269 \bullet (Qv/3.6)^2 - 2.988 \bullet (Qv/3.6) + 59.212 \qquad (A3\text{-}12)$$

which was tightly fit to all 10 points (correlation coefficient R^2 = 0.999). In this correlation expression Q_v represents the net calorific value related to the volume under "trade conditions" (101.3 kPa, 15° C).

The calculations of the regression curve for the samples 5 – 10 indicated in particularly close range of Qv: 34.11 – 34.27 MJ/m^3. The lowest net calorific value (31.31 MJ/m^3) was determined for sample number 3 (Dutch field) and the highest (38.28 MJ/m^3) for Norwegian gas type. The low net calorific value of Dutch Natural Gas is caused by relatively high content of nitrogen; the high net calorific value of the Norwegian Natural Gas is a result of the higher content of C2, C3 and C4 hydrocarbons (especially ethane).

The above-described methodology was tested on a relatively small dataset. To obtain sufficiently reliable correlation, this methodology had to be tested on a dataset which would provide composition of Natural Gas in sufficient time series. In cooperation with CzSO a dataset comprising analyses of Natural Gas composition was obtained. These analyses are continuously evaluated in the laboratory of NET4GAS, Ltd. Daily average values on the Natural Gas composition from the first day in the month were available for evaluation of the CO_2 emission factor. The dataset of these analyses began on 1st January 2007 and the last data are from 1st September 2011. Furthermore data for 1st February 2012 were also available. The report on each analysis contains data on the molar composition of the Natural Gas, physical characteristics and conditions during which the analysis was performed. Overall, 58 analyses were available. Fig. A3 3 depicts the trend of net calorific values in time.

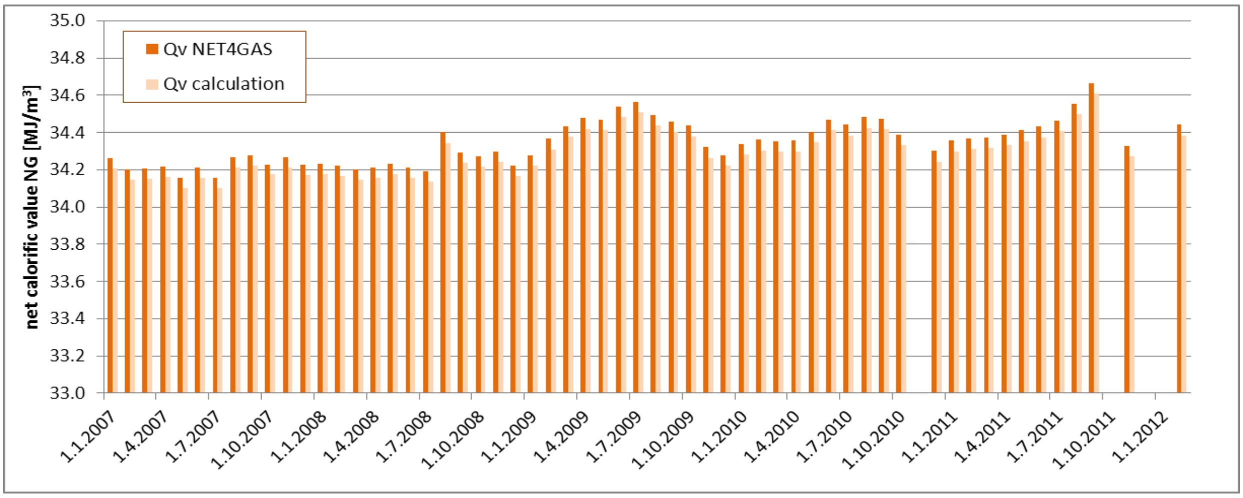


Fig. A3 3 Net calorific values given in NET4GAS Ltd. reports and net calorific values calculated on the basis of composition of Natural Gas in 1.1.2007 – 1.2.2012 (both values are given at 15°C)

The figure indicates a good match between the two depicted values; the deviation is almost constant and reaches an average value of 0.16%. The deviation is probably caused by the fact that the measured values correspond to the non-state gas behaviour; however the calculation is based on the assumption of ideal gas behaviour. For this reason, the net calorific values from the NET4GAS Ltd. reports were used for calculation of the emission factor. The reports contain data related to the reference temperature 20° C; thus, it was necessary to recalculate net calorific values and densities for 15° C.

The results of the calculations are depicted in Fig.A2- 2. This figure also contains computation of the correlation

$$EF\ (CO_2) = 0.787 \bullet Qv + 28.21 \qquad (A3\text{-}13)$$

where Q_v [MJ/m^3] is the net calorific value of Natural Gas at "trade conditions": temperature 15°C and pressure of 101.3 kPa.

These findings were compared with the results obtained during preparation of this research. First, the data about analyses of Natural Gas obtained from RWE Transgas were used for comparison. This dataset contains data from 2003, 2004 and 2009 and evaluation of these data resulted in the correlation

$$EF\ (CO_2) = 0.6876 \bullet Qv + 31.619 \qquad (A3\text{-}14)$$

The second source for comparison is the paper of Čapla and Havlát (2006), where the correlation resulted in equation (A3-13).

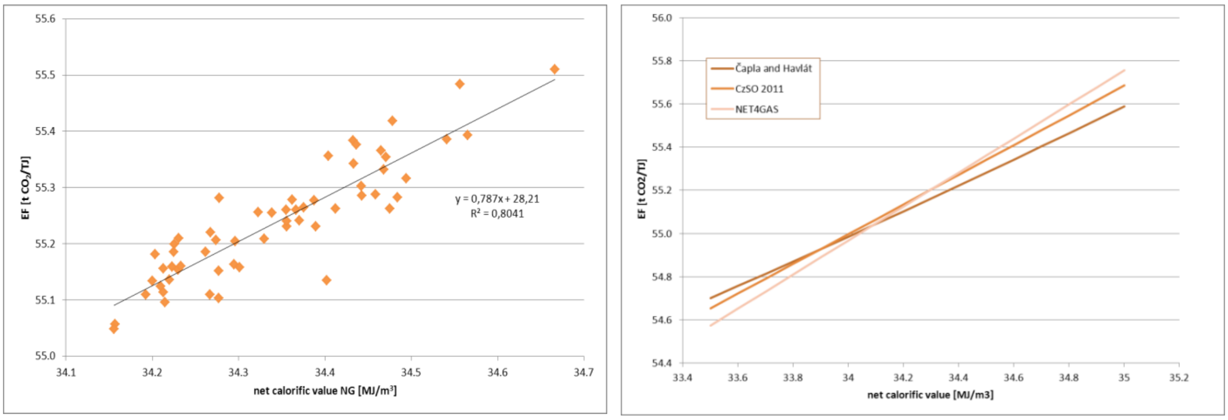


Fig. A3 4 Correlation of EF [t CO_2/TJ] and net calorific value of Natural Gas and Comparison of three approaches used for calculation

Fig. A3- 4 indicates good correlation between all three approaches in the region of 34.1 – 34.3 MJ/m^3, where the deviation between the results is 0.3% in maximum.

Each year in its energy balance, the Czech Statistical Office reports the average value of net calorific value of Natural Gas. Fig. A3- 4 indicates the trend of these calorific values. It is apparent that NCV is continuously slightly increasing.

The dark line in Fig. A2- 4 indicates the lowest net calorific value determined in the dataset provided by NET4GAS Ltd in 2007 - 2012. For the period of 2007 towards all the net calorific values are lower than 34.1 MJ/m^3. For this reason, it is more accurate to use the correlation obtained from the dataset representing the data before this year, i.e. the correlation evaluated by Čapla and Havlát (2006).

Fig. A3- 5 depicts the correlation curve combined on the basis of both correlations. It is given for the whole range of net calorific values, which was identified in Natural Gas in the Czech Republic in the 1990 - 2010 period. The value 34.1 MJ/m^3 is depicted by the dashed line.

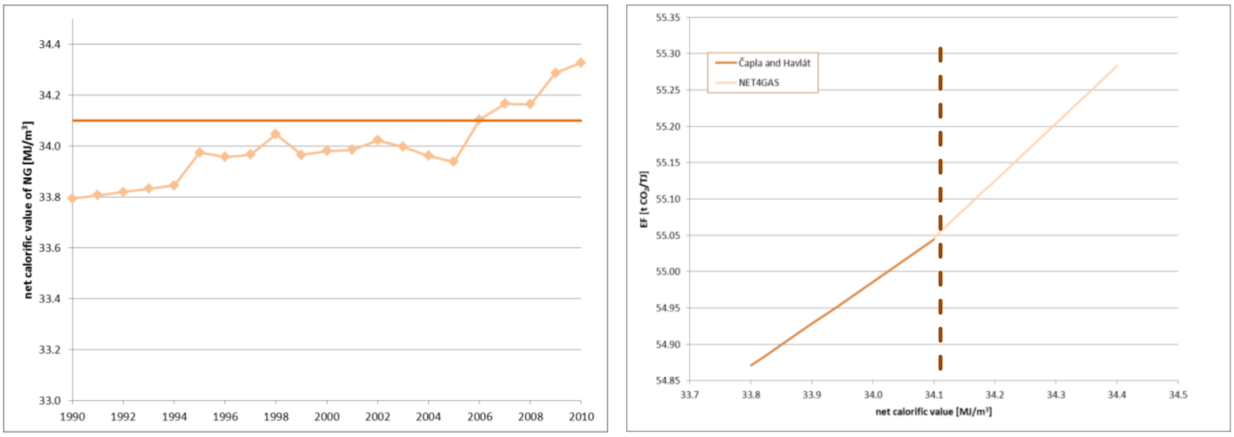


Fig. A3 5 Trend in Natural Gas NCV 1990 – 2010 and Correlation between NCV and EF combined from two approaches – Čapla and Havlát (NCV lower than 34.1 MJ/m^3) and computed correlation on the basis of NET4GAS dataset (NCV higher than 34.1 MJ/m^3)

Evaluation of CO_2 emission factors for Natural Gas combustion is based on the computational approach described above. There are two correlation relations; each of them is used for a different range of net calorific values. As depicted in Fig. A2- 5, both correlations follow each other closely. Tab A3 - 6 lists all the calculated emission factors for both correlations; the recommended values are in bold.

Tab. A3 - 6 Comparison of both recommended correlations

year	Average net calorific value of NG reported by CzSO	EF CO_2 calculated on the basis of Čapla and Havlát correlation (eq. A2-5)	EF CO_2 calculated on the basis of NET4GAS, Ltd. dataset correlation (eq. A2-6)
	[MJ/m^3]	[t CO_2/TJ]	[t CO_2/TJ]
1990	33.794	**54.87**	*54.81*
1991	33.807	**54.87**	*54.82*
1992	33.820	**54.88**	*54.83*
1993	33.832	**54.89**	*54.84*
1994	33.845	**54.90**	*54.85*
1995	33.975	**54.97**	*54.95*
1996	33.957	**54.96**	*54.93*
1997	33.966	**54.97**	*54.94*
1998	34.046	**55.01**	*55.00*
1999	33.965	**54.97**	*54.94*
2000	33.980	**54.97**	*54.95*
2001	33.986	**54.98**	*54.96*
2002	34.023	**55.00**	*54.99*
2003	33.997	**54.98**	*54.97*
2004	33.962	**54.96**	*54.94*
2005	33.938	**54.95**	*54.92*
2006	34.105	*55.05*	**55.05**
2007	34.167	*55.08*	**55.10**
2008	34.164	*55.08*	**55.10**
2009	34.288	*55.16*	**55.19**
2010	34.328	*55.18*	**55.23**

The deviations between the two calculations are less than 0.15%. The values written in bold were used for recalculation of CO_2 emissions from Natural Gas combustion for the 1990 – 2010 time series (held in 2013 submission). Former submissions employed the default emission factor 56.1 t CO_2/TJ, which overestimated the CO_2 emissions from Natural Gas combustion, especially at the beginning of the nineteen nineties (about 2.4% in 1990).

For years 2011 and 2012 the correlation relation based on the NET4GAS, Ltd. dataset was used (eq. A3-13):

$$EF\ (CO_2) = 0.787 \bullet Qv + 28.21 \qquad \text{(A3-15)}$$

The availability of analyses of the Natural Gas composition should be ensured in the coming years. The validity of equation (A2-7) will be continuously tested using new data, and if necessary, the correlation equation will be modified to fit the new data as best as possible.

Starting with submission 2013 updated emission factors are be used for all categories in 1A Energy for the whole time series.

For other detailed discussion of methodology and data for estimating CO_2 emissions from fossil fuel combustion please see the discussion of methodology in Chapter 3.4 and in the Annex 4.

A3. 5 Methodology for Road Transport (1.A.3.b)

The Methodology of determination of air polluting emissions from transport in the Czech Republic is used for transport emission calculations on a national and regional level. The results are reported not only to UNFCCC, but also to CLRTAP and other international bodies. The methodology was adopted by the Ministry of Transport, Ministry of Environment and Czech Hydrometeorological Institute in 2002 and was updated in 2006. The methodology includes only emissions from transport and does not include emissions from electricity production used by electric vehicles. It also does not include emissions from the engines of off-road machines and vehicles used, for example, in agriculture, the building industry, the army or households.

The underlying principles of the methodology are:

- categorization of vehicles
- measured emission factors
- distribution of fuel consumption between individual transport modes
- annual mileages in selected vehicle categories

The methodology is based on the classification of vehicles in 23 categories using the following criteria: transport mode, fuel type, weight of vehicles (in road freight traffic) and equipment with effective catalytic converter systems (cars). Every category has associated emission factors for CO_2, CO, NO_X, N_2O, CH_4, NMVOC, SO_2, Pb and PM, based on the available measurements. Emission factors are expressed in $g.kg^{-1}$ of fuel and are processed in the MS Access database.

Two parallel approaches are used for classification of fuel consumption. The first one is "top - down", i.e. allocating total fuel consumption according to transport performances and numbers of vehicles, and the second one is "bottom - up", i.e. from annual mileages and average consumption in $1.100km^{-1}$. This consumption is classified in 5 categories (motorcycles, gasoline passenger cars with or without catalytic converter systems, diesel light duty vehicles, diesel heavy duty vehicles), taken from the 23 categories mentioned above, which exhibit the largest differences in annual mileages ($km.year^{-1}$).

Mileages are reported in a manner such that the sum of the fuel consumptions in the first three categories (motorcycles, gasoline passenger cars with or without catalytic convert systems) calculated using the "bottom - up" method is identical with the fuel consumption in the individual transport categories calculated using the "top - down" method. A similar approach is employed for road freight transport. The relationship of the mileages employed must be in line with the relationships of the above mentioned categories in real situations. These are derived from the transport census. This is based on the total fuel consumption in the appropriate transport modes. Transport performances are used to derive the relative fuel consumption for the individual transport modes.

The categorization of vehicles enables separate calculation of the N_2O production from the total amount of NO_X. VOCs are separated into CH_4 (which contributes to the greenhouse effect) and nonmethane VOCs. Every category has associated emission factors according to the available measurements in the Czech Republic and the recommended values from international statistics (IPCC, Emission Inventory Guidebook). Emission factors are given in $g.kg^{-1}$ of fuel and are processed in the MS Access database.

Reference:
DUFEK, J., HUZLÍK, J., ADAMEC, V. Methodology of determination of air pollution emissions from transport in the Czech Republic. Brno: CDV, 2006, 26 s.(in Czech). http://www.cdv.cz/metodiky/

A3. 6 Country specific CO_2 emission factor for Lime Production

Emissions of GHG from lime production are classified into two different categories. The first category relates to the combustion processes, ongoing in the production of lime, and emissions from it are reported in sector "Energy" in the Czech National Inventory Report. In the second category are included emissions from decomposition of carbonates, of decomposition of organic carbon, contained in the raw material, used for the production of lime. These emissions are described in sector "Industrial processes", in subsector 'Mineral industry'. The following calculations apply only to the second category of emissions.

Production of lime is based on heating limestone, during which decomposition (calcination) of carbonates, contained in limestone, occurs and carbon dioxide is released. In limestone mainly calcium carbonate and magnesium carbonate mixture is present in range of 75.0 to 98.5% of weight, of which the magnesium carbonate is 0.5 to 15.0% of weight. Detailed chemical composition and the division into classes of limestone, according to the national standards are shown in Tab. A3 - 7 (ČSN, 1992).

Tab. A3 - 7 Division of limestone, according to chemical composition

Chemical composition in% weight		Quality class							
		I	II	III	IV	V	VI	VII	VIII
$CaCO_3 + MgCO_3$	min	98.5	97.5	96.0	95.0	93.0	85.0	80.0	75.0
from which $MgCO_3$	min	0.5	0.8	2.0	4.0	6.0	10.0	15.0	
SiO_2	max	0.3	0.8	1.5	3.0	4.5	6.0	8.0	18.0
$Al_2O_3 + Fe_2O_3$	max	0.2	0.4	0.8	2.0	3.5	5.0	6.0	6.0
from which Fe_2O_3	max	0.03	0.1	0.03	1.0	2.0	2.5	2.5	
MnO	max	0.01	0.03	0.03	0.03				
SO_3	max	0.08	0.1	0.2	0.2	0.3	0.5	0.5	2.0

The composition of limestone is closely associated with the emission factor. As calcium carbonate and magnesium carbonate have a different emission factors, the ratio between the two emission factors is reflected in the resulting emission factor. Emission factor derived from $CaCO_3$ or $MgCO_3$ is defined as emission factor of method A. This method is based on the input materials in the process of lime production. Further emission factor can be determined for outgoing materials or for CaO and MgO in lime. This procedure is called method B. Emission factors from method A and B are described in Tab. A3-8 (Commission Regulation (EU) № 601/2012).

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

Method	Material	EF [t CO_2/ t material]
A (input)	$CaCO_3$	0.440
	$MgCO_3$	0.522
B (output)	CaO	0.785
	MgO	1.092

Additional ingredients (other carbonates and organic carbon), which occur in limestone in very small quantities, may also be a source of emissions. These small amounts will affect to a minor extent the total emission factor; therefore for the inventory of GHG can be considered as negligible.

Thus the most significant impact on the emission factor has the composition of the input material, which subsequently is reflected in the composition of lime. Therefore we can affirm that, it is inessential, if we calculate from the composition of the input material (Method A) or the composition of the output material (Method B), both ways would lead to the same emission factor for the given process.

The best way to do that is to observe the relation between the emission factor and mass in% of $MgCO_3$ in the input material (Method A). This dependence can be observed on Fig. A3-6.

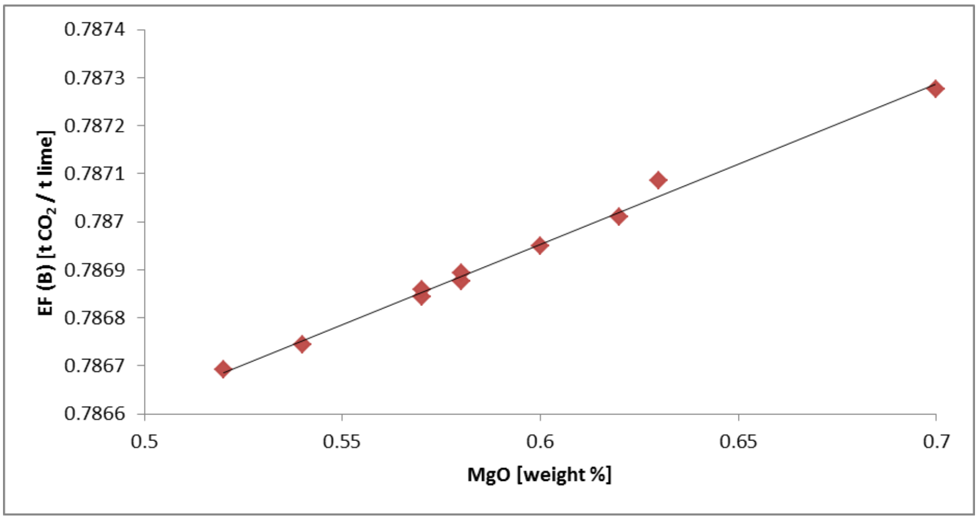


Fig. A3 6 Correlation between emission factor and mass representation of $MgCO_3$ in input material

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

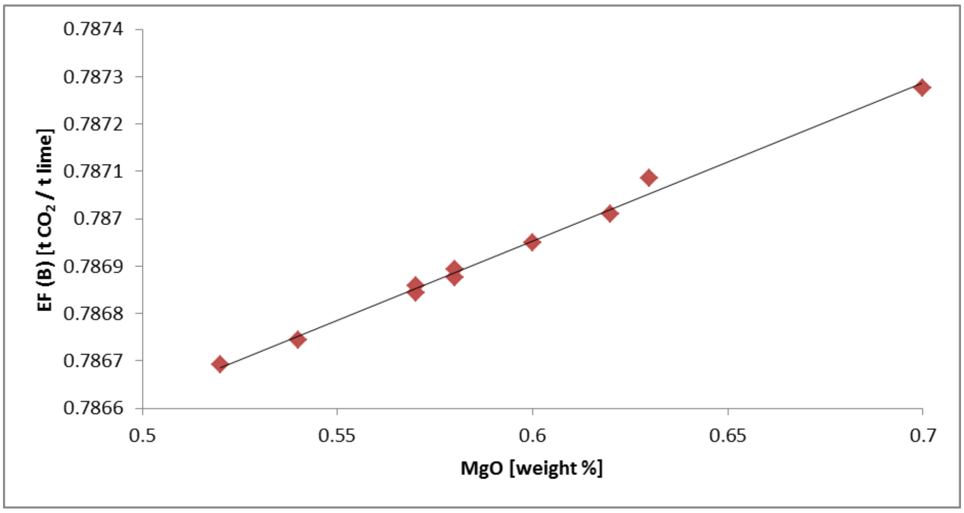


Fig. A3 7 Correlation of emission factor in mass representation of MgO in output material

As Fig. A3 - 6 and A3 - 7 shows, the emission factor varies with the amount of MgCO3 or MgO only very slightly. Limestone, which is processed in the Czech Republic, is supplied to the lime plants from the same source and the composition of it for the individual sources does not change much with time. These facts reveal that, similarly, the emission factor for lime production will move only within a narrow range, which will have a small impact on the calculation of the emissions. As it is evident from Fig. A3 – 6 the emissions calculated, using Tier 1 approach, which adopts country specific emission factor (Vacha, 2004), are only very slightly overestimated compared to emissions from the ETS, which are obtained by measuring or Tier 3 approach.

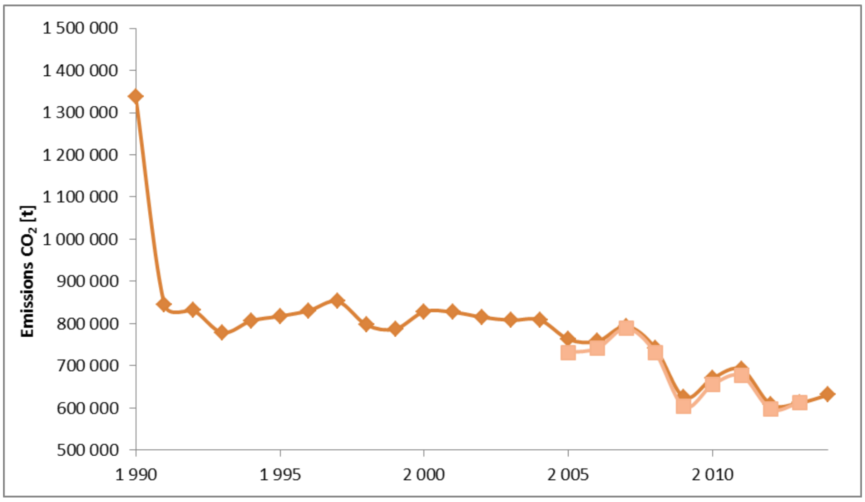


Fig. A3 8 Development of emissions of CO_2 from production of lime in CR for period 1990 – 2014

Figure A3 - 7 shows oscillating weighted total emission factor derived from the ETS which fluctuates near the country specific emission factor values. From Fig.A3 9 it is observed that there could be a slight decrease in the emission factor since 2009, but it will be rather an incidental drop. For the period 1990 - 2004, for which ETS data are not available, the emission factors could be calculated as the average of the available data from the ETS. The average of these values is 0.7885 t CO_2/t lime and it differs from the country specific emission factor only by one ten-thousandth. For this reason, for this time period it is considered to keep the country specific emission factor.

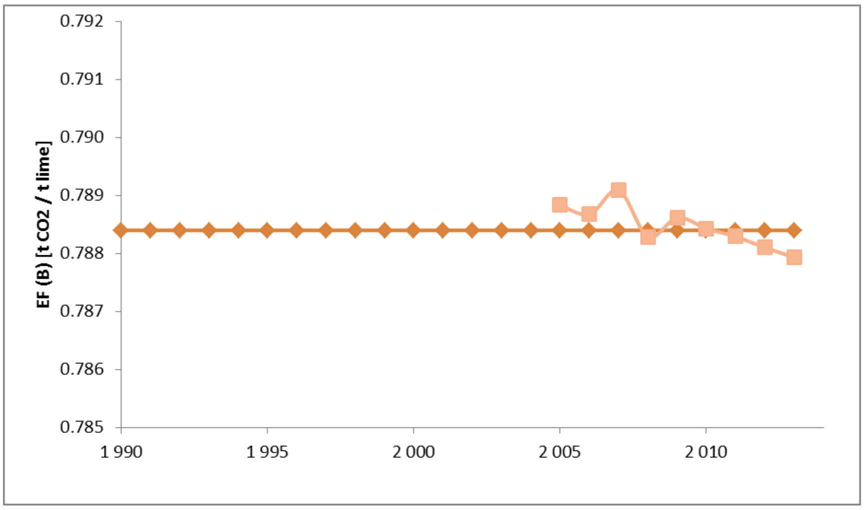


Fig. A3 9 Development of EF for production of lime in CR for period 1990 - 2014 (method B)

Since the composition of limestone from 1990 to the present has not changed significantly, the emission factor does not undergo any major change. Therefore for the period 1990 - 2009 the country specific emission factor (0.7884 t CO_2/t lime; Vacha, 2004) can be used and for the remaining period 2010-2014 will be applied emission factors derived from the ETS.

Due to the very small variation of $MgCO_3$ content in limestone, the emission factor changes slightly over time. We can use as an emission factor for the period 1990-2009 the proposed country specific, which is equal to 0.7884 t CO_2/t lime (Method B) and activity data for emission calculations utilize the Czech Statistical Office and Czech Lime Association. Since 2010 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 2016.

Tab. A4 - 1 Energy balance for solid fuels 2016

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	3384	3 516	38 528	2 209	187
Total Imports (Balance)	1661	1 821	138	498	346
Total Exports (Balance)	2088	1 426	855	543	7
International Marine Bunkers	0	0	0	0	0
Stock Changes (National Territory)	160	651	405	-2	0
Inland Consumption (Calculated)	3117	4 619	38 216	2 162	526
Statistical Differences	231	106	-26	-94	-9
Transformation Sector	2886	3 912	34 867	1 909	81
Main Activity Producer Electricity Plants	0	0	7 547	0	0
Main Activity Producer CHP Plants	0	3 528	23 410	0	0
Main Activity Producer Heat Plants	0	7	146	0	1
Autoproducer Electricity Plants	0	0	0	0	0
Autoproducer CHP Plants	0	58	2 353	0	5
Autoproducer Heat Plants	0	0	9	0	0
Patent Fuel Plants (Transformation)	0	0	0	0	0
Coke Ovens (Transformation)	2886	0	0	67	0
BKB Plants (Transformation)	0	0	0	0	0
Gas Works (Transformation)	0	0	1 402	0	75
Blast Furnaces (Transformation)	0	319	0	1 842	0
Coal Liquefaction Plants (Transformation)	0	0	0	0	0
Non-specified (Transformation)	0	0	0	0	0
Energy Sector	0	0	847	0	0
Own Use in Electricity, CHP and Heat Plants	0	0	0	0	0
Coal Mines	0	0	847	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	29	45	0	0
Total Final Consumption	0	572	2 490	347	450
Total Non-Energy Use	0	0	200	0	433
Final Energy Consumption	0	572	2 290	347	17
Industry Sector	0	231	803	312	17
Iron and Steel	0	24	18	259	0
Chemical (including Petrochemical)	0	37	514	0	0
Non-Ferrous Metals	0	0	0	4	0
Non-Metallic Minerals	0	151	20	35	17
Transport Equipment	0	0	18	0	0
Machinery	0	0	16	7	0
Mining and Quarrying	0	1	0	0	0
Food, Beverages and Tobacco	0	18	94	7	0
Paper, Pulp and Printing	0	0	102	0	0
Wood and Wood Products	0	0	3	0	0
Construction	0	0	4	0	0
Textiles and Leather	0	0	8	0	0
Non-specified (Industry)	0	0	6	0	0
Transport Sector	0	1	1	0	0
Other Sectors	0	340	1 486	35	0
Commercial and Public Services	0	1	66	3	0
Residential	0	338	1 402	31	0

Agriculture/Forestry	0	1	18	1	0
Fishing	0	0	0	0	0
Non-specified (Other)	0	0	0	0	0

Tab. A4 - 2 Energy balance for solid fuels 2016

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	16 933	17 859	20 643	5 725
Total Imports (Balance)	159	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)	155	16 933	17 859	20 643	5 725
Statistical Differences	19	0	-415	146	328
Transformation Sector	0	15 144	4 288	8 150	1 139
Main Activity Producer Electricity Plants	0	0	0	0	0
Main Activity Producer CHP Plants	0	0	4 288	8 150	522
Main Activity Producer Heat Plants	0	0	0	0	0
Autoproducer Electricity Plants	0	0	0	0	0
Autoproducer CHP Plants	0	15 144	0	0	617
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	1 789	7 631	7 019	1 052
Own Use in Electricity, CHP and Heat Plants	0	0	0	0	60
Coal Mines	0	1 789	0	0	933
Patent Fuel Plants (Energy)	0	0	0	0	0
Coke Ovens (Energy)	0	0	7 436	1 700	0
BKB Plants (Energy)	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	3 931	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	195	1 388	59
Total Final Consumption	120	0	5 211	5 609	3 493
Total Non-Energy Use	0	0	0	0	823
Final Energy Consumption	120	0	5 211	5 609	2 670
Industry Sector	0	0	5 211	5 606	2 670
Iron and Steel	0	0	5 121	0	1 213
Chemical (including Petrochemical)	0	0	0	0	1 400
Non-Ferrous Metals	0	0	0	2	0
Non-Metallic Minerals	0	0	62	0	57
Transport Equipment	0	0	0	1	0
Machinery	0	0	28	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	120	0	0	0	0
Commercial and Public Services	0	0	0	0	0
Residential	120	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 2016

LIQUID FUELS	Crude Oil [kt/year]	Refinery Feedstocks [kt/year]	Additives Oxygenates [kt/year]
Indigenous Production	117		70
From Other Sources			349
From Other Sources - Solid fuels			
From Other Sources - Natural Gas			
From Other Sources - Renewables			349
Backflows		49	
Primary Product Receipts			
Refinery Gross Output			
Inputs of Recycled Products			
Refinery Fuel			
Total Imports (Balance)	5 325	21	16
Total Exports (Balance)	28		
International Marine Bunkers			
Interproduct Transfers			
Products Transferred		132	
Direct Use			344
Stock Changes (National Territory)		2	-3
Refinery Intake (Calculated)	8	200	88
Gross Inland Deliveries (Calculated)	5 422		
Statistical Differences	0	0	0
Gross Inland Deliveries (Observed)	0	0	
Refinery Intake (Observed)	5 422	200	88

Tab. A4 - 4 Energy balance for liquid fuels 2016

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	101	255	394	1 179	85	0
Refinery Fuel	89	0	0	0	0	0
Total Imports (Balance)	0	183	6	805	9	3
Total Exports (Balance)	0	139	277	403	19	0
International Marine Bunkers	0	0	0	0	0	0
Stock Changes (National Territory)	0	-5	3	-8	-1	0
Gross Inland Deliveries (Calculated)	12	294	178	1 606	74	3
Statistical Differences	0	0	0	0	0	0
Gross Inland Deliveries (Observed)	12	294	178	1 606	74	3
Refinery Intake (Observed)	0	0	0	0	0	0
Non-energy use in Petrochemical industry	0	104	178	0	0	0

LIQUID FUELS	Refinery Gas [kt/year]		LPG [kt/year]		Naphtha [kt/year]		Motor Gasoline [kt/year]		Biogasoline [kt/year]		Aviation Gasoline [kt/year]	
	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	12	0	7	0	0	0	12	0	7	0	0	0
Main Activity Producer Electricity Plants												
Autoproducer Electricity Plants												
Main Activity Producer CHP Plants	12		7				12		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	183	104	0	178	0	0	183	104	0	178
Transport Sector	0	0	99	0	0	0	0	0	99	0	0	0
International Aviation												
Domestic Aviation												
Road			98						98			
Rail												
Domestic Navigation												
Pipeline Transport												
Non-specified (Transport)												
Industry Sector	0	0	31	104	0	178	0	0	31	104	0	178
Iron and Steel												
Chemical (including Petrochemical)			3	104		178			3	104		178
Non-Ferrous Metals												
Non-Metallic Minerals			2						2			
Transport Equipment			1						1			
Machinery			3						3			
Mining and Quarrying												
Food, Beverages and Tobacco			2						2			
Paper, Pulp and Printing												
Wood and Wood Products												
Construction			3						3			
Textiles and Leather			1						1			
Non-specified (Industry)			16						16			
Other Sectors	0	0	53	0	0	0	0	0	53	0	0	0
Commercial and Public Services			6						6			
Residential			43						43			
Agriculture/Forestry			4						4			
Fishing												
Non-specified (Other)												

Tab. A4 - 5 Energy balance for liquid fuels 2016

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	60		0		2 376		0		122		104	
Refinery Fuel	0		0		0		0		0		0	
Total Imports (Balance)	273		2		2 823		72		38		0	
Total Exports (Balance)	0		0		827		49		30		84	
International Marine Bunkers	0		0		0		0		0		0	
Stock Changes (National Territory)	11		0		12		4		0		22	
Gross Inland Deliveries (Calculated)	344		2		4 643		286		130		29	
Statistical Differences	0		0		-5		0		0		0	
Gross Inland Deliveries (Observed)	344		2		4 643		286		130		29	
Refinery Intake (Observed)	0		0		0		0		0		0	
Non-energy use in Petrochemical industry	0		0		0		0		6		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	0	0	0	0
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												
Patent Fuel Plants (Transformation)												
Non-specified (Transformation)												
Energy Sector	0	0	0	0	16	0	0	0	0	0	16	0
Coal Mines					16						16	
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	344	344	2	0	4 632	0	344	344	2	0	4 632	0
Transport Sector	344	344	0	0	4 252	0	344	344	0	0	4 252	0
International Aviation	306	306					306	306				
Domestic Aviation	38	38					38	38				
Road					4 248						4 248	
Rail												
Domestic Navigation					4						4	
Pipeline Transport												
Non-specified (Transport)												
Industry Sector	0	0	0	0	46	0	0	0	0	0	46	0
Iron and Steel												
Chemical (including Petrochemical)												
Non-Ferrous Metals												
Non-Metallic Minerals												
Transport Equipment												
Machinery												
Mining and Quarrying												
Food, Beverages and Tobacco												
Paper, Pulp and Printing												
Wood and Wood Products												
Construction					43						43	
Textiles and Leather												
Non-specified (Industry)					3						3	
Other Sectors	0	0	2	0	334	0	0	0	2	0	334	0
Commercial and Public Services					9						9	
Residential												
Agriculture/Forestry					317						317	
Fishing												
Non-specified (Other)			2		8				2		8	

Tab. A4 - 6 Energy balance for liquid fuels 2016

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		84		363		10		62		494	
Refinery Fuel	0		0		0		0		62		0	
Total Imports (Balance)	19		201		329		10		8		148	
Total Exports (Balance)	0		74		223		10		2		156	
International Marine Bunkers	0		0		0		0		0		0	
Stock Changes (National Territory)	0		0		-2		0		0		-9	
Gross Inland Deliveries (Calculated)	19		195		467		10		6		365	
Statistical Differences	0		0		0		0		0		0	
Gross Inland Deliveries (Observed)	19		195		467		10		6		365	
Refinery Intake (Observed)	0		0		0		0		0		0	
Non-energy use in Petrochemical industry	0		0		0		0		0		306	
	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	0
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												
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	195	2	468	0	18	0	195	2	468
Transport Sector	0	0	0	146	0	0	0	0	0	146	0	0
International Aviation												
Domestic Aviation												
Road				140						140		
Rail				6						6		
Domestic Navigation												
Pipeline Transport												
Non-specified (Transport)												
Industry Sector	0	19	0	49	0	466	0	19	0	49	0	466
Iron and Steel												
Chemical (including Petrochemical)		1						1				
Non-Ferrous Metals												
Non-Metallic Minerals												
Transport Equipment												
Machinery												
Mining and Quarrying												
Food, Beverages and Tobacco												
Paper, Pulp and Printing												
Wood and Wood Products												
Construction						466						466
Textiles and Leather												
Non-specified (Industry)		18		49				18		49		
Other Sectors	0	0	0	0	2	0	0	0	0	0	2	0
Commercial and Public Services												
Residential												
Agriculture/Forestry												
Fishing												
Non-specified (Other)					2						2	

Tab. A4 - 7 Energy balance for Natural Gas 2016 [TJ] in GCV

Indigenous Production	8384
Associated Gas	4705
Non-Associated Gas	0
Colliery Gas	3679
From Other Sources	0
Total Imports (Balance)	312387
Total Exports (Balance)	0
International Marine Bunkers	0
Stock Changes (National Territory)	5628
Inland Consumption (Calculated)	326399
Statistical Differences	0
Inland Consumption (Observed)	326399
Recoverable Gas	
Opening Stock Level (National Territory)	77674
Closing Stock Level (National Territory)	72046
Opening stock level (Held abroad)	14893
Closing stock level (Held abroad)	11116
Memo:	
Gas Vented	0
Gas Flared	0
Memo: Cushion Gas	
Cushion Gas Closing Stock Level	43892
Memo: From other sources	
From Other Sources - Oil	0
From Other Sources - Coal	0
From Other Sources - Renewables	0

Transformation Sector	67100
Main Activity Producer Electricity Plants	13401
Autoproducer Electricity Plants	10
Main Activity Producer CHP Plants	22732
Autoproducer CHP Plants	2203
Main Activity Producer Heat Plants	19279
Autoproducer Heat Plants	9475
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	3696
Coal Mines	0
Oil and Gas Extraction	101
Petroleum Refineries	3595
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	5128
Transport Sector	2536
Road	2281
of which Biogas	0
Pipeline Transport	255
Non-specified (Transport)	0
Industry Sector	93748
Iron and Steel	9125
Chemical (including Petrochemical)	7609
Non-Ferrous Metals	2191
Non-Metallic Minerals	22732
Transport Equipment	7252
Machinery	11292
Mining and Quarrying	2268
Food, Beverages and Tobacco	13951
Paper, Pulp and Printing	4398
Wood and Wood Products	517
Construction	4094
Textiles and Leather	4099
Non-specified (Industry)	4220
Other Sectors	149526
Commercial and Public Services	52460
Residential	92746
Agriculture/Forestry	2845
Fishing	5
Non-specified (Other)	1470

Annex 5 Any additional information, as applicable

Information provided in A5.1 – A5.2 are related to emission estimation in Energy sector.

A5.1 Improved ratio NCV/GCV for Natural Gas

Default ratio NCV/GCV for natural gas according to the IPCC methodology (IPCC 2006) is equal to 0.9

For more accurate determination of the ratio, data set NET4GAS was used. This data set contains, among other values, NCV and GCV in MJ/m^3 for reference temperature of 20˚C, for each month and for the time period of 5 years (1997 to 2011). All monthly values for NCV and GCV were recalculated for temperature of 15 ˚C (i.e. trading conditions), and further it was determined annual average of the monthly values for NCV and GCV and their ratio NCV/GCV, see Tab. A5-1.

Tab. A5 1 Annual average NCV, GCV and their ratio (determined and calculated using correlation)

MJ/m^3	2007	2008	2009	2010	2011	Average	Standard deviation	%Standard deviation
NCV, 15 ˚C	34.2236	34.2498	34.4267	34.3921	34.4469	34.3478	0.0927	0.27%
GCV, 15 ˚C	37.9572	37.9841	38.1724	38.1363	38.1942	38.0888	0.0986	0.26%
Ratio NCV/GCV	0.90164	0.90169	0.90187	0.90182	0.90189	0.90178	0.0001	0.01%
0.001011*GCV + 0.863274 [a)]	0.90165	0.90168	0.90187	0.90183	0.90189			

[a)] *Precise calculation of the ratio NCV/GCV*

As CzSO reports mainly yearly gross calorific values for natural gas (GCV), while data expressing net calorific value (NCV) is needed, correlation for the calculation of NCV from known values for GCV, reported every year from CzSO, was determined by linear regression, see. Fig. A5-1

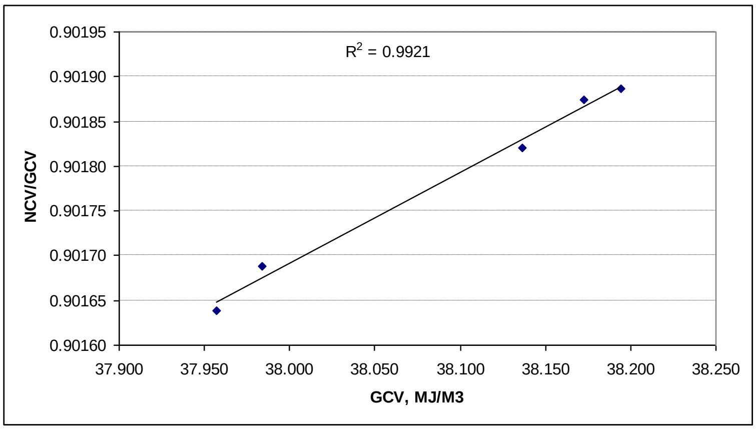


Fig. A5 1 Regression line corresponds with the data shown in Tab. A5-1.

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

NCV = (0.001011 * GCV + 0.863274) * GCV (A5 – 1)

where NCV and GCV are expressed in MJ/m^3 in the reference temperatures of 15 ˚C (i.e. trading conditions)

A5.2 Improved ratio NCV/GCV for coke oven gas

Recommended ratio NCV/GCV for coke oven gas according to the CzSO is equal to 0.9

For more accurate determination of the ratio, the data set obtained from the one of the significant coke producer in the Czech Republic, was mostly used. This data set uses calculation sheets developed by CHMI for determination of emission factors for CO_2, density and NCV for gaseous fuels, calculated from its composition, etc.

This calculation sheet uses for calculation of NCV and GCV for fuels in gaseous state, calorific value and GCV, based on the weight of the individual components that are listed in regulation ČSN 38 5509 (DIN 1872), so it enables also the calculation of the ratio NCV/GCV.

Unlike in natural gas, in industrially produced fuels NCV and GCV are usually provided in reference temperature of 0˚C (273.15 K), i.e. in "normal conditions". The same is used in the above mentioned data set. Default ratio NCV/GCV does not depend on the reference temperature, because recalculation coefficients for different reference temperatures in the ratio NCV/GCV are canceled out. The ratio NCV/GCV is calculated for each month in 2010, i.e. 12 times, from which the ratio, standard deviation and its relative value are calculated.

Results are presented in Tab. A5-2.

Tab. A5 2 Annual averages of NCV, GCV under normal condition (i.e. 0˚C) and their ratio

Month	1	2	3	4	5	6	7	
NCV. MJ/Nm^3	16.935	17.108	16.847	16.040	16.459	17.210	17.162	
GCV, MJ/NM^3	19.053	19.251	18.953	18.059	18.530	19.342	19.270	
NCV/GCV	0.8888	0.8886	0.8889	0.8882	0.8883	0.8898	0.8906	
Month	8	9	10	11	12	Average	Standard deviation	%
NVC. MJ/Nm^3	17.177	16.832	17.056	17.218	17.312	16.946	0.353	2.1%
GCV, MJ/NM^3	19.309	18.925	19.183	19.357	19.443	19.056	0.386	2.0%
NCV/GCV	0.8896	0.8894	0.8891	0.8895	0.8904	0.8893	0.0007	0.1%

Average value of the ratio NCV/GCV is **0.8893** (precisely 0.88926).

In addition to this, a control calculation was conducted, based on the data obtained from another significant coke producer. Due to the incompleteness of the data in comparison with the dataset mentioned above, the ratio NCV/GCV was determined from the average of 4 values (January, April, July, October) and the value is 0.8861, which is relatively close to the more precisely identified value above.

A5.3 Net calorific values of individual types of fuels in the period 1990-2014

Net Calorific Values (NCV) of each individual fossil fuel in the period 1990-2014 used in the Energy sector were taken from the standard CzSO Questionnaires (IEA/OECD, Eurostat, UN Questionnaires). For liquid fuels, CzSO provides for each year one net calorific value for all sectors, while for solid fuels, generally indicates three values: for 1A1, 1A2 and 1A4 which were used in the sectoral approach. In Table A5- 3 are shown for clarity aggregated values, calculated as a weighted average of these three values.

In case of solid and liquid fuels are calorific values expressed in kJ/kg. For natural gas CzSO presents primarily Gross Calorific Values (GCV) in kJ/m^3 (volume related to the trading conditions: 15 ° C and 101.3 kPa). Conversion GCV to NCV, derived in the Czech Hydrometeorological Institute in cooperation with KONEKO, is shown in this Annex above. For the COG (Coke Oven Gas) CzSO presents activity data directly in energy units TJ related to GCV (marked as TJ_{Gross}), but without GCV values for individual years. Conversion to TJ related to NCV (marked as TJ_{Net}), which is required for the calculation of emissions with respect to the definition of emission factors, also appears in this Annex. It is visible that the ratio NCV/GCV = 0.8893 is equal to the ratio TJ_{Net}/TJ_{Gross}.

In Table A5-3 are shown the net calorific values of solid and liquid fuels in the period 1990 - 2014. The symbol "NO" means, as in CRF, that the fuel was not used, “NE” symbol indicates that the value of NCV has not been estimated. Table A5-3 provides definitions of fuels used by CzSO. In most cases, these definitions of fuel are identical to the definitions of IPCC (IPCC 2006). It is noted, however, that fuels marked as "Fuel oil - high sulfur" and "Fuel oil - low sulfur" in the table, according to the terminology of CzSO, fall according to the IPCC under "Residual Fuel Oil". Similarly fuels marked as "Road diesel" and "Heating and other gas oil" are covered by the IPCC under " Gas/Diesel Oil ".

Tab. A5 3a Net calorific values for fossil fuels

NCV [kJ/kg]	1990	1991	1992	1993	1994	1995	1996	1997	1998
Anthracite	NO	NO	NO	NO	NO	NO	NO	NO	NO
Bituminous Coal	19 559	19 372	21 420	21 633	21 704	21 888	22 025	22 332	23 812
Coking Coal	28 413	27 178	28 419	28 467	28 467	28 466	28 464	28 608	28 608
Lignite	12 083	12 068	12 050	12 082	12 213	12 494	12 610	12 115	12 115
Coke Oven Coke	27 167	27 177	27 426	27 375	27 215	27 216	27 218	28 225	28 230
Coal Tar	NE	NE	NE	NE	NE	NE	NE	NE	NE
BKB	22 868	23 058	21 854	22 922	23 136	22 941	22 918	22 924	24 080
Crude Oil	41 646	41 646	41 650	41 652	41 652	41 652	41 650	41 650	41 622
Refinery gas	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
Naphtha	43 300	43 300	43 300	43 300	43 300	43 352	43 416	43 391	43 709
Motor gasoline	43 340	43 332	43 342	43 340	43 308	43 320	43 320	43 300	43 300
Aviation gasoline	43 836	43 836	43 836	43 836	43 836	43 836	43 836	43 800	43 800
Biogasoline	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
Other kerosene	42 800	42 800	42 800	42 800	42 800	42 800	42 800	42 800	42 800
Road diesel	42 485	42 473	42 490	42 502	42 517	42 506	42 528	42 552	42 555
Heating and other gas oil	42 300	42 300	42 300	42 300	42 300	42 279	42 310	42 300	42 300
Biodiesel	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
Fuel oil - high sulphur	40 700	40 700	40 700	40 700	40 700	40 863	40 804	40 783	40 775
Residential Fuel Oil	40 576	40 589	40 619	40 626	40 635	40 738	40 258	40 595	40 538
Petroleum coke	37 500	37 500	37 500	37 500	37 500	37 500	37 500	37 500	37 500
Other products*)	40 193	40 193	40 193	40 193	40 193	41 530	39 373	39 392	38 387

**) 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]	1999	2000	2001	2002	2003	2004	2005	2006	2007
Anthracite	NO	NO	NO	32 000	32 000	32 000	32 000	30 941	30 000
Bituminous Coal	24 065	21 719	22 210	23 121	23 432	23 294	22 332	22 388	23 445
Coking Coal	28 537	28 392	28 596	28 752	28 971	28 745	28 818	29 148	29 279
Lignite	12 824	12 484	12 444	12 442	12 420	12 607	12 687	12 797	12 455
Coke Oven Coke	28 688	28 013	28 502	28 542	28 562	28 024	27 870	28 622	28 312
Coal Tar	NE	NE	NE	14 594	15 041	18 846	37 336	36 341	37 000
BKB	24 620	24 912	24 243	23 803	25 505	24 025	22 948	23 643	23 528
Crude Oil	41 628	41 543	41 889	41 483	41 991	41 980	41 980	41 986	42 259
Refinery gas	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
Naphtha	43 686	43 669	42 837	42 858	42 940	42 841	42 841	42 841	43 935
Motor gasoline	43 300	43 300	43 300	43 300	43 300	43 300	43 300	43 817	43 800
Aviation gasoline	43 800	43 800	43 800	43 800	43 793	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
Kerosene Jet Fuel	43 000	43 000	42 800	42 800	42 800	42 800	42 800	43 300	43 300
Other kerosene	42 800	42 800	42 800	42 800	42 800	42 800	42 800	42 800	42 800
Road diesel	42 686	42 691	41 920	41 940	41 929	41 873	41 829	42 779	42 749
Heating and other gas oil	42 412	42 461	41 764	41 748	41 711	41 718	41 800	42 600	42 600
Biodiesel	37 000	37 000	37 000	37 000	37 000	37 000	37 000	37 000	37 000
Fuel oil - low sulphur	39 639	39 694	39 286	39 313	40 000	39 584	39 538	39 599	41 484
Fuel oil - high sulphur	40 917	40 893	39 636	40 316	40 371	40 519	39 869	39 663	39 758
Residential Fuel Oil	40 544	40 659	39 511	39 670	40 182	39 997	39 686	39 628	40 594
Petroleum coke	37 500	37 500	37 500	37 500	37 500	37 500	37 500	37 500	37 500
Other products*)	39 290	39 398	40 754	40 711	40 660	40 820	40 894	39 300	39 300

**) 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 3c Net calorific values for fossil fuels

NCV [kJ/kg]	2008	2009	2010	2011	2012	2013	2014	2015	2016
Anthracite	30 000	30 000	30 000	29 809	28 170	28 944	28 756	28 476	28 196
Bituminous Coal	23 413	22 659	23 578	23 384	23 751	23 344	22 848	22 023	22 331
Coking Coal	29 326	29 381	29 385	29 207	29 373	29 244	29 468	29 536	29 509
Lignite	12 616	12 482	12 649	12 227	12 225	12 205	12 163	12 119	12 081
Coke Oven Coke	28 344	28 590	27 888	27 814	28 204	28 465	28 571	28 750	28 674
Coal Tar	37 000	37 161	36 936	36 995	37 829	37 754	36 738	36 801	35 567
BKB	22 059	22 203	20 732	19 500	19 500	19 500	19 500	19 793	20 005
Crude Oil	42 357	42 353	42 400	42 370	42 392	42 400	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
LPG	45 945	45 945	45 945	45 945	45 945	45 945	45 945	45 945	45 945
Naphtha	43 951	43 947	43 961	43 971	43 993	43 600	43 600	43 600	43 600
Motor gasoline	43 839	44 165	44 235	44 308	44 302	44 315	44 433	44 487	44 192
Aviation gasoline	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
Kerosene Jet Fuel	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
Road diesel	42 870	42 976	43 037	42 985	42 958	42 962	42 991	42 943	42 957
Heating and other gas oil	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
Fuel oil - low sulphur	39 718	39 700	39 696	39 522	39 436	39 439	39 500	39 500	39 500
Fuel oil - high sulphur	39 700	39 695	39 489	39 427	39 581	39 500	39 500	39 500	39 500
Residential Fuel Oil	39 710	39 698	39 603	39 482	39 509	39 475	39 500	39 500	39 500
Petroleum coke	37 500	37 500	37 500	37 500	38 500	38 500	38 500	38 500	39 400
Other products*)	40 000	40 074	39 821	40 189	40 354	40 179	39 910	39 438	39 220

Tab. A5 4 Net calorific values for Natural Gas

NCV [MJ/m3]	1990	1991	1992	1993	1994	1995	1996	1997	1998
Natural Gas	33 436	33 431	33 458	33 908	33 962	34 037	34 008	34 020	34 104
NCV [MJ/m^3]	1999	2000	2001	2002	2003	2004	2005	2006	2007

Natural Gas	34 021	34 035	34 041	34 079	34 052	34 015	34 029	34 165	34 234
NCV [MJ/m^3]	2008	2009	2010	2011	2012	2013	2014	2015	2016
Natural Gas	34 228	34 263	34 405	34 371	34 295	34 424	34 489	34 497	34 597

***) 15 °C, 101.3 kPa*

A5.4 Oxidation factor for waste incineration (CRF Sector 5.C)

In the sector 5C equation for CO_2 estimation apply OFj – oxidation factor how much carbon from total carbon content is actually oxidized. Official methodology IPCC 2006 suggested new oxidation factor for waste incineration. Change of the factor in previous methodologies is shown in Tab. A5 5a.

Tab. A5 5a Overview of oxidation factors in IPCC methodology

Methodology	IPCC 1996	GPG 2000	IPCC 2006
Name	NA	EFi	OFj
Value	NA (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 facilites

National studies are limited (only one focused on unburnt carbon from biomaterials), however all the studies show that OFj is less than 1. Overview of reviewed studies is in Tab A5 5b. Please note that studies in table did reviewed several facilities an/or samples from various places. They do show consistently, that oxidation of carbon in waste (fossil or organic) is not 100%. We argue that by using default factor methodology suggest we would overestimate real emission from waste incineration, hence are using factors presented in particular chapters in NIR to produce results that have managed uncertainty of estimate.

Related references

André van Zomeren, Rob N.J. Comans, Carbon speciation in municipal solid waste incinerator (MSWI) bottom ash in relation to facilitated metal leaching, Waste Management, Volume 29, Issue 7, July 2009, Pages 2059-2064, ISSN 0956-053X, http://dx.doi.org/10.1016/j.wasman.2009.01.005.

Eva Rendek, Gaëlle Ducom, Patrick Germain, Assessment of MSWI bottom ash organic carbon behavior: A biophysicochemical approach, Chemosphere, Volume 67, Issue 8, April 2007, Pages 1582-1587, ISSN 0045-6535, http://dx.doi.org/10.1016/j.chemosphere.2006.11.054.

Eva Rendek, Gaëlle Ducom, Patrick Germain, Carbon dioxide sequestration in municipal solid waste incinerator (MSWI) bottom ash, Journal of Hazardous Materials, Volume 128, Issue 1, 16 January 2006, Pages 73-79, ISSN 0304-3894, http://dx.doi.org/10.1016/j.jhazmat.2005.07.033.

H. Bjurström, B.B. Lind, A. Lagerkvist, Unburned carbon in combustion residues from solid biofuels, Fuel, Volume 117, Part A, 30 January 2014, Pages 890-899, ISSN 0016-2361, http://dx.doi.org/10.1016/j.fuel.2013.10.020.

Pavel Straka, Jana Náhunková, Margit Žaloudková, Analysis of unburned carbon in industrial ashes from biomass combustion by thermogravimetric method using Boudouard reaction, Thermochimica Acta, Volume 575, 10 January 2014, Pages 188-194, ISSN 0040-6031, http://dx.doi.org/10.1016/j.tca.2013.10.033.

Stefano Ferrari, Hasan Belevi, Peter Baccini, Chemical speciation of carbon in municipal solid waste incinerator residues, Waste Management, Volume 22, Issue 3, June 2002, Pages 303-314, ISSN 0956-053X, http://dx.doi.org/10.1016/S0956-053X(01)00049-6.

A5. 5 General quality control protocol used in NIS

The following table shows general QC form for NIR, which is used for QC procedures in each specific sector. The QC form follows the guidance provided in IPCC 2006 Gl.

Detailed checklist for Inventory Document

(NIR)

Reviewed documents: (e.g. relevant chapter in NIR)

Responsible compiler of reviewed category: ...

Persons, who carried out the controls: autocontrol – ..., control – ...

Date of finalization of control:

Instructions for filling

This form should be fulfilled after finalizing the whole chapter of the NIR. This form should be fulfilled in line with QA/QC plan. In case when it is not clear how to solve founded discrepancies the worker responsible for control should problematic issues discuss with the sector compiler and if needed with other relevant experts.

The table should be fulfilled according to each listed item. In the form can be added additional issues which are characteristic for the relevant chapter.

Checklist for Inventory Document

Activities	Task completed	
	Name	Date
Tables and Figures		
All numbers in tables match numbers in spreadsheets		
Check that all tables have correct number of significant digits		
Check alignment in columns and labels		
Check that table formatting is consistent		
Check that all tables and figures are updated with new data and referenced in the text		
Check table and figure titles for accuracy and consistency with content		
Check that figure formatting is consistent		
Check that coloring of figures is consistent		
Other (specify)		
Equations		
Check for consistency in equation formatting		
Check that variables used in equations are defined following the equation		
Other (specify)		
References		
Check consistency of references		
Check that in text citations and references match		
Other (specify)		

General Format		
All acronyms and abbreviations are spelled out first time and not subsequent times throughout each chapter		
All headings, titles and subheadings are kept the same as the original structure		
All fonts in the text are consistent		
All highlighting, notes and comments are removed from the final document		
Size, style and indenting of bullets are consistent		
Spell check is complete		
Check the consistency in names and numbering of CRF categories		
Other (specify)		
Other Issues		
Check that each section is updated with current year (or most recent year that inventory report includes)		
Check that the most recent relevant IPCC methodology is used		
Check that all sections and subchapters follow the provided structure		
Other (specify)		

Notes or comments:

....

The following table shows QC form for general technical control (Tier 1). The QC form follows the guidance provided in IPCC 2006 Gl.

QC form for general technical control

QC (Tier 1)

Source category/ removals: (e.g. 2A Mineral Products)

Reviewed documents: (e.g. CRF Reporter, computational spreadsheet for 2A, relevant chapter in NIR)

Responsible compiler of reviewed category: ...

Persons, who carried out the controls: autocontrol – ..., control – ...

Date of finalization of control:

Instructions for filling

This form should be completed for each source/sink category and provides a record of the checks which were carried out and possible consequent corrections. This form should be fulfilled in line with QA/QC plan. In case when it is not clear how to solve founded discrepancies the worker responsible for control should discuss the problematic issues with the sector compiler and if needed with other relevant experts.

The first part of the form summarizes results of the controls (once completed) and highlights all significant findings or actions. The second part should be fulfilled according to each listed item. Some explanations of items are given below the checklist. For particular categories not all checks (items) will be applicable - these items are then noted as not relevant (n.r.) or not available (n.a.). This way no check and no row should be left blank or deleted. On the contrary, rows for additional checks that are relevant to the source/sink category can be added to the form.

Summary of control results

Overview of findings and corrections:

description of findings

Suggested corrections, which should be realized in the next submission:

description of suggested corrections

Issues remaining after the corrections:

description of remaining issues

QC form for general and technical control (QC, Tier 1)

Item		Checked completed			Corrective action		
		Date	Individual (first initial, last name)	Errors (Y/N)	Date	Individual (first initial, last name)	Supporting documents
Input data QC							
1	Cross-check activity data from each category (either measurements or parameters used in calculations) for transcription error (errors between the source of data and spreadsheets).						
2	Check that units are properly labelled in calculation sheets.						
3	Check that units are correctly carried through from beginning to end of calculations.						
4	Check that conversion factors are correct.						
5	Check that temporal and spatial adjustment factors are used correctly.						
6	Cross-check activity data between calculation spreadsheets and **CRF** tables (and if needed in **NIR**).						
7	Other (please specify)						
Calculation							
8	Reproduce a set of emissions and removals calculations.						
9	Use a simple approximation method that gives similar results to the original and more complex calculation to ensure that there is no data input error or calculation error.						
10	Identify parameters (e.g., activity data, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emission/removal calculations.						
11	Check that emissions and removals data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries (also in **CRF** tables)						

12	Check that emissions and removals data are correctly transcribed between different intermediate products, including calculation spreasheets, **CRF** tables and **NIR**						
13	Other (please specify)						
Database files							
14	Confirm that the appropriate data processing steps are correctly represented in the database.						
15	Confirm that data relationships are correctly represented in the database.						
16	Ensure that data fields are properly labelled and have the correct design specifications.						
17	Ensure that adequate documentation of database and model structure and operation are archived.						
18	Other (please specify)						
Consistency							
19	Check for temporal consistency in time series input data for each category.						
20	Check for consistency in the algorithm/method used for calculations throughout the time series.						
21	Check methodological and data changes resulting in recalculations.						
22	Check that the effects of mitigation activities have been appropriately reflected in time series calculations.						
23	Other (please specify)						
Completeness							
24	Confirm that estimates are reported for all categories and for all years from the appropriate base year to the period of the current inventory.						
25	For subcategories, confirm that entire category is being covered.						
26	Provide clear definition of 'Other' type categories (**NIR** and spreadsheets)						

27	Check that known data gaps that result in incomplete estimates are documented, including a qualitative evaluation of the importance of the estimate in relation to total emissions (e.g., subcategories classified as 'not estimated').						
28	Other (please specify)						
Trend QC							
29	For each category, current inventory estimates should be compared to previous estimates, if available.						
30	If there are significant changes from expected trends, re-check estimates and explain any differences.						
31	Check value of implied emission factors (aggregate emissions divided by activity data) across time series.						
32	Do any years show outliers that are not explained?						
33	If they remain static across time series, are changes in emissions or removals being captured?						
34	Check if there are any unusual and unexplained trends noticed for activity data or other parameters across the time series.						
35	Other (please specify)						
Data documentation (NIR + DATA)							
36	Check of data file (e.g. importing tables) from the view of completeness						
37	Confirm that bibliographical data references are properly cited in the internal documentation						
38	Check of the references on source of input data in the spreadsheets						
39	Check that all references in spreadsheets are documented						
40	Check of completeness of references on the sources of input data in the computational spreadsheets						
41	Random check of referred materials, if they really contains referred data						

42	Check that assumptions and criteria for the selection of activity data, emission factors and other estimation parameters are properly recorded and archived.						
43	Check that the changes in data or methodology (e.g. recalculations) are described and documented						
44	Check that quotes are realized uniformly						
45	Other (please specify)						

Explanations of some items:

5. Spatial adjustment factors refer to factors used to adjust average data, obtained from one or more locations within the Member State to national average data.

22. Check that effects of actions/activities taken to avoid or minimize environmental damage are considered and reflected in time series.

General notes to controls

description

Notes for each parts and founded issues

notes which are needed to add in order to finish adequate control

The following table shows QC form for category – specific technical control (QC Tier 2). The QC form follows the guidance provided in IPCC 2006 Gl.

QC form for category-specific technical control

QC (Tier 2)

Source category/ removals: (e.g. 2A Mineral Products)

Reviewed documents: (e.g. CRF Reporter, computational spreadsheet for 2A, relevant chapter in NIR)

Responsible compiler of reviewed category: ...

Persons, who carried out the controls: autocontrol – ..., control – ...

Date of finalization of control:

Instructions for filling

This form should be completed for key categories or categories where significant methodological and data revision have taken place and provides a record of the checks which were carried out and possible consequent corrections. This form should be fulfilled in line with QA/QC plan. In case when it is not clear how to solve founded discrepancies the worker responsible for control should problematic issues discuss with the sector compiler and if needed with other relevant experts.

The first part of the form summarizes results of the controls (once completed) and highlights all significant findings or actions. The second part should be fulfilled according to each listed item. Some explanations of items are given below the checklist. For particular categories not all checks (items) will be applicable - these items are then noted as not relevant (n.r.) or not available (n.a.). This way no check and no row should be left blank or deleted. On the contrary, rows for additional checks that are relevant to the source/sink category can be added to the form.

Summary of control results

Overview of findings and corrections:

description of findings

Suggested corrections, which should be realized in the next submission:

description of suggested corrections

Issues remaining after the corrections:

description of remaining issues

QC form for category-specific and technical control (QC, Tier 2)

Item		Checked completed			Corrective action		
		Date	Individual (first initial, last name)	Errors (Y/N)	Date	Individual (first initial, last name)	Supporting documents
EMISSION DATA QUALITY CHECKS							
1	Are emission comparisons for historical data source performed						
2	Are emission comparisons for significant sub-source categories performed						
3	If applicable, are checks against independent estimates or estimates based on alternative methods performed						
4	Are reference calculations performed						
5	Is completeness check performed						
6	Other (detailed checks)						
EMISSION FACTOR QUALITY CHECKS							
IPCC default emission factors							
7	Are the national conditions comparable to the context of the IPCC default emission factors study						
8	Are default IPCC factors compared with site or plant-level factors						
Country-specific emission factors							
QC on models							
9	Are the model assumptions appropriate and applicable to the GHG inventory methods and national circumstances						
10	Are the extrapolations/interpolations appropriate and applicable to the GHG inventory methods and national circumstances						
11	Are the calibration-based modifications appropriate and applicable to the GHG inventory methods and national circumstances						

12	Are the data characteristics appropriate and applicable to the GHG inventory methods and national circumstances						
13	Are the model documentation (including descriptions, assumptions, rationale, and scientific evidence and references supporting the approach and parameters used for modelling) available						
14	Are model validation steps performed by model developers and data suppliers						
15	Are QA/QC procedures performed by model developers and data suppliers						
16	Are the responses to these results documented						
17	Are plans to periodically evaluate and update or replace assumptions with appropriate new measurements prepared						
18	Is there completeness in relation to the IPCC source/sink categories						
	Comparisons						
19	Are country-specific factors compared with IPCC default factors						
20	Is comparison between countries, including historical trends, min and max value, base and most recent year value, IEF performed						
21	If applicable, is comparison to plant-level emission factors performed						
22	Other (detailed checks)						
ACTIVITY DATA QUALITY CHECKS							
	National level activity data						
23	Are alternative activity data sets based on independent data available						
24	Were comparisons with independently compiled data sets performed						
25	Were the national data compared with extrapolated samples or partial data at sub-national level						
26	Was a historical trend check performed						

27	Are any sharp increases/decreases detected and checked for calculation errors						
28	Are any sharp increases/decreases explained and documented						
	Site-specific activity data						
29	Are there any inconsistencies between the sites						
30	If yes, was a QC check performed to identify the cause of the inconsistency (errors, different measurement techniques or real differences in emissions, operating conditions or technology)						
31	Are the activity data compared between different reference sources and geographic scales (national production statistics vs. aggregated activity data)						
32	Are the differences explained						
33	If applicable, is a comparison between bottom up (site-specific) and top down (national level) account balance performed						
34	Are large differences explained						
35	Other (please specify)						
CALCULATION RELATED QUALITY CHECKS							
36	Are checks of the calculation algorithm (duplications, unit conversion, calculation errors) performed						
37	Are the calculations reproducible						
38	Are all calculation procedures recorded						
39	Other (please specify)						

Explanations of some items:

3. For example comparisons can be made to similar statistics prepared by FAO (for agriculture), IEA (for energy) etc.

8. Compare IPCC default emission factors with site or plant-level factor to determine their representativeness relative to actual sources in the country. This check is good practice even if data are only available for a small percentage of sites or plants.

18. If the model computes and comprises all data covered/required by the IPCC category.

19. Comparison should be made, taking into consideration the characteristics and properties on which the default factors are based. The intent is to determine whether country-specific factors are reasonable, given the similarities or differences between the national category and the "average" category, represented by the default.

25. For example, if national production data are being used to calculate the inventory, it may also be possible to obtain plant-specific production or capacity data for a subset of the total population of plants. The effectiveness of this check depends on how representative the sub-sample is of the national population, and how well the extrapolation technique captures the national population.

General notes to controls

description

Notes for each parts and founded issues

notes which are needed to add in order to finish adequate control

A5. 6Completeness check form used for controlling of data in CRF Reporter

Following table is presenting example of form used for completeness evaluation for all sectors. The table contain also comments by expert in case the completeness function is not working properly. Following shortcuts have been used:

COMPLETED	C
PARTLY COMPLETED	P
INCOMPLETE	I
MISSING	M

Tab. A5 – 6 Completeness check for Waste sector (2015)

Waste		15 May check	19 October check	Comment by expert
5	Waste	i	p	complete
5.A	Solid waste disposal	c	p	complete
5.A.1	Managed waste disposal sites	c	p	complete
5.A.1.a	Anaerobic	c	p	complete
5.A.1.b	Semi-aerobic	c	c	
5.A.2	Unmanaged waste disposal sites	c	c	
5.A.3	Uncategorised waste disposal sites	c	c	
5.B	Biological treatment of solid waste	c	p	complete
5.B.1	Composting	c	p	complete
5.B.1.a	Municipal solid waste	c	c	
5.B.1.b	Other	c	i	complete
5.B.2	Anaerobic digestion at biogas facilities	c	p	complete
5.B.2.a	Municipal solid waste	c	p	complete
5.B.2.b	Other	c	i	complete
5.C	Incineration and open burning of waste	c	p	complete
5.C.1	Waste incineration	c	p	complete
5.C.1.1	Biogenic	c	p	complete
5.C.1.1.a	Municipal solid waste	c	p	complete
5.C.1.1.b	Other	c	i	complete
5.C.1.2	Non-biogenic	c	p	complete
5.C.1.2.a	Municipal solid waste	c	p	complete
5.C.1.2.b	Other	c	c	
	Hazardous waste		c	
5.C.2	Open burning of waste	c	c	
5.C.2.1	Biogenic	c	c	
5.C.2.1.a	Municipal solid waste	c	c	
5.C.2.1.b	Other	c	i	complete
5.C.2.2	Non-biogenic	c	c	
5.C.2.2.a	Municipal solid waste	c	c	
5.C.2.2.b	Other	c	i	complete
5.D	Wastewater treatment and discharge	i	p	complete
5.D.1	Domestic wastewater treatment and discharge	c	c	
5.D.2	Industrial waste water and discharge	c	p	complete
5.D.3	Other	i	i	complete
5.E	Other	c	i	complete
5.F	Memo Items	c	p	complete
5.F.1	Long-term Storage of C in Waste Disposal Sites	c	c	
5.F.2	Annual Change in Total Long-term C Storage	c	c	
5.F.3	Annual Change in Total Long-term C Storage in HWP Waste	c	p	complete

The following tables shows categories that are not estimated (NE) including relevant explanations of the reasons. Categories that are included elsewhere (IE) are shown in similar way.

A5. 7 Additional information to be considered as part of the annual inventory submission and the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol or other useful reference information

Standard electronic format (SEF) tables

SEF Table 1

Party	Czech Republic
Submission year	2018
Reported year	2017
Commitment period	2

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

	Account type	Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Party holding accounts	NO	NO	NO	NO	NO	NO
2	Entity holding accounts	NO	NO	NO	NO	NO	NO
3	Retirement account	NO	NO	NO	NO	NO	NO
4	Previous period surplus reserve account	NO					
5	Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
6	Non-compliance cancellation account	NO	NO	NO	NO		
7	Voluntary cancellation account	NO	NO	NO	NO	NO	NO
8	Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO	NO
9	Article 3.1 ter and quater ambition increase cancellation account	NO					
10	Article 3.7 ter cancellation account	NO					
11	tCER cancellation account for expiry					NO	
12	lCER cancellation account for expiry						NO
13	lCER cancellation account for reversal of storage						NO
14	lCER cancellation account for non-submission of certification report						NO
15	tCER replacement account for expiry	NO	NO	NO	NO	NO	
16	lCER replacement account for expiry	NO	NO	NO	NO		
17	lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
18	lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
	Total	NO	NO	NO	NO	NO	NO

SEF Table 2A

Party	Czech Republic
Submission year	2018
Reported year	2017
Commitment period	2

Table 2 (a). Annual internal transactions

	Transaction type	Additions						Subtractions					
		Unit type						Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
	Article 6 issuance and conversion												
1	Party-verified projects		NO					NO		NO			
2	Independently verified projects		NO					NO		NO			
	Article 3.3 and 3.4 issuance or cancellation												
3	3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
4	3.3 Deforestation			NO				NO	NO	NO	NO		
5	3.4 Forest management			NO				NO	NO	NO	NO		
6	3.4 Cropland management			NO				NO	NO	NO	NO		
7	3.4 Grazing land management			NO				NO	NO	NO	NO		
8	3.4 Revegetation			NO				NO	NO	NO	NO		
9	3.4 Wetlands drainage and management			NO				NO	NO	NO	NO		
	Article 12 afforestation and reforestation												
10	Replacement of expired tCERs							NO	NO	NO	NO	NO	
11	Replacement of expired lCERs							NO	NO	NO	NO		
12	Replacement for reversal of storage							NO	NO	NO	NO		NO
13	Cancellation for reversal of storage												NO
14	Replacement for non-submission of certification report							NO	NO	NO	NO		NO
15	Cancellation for non-submission of certification report												NO
	Other cancelation												
16	Voluntary cancellation							NO	NO	NO	NO	NO	NO
17	Article 3.1 ter and quater ambition increase cancellation							NO					
	Sub-total		NO	NO				NO	NO	NO	NO	NO	NO

	Transaction type	Retirement					
		Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Retirement	NO	NO	NO	NO	NO	NO
2	Retirement from PPSR	NO					
	Total	NO	NO	NO	NO	NO	NO

SEF Table 2BCDE

Party	Czech Republic
Submission year	2018
Reported year	2017
Commitment period	2

Table 2 (b). Total annual external transactions

		Additions						Subtractions					
		Unit type						Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
	Total transfers and acquisitions												
	Sub-total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 2 (c). Annual transactions between PPSR accounts

		Additions						Subtractions					
		Unit type						Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
	Transfers and acquisitions between PPSR accounts												
	Sub-total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 2 (d). Share of proceeds transactions under decision 1/CMP.8, paragraph 21 - Adaptation fund

		Amount transferred or converted						Amount contributed as SoP to the adaptation fund					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	First international transfers of AAUs	NO						NO					
2	Issuance of ERU from party-verified projects		NO						NO				
3	Issuance of independently verified ERUs		NO						NO				

Table 2 (e). Total annual transactions

1	**Total (Sum of sub-totals in table 2a and table 2b)**	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

SEF Table 3

Party Czech Republic
Submission year 2018
Reported year 2017
Commitment period 2

Table 3. Annual expiry, cancellation and replacement

	Transaction or event type	Requirement to replace or cancel			Replacement						Cancellation					
		Unit type			Unit type						Unit type					
		tCERs	lCERs	CERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
	Temporary CERs															
1	Expired in retirement and replacement accounts	NO			NO	NO	NO	NO	NO							
2	Expired in holding accounts	NO													NO	
	Long-term CERs															
3	Expired in retirement and replacement accounts		NO		NO	NO	NO	NO								
4	Expired in holding accounts		NO													NO
5	Subject to reversal of storage		NO		NO	NO	NO	NO		NO						NO
6	Subject to non-submission of certification Report		NO		NO	NO	NO	NO		NO						NO
	Carbon Capture and Storage CERs															
7	Subject to net reversal of storage			NO							NO	NO	NO	NO		
8	Subject to non-submission of certification report			NO							NO	NO	NO	NO		
	Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

SEF Table 4

Party Czech Republic
Submission year 2018
Reported year 2017
Commitment period 2

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

	Account type	Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Party holding accounts	NO	NO	NO	NO	NO	NO
2	Entity holding accounts	NO	NO	NO	NO	NO	NO
3	Retirement account	NO	NO	NO	NO	NO	NO
4	Previous period surplus reserve account	NO					
5	Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
6	Non-compliance cancellation account	NO	NO	NO	NO		
7	Voluntary cancellation account	NO	NO	NO	NO	NO	NO
8	Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO	NO
9	Article 3.1 ter and quater ambition increase cancellation account	NO					
10	Article 3.7 ter cancellation account	NO					
11	tCER cancellation account for expiry					NO	
12	lCER cancellation account for expiry						NO
13	lCER cancellation account for reversal of storage						NO
14	lCER cancellation account for non-submission of certification report						NO
15	tCER replacement account for expiry	NO	NO	NO	NO	NO	
16	lCER replacement account for expiry	NO	NO	NO	NO		
17	lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
18	lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
	Total	NO	NO	NO	NO	NO	NO

SEF Table 5ABCDE

Party Czech Republic
Submission year 2018
Reported year 2017
Commitment period 2

Table 5 (a). Summary information on additions and subtractions

		Additions						Subtractions					
		Unit type						Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Assigned amount units issued	NO											
2	Article 3 paragraph 7 ter cancellations							NO					
3	Cancellation following increase in ambition							NO					
4	Cancellation of remaining units after carry over							NO	NO	NO	NO	NO	NO
5	Non-compliance cancellation							NO	NO	NO	NO		
6	Carry-over		NO		NO				NO		NO		
7	Carry-over to PPSR	NO						NO					
	Total	NO	NO		NO			NO	NO	NO	NO	NO	NO

Table 5 (b). Summary information on annual transactions

		Additions						Subtractions					
		Unit type						Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Year 1 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2	Year 2 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3	Year 3 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4	Year 4 (2016)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	Year 5 (2017)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	Year 6 (2018)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	Year 7 (2019)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	Year 8 (2020)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	Year 2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	Year 2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
11	Year 2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 5 (c). Summary information on annual transactions between PPSR accounts

		Additions						Subtractions					
		Unit type						Unit type					
		AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Year 1 (2013)	NO						NO					
2	Year 2 (2014)	NO						NO					
3	Year 3 (2015)	NO						NO					
4	Year 4 (2016)	NO						NO					
5	Year 5 (2017)	NO						NO					
6	Year 6 (2018)	NO						NO					
7	Year 7 (2019)	NO						NO					
8	Year 8 (2020)	NO						NO					
9	Year 2021	NO						NO					
10	Year 2022	NO						NO					
11	Year 2023	NO						NO					
	Total	NO						NO					

Table 5 (d). Summary information on expiry, cancellation and replacement

		Requirement to replace or cancel			Replacement						Cancellation					
		Unit type			Unit type						Unit type					
		tCERs	lCERs	CERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Year 1 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2	Year 2 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3	Year 3 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4	Year 4 (2016)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	Year 5 (2017)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	Year 6 (2018)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	Year 7 (2019)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	Year 8 (2020)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	Year 2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	Year 2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
11	Year 2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 5 (e). Summary information on retirement

		Retirement					
		Unit type					
	Year	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
1	Year 1 (2013)	NO	NO	NO	NO	NO	NO
2	Year 2 (2014)	NO	NO	NO	NO	NO	NO
3	Year 3 (2015)	NO	NO	NO	NO	NO	NO
4	Year 4 (2016)	NO	NO	NO	NO	NO	NO
5	Year 5 (2017)	NO	NO	NO	NO	NO	NO
6	Year 6 (2018)	NO	NO	NO	NO	NO	NO
7	Year 7 (2019)	NO	NO	NO	NO	NO	NO
8	Year 8 (2020)	NO	NO	NO	NO	NO	NO
9	Year 2021	NO	NO	NO	NO	NO	NO
10	Year 2022	NO	NO	NO	NO	NO	NO
11	Year 2023	NO	NO	NO	NO	NO	NO
	Total	NO	NO	NO	NO	NO	NO

SEF Table 6ABC

Party	Czech Republic
Submission year	2018
Reported year	2017
Commitment period	2

Table 6 (a). Memo item: Corrective transactions relating to additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6 (b). Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6 (c). Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Fig. A7 1 Annex A – CP2 SEF Tables

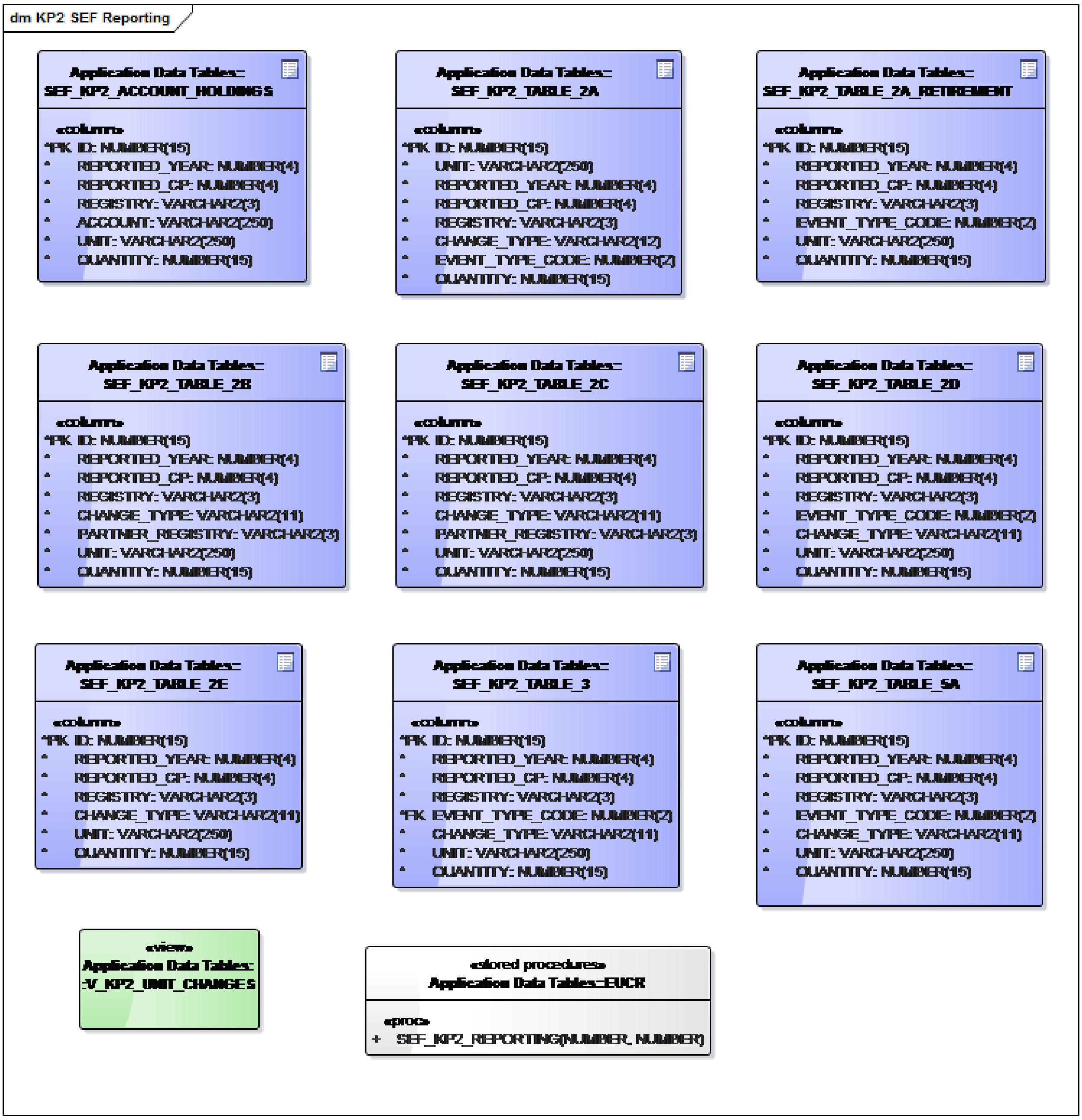
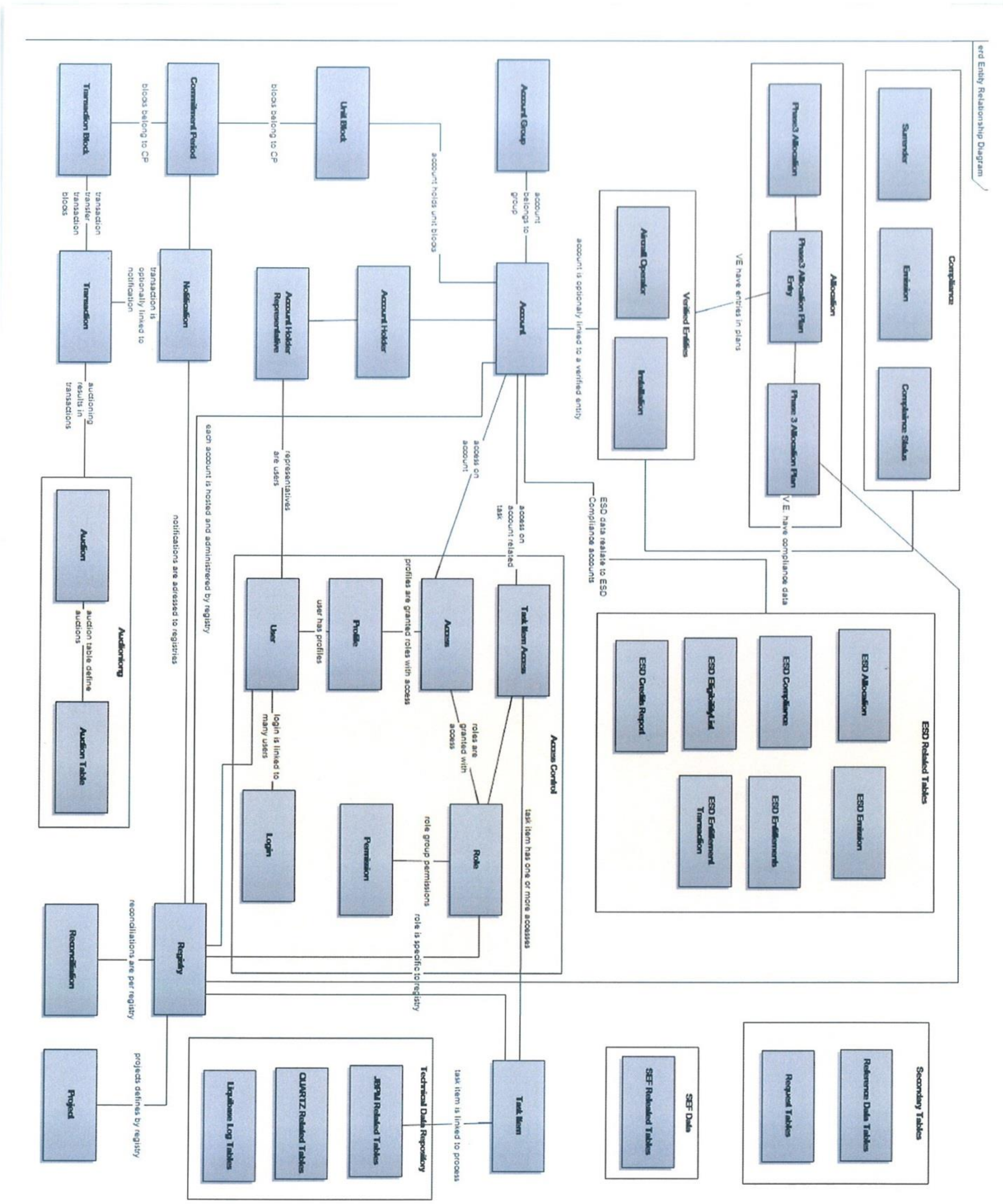


Fig. A7 2 Annex A - CSEUR



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