NATIONAL GREENHOUSE GAS INVENTORY REPORT OF THE CZECH REPUBLIC

SUBMISSION UNDER UNFCCC AND UNDER THE KYOTO PROTOCOL

REPORTED INVENTORIES 1990-2017

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(reported inventories 1990- 2017)
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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, např. 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 2017 s důrazem na poslední vykazovaný rok, tedy 2017. Všechny dříve provedené změny ve vykazování jsou i nadále součástí tohoto dokumentu.

Inventarizace emisí a propadů skleníkových plynů byla připravena v souladu s metodickými pokyny Mezivládního panelu pro změnu klimatu: IPCC 2006 Guidelines. Konkrétní využití této metodiky a využití územně specifických postupů je popsáno 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 konzistentní 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 také 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 požadavkům Kjótského 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 sekretariátu 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 2017 with specific accent on the latest year 2017 while keeping track of already performed/planned changes according to the previous versions.

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

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

The both parts of the National Inventory Report, together with the data output - Common Reporting Format (CRF) Tables, are submitted annually by 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 2017, the most important GHG in the Czech Republic was CO_2 contributing 82.1% to total national GHG emissions and removals expressed in CO_2 eq., followed by CH_4 10.5% and N_2O 4.5%. PFCs, HFCs, SF_6 and NF_3 contributed for 2.9% to the overall GHG emissions in the country.

Tab. ES 1 provides data on GHG emissions in comparison of overall trend from 1990 to 2017. For overview of GHG emissions and removals by categories please see chapter ES 3.

Tab. ES 1 GHG emission/removal overall trends

	Base year	2017	Base year	2017	trend
	[kt CO_2 eq.]		%		
CO_2 emissions without net CO_2 from LULUCF	164 203.58	105 607.27	83.19	82.07	-35.69
CO_2 emissions with net CO_2 from LULUCF	158 893.50	103 403.77	82.69	81.72	-34.92
CH_4 emissions without CH_4 from LULUCF	23 492.14	13 510.83	11.90	10.50	-42.49
CH_4 emissions with CH_4 from LULUCF	23 536.29	13 548.91	12.25	10.71	-42.43
N_2O emissions without N_2O from LULUCF	9 612.74	5 837.72	4.87	4.54	-39.27
N_2O emissions with N_2O from LULUCF	9 652.77	5 868.20	5.02	4.64	-39.21
F-gases	84.24	3 719.22	0.04	2.94	
Total (without LULUCF)	**197 392.70**	**128 675.05**			**-34.81**
Total (with LULUCF)	**192 166.80**	**126 540.11**			**-34.15**
Total (without LULUCF, with indirect)	**199 242.03**	**129 383.52**			**-35.06**
Total (with LULUCF, with indirect)	**194 016.12**	**127 248.59**			**-34.41**

Over the period 1990 - 2017 CO_2 emissions and removals decreased by 35.69%, CH_4 emissions decreased by 42.49% during the same period mainly due to lower emissions from 1 Energy, 3 Agriculture and 5 Waste; N_2O emissions decreased by 39.27% 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

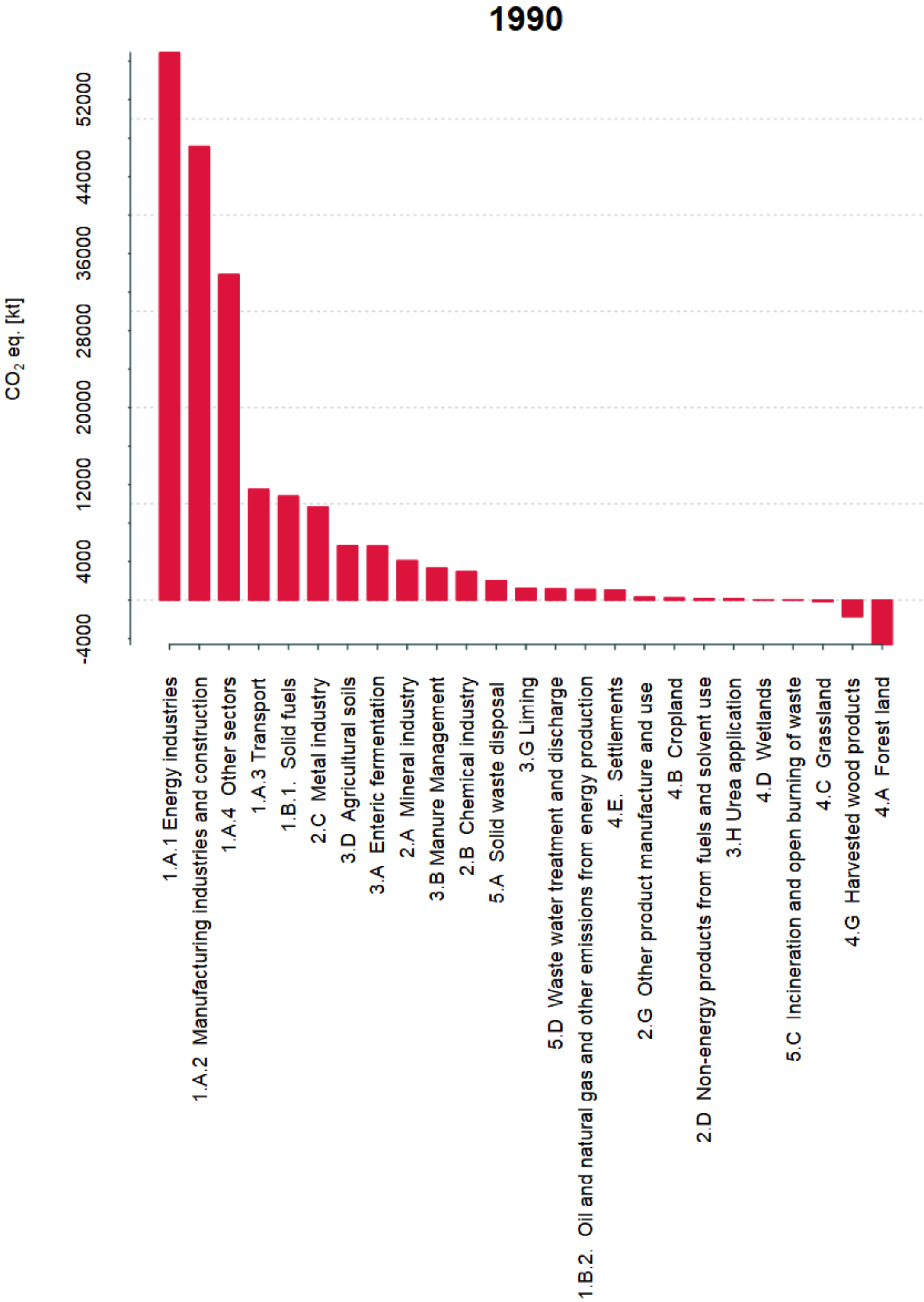


Fig. ES 1 Sources and sinks of greenhouse gases in 1990 (kt CO_2 eq.)

ES 4.1 GHG inventory

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

	Base year kt CO_2 eq.	2017 kt CO_2 eq.	2017 Total share [%]	2017 Sectoral share [%]	Trend %
1. Energy	**161315.59**	**98936.38**	**78.19**	**100.00**	**-38.67**
A. Fuel combustion (sectoral approach)	149454.08	95300.97	75.31	96.33	-36.23
1. Energy industries	56855.14	51764.51	40.91	52.32	-8.95
2. Manufacturing industries and construction	47113.14	10423.08	8.24	10.54	-77.88
3. Transport	11484.14	18658.56	14.75	18.86	62.47
4. Other sectors	33807.41	13989.97	11.06	14.14	-58.62
5. Other	194.26	464.84	0.37	0.47	139.29
B. Fugitive emissions from fuels	11861.51	3635.42	2.87	3.67	-69.35
1. Solid fuels	10779.39	3023.02	2.39	3.06	-71.96
2. Oil and natural gas and other emissions from energy production	1082.12	612.40	0.48	0.62	-43.41
C. CO_2 transport and storage	NO	NO	NA	NA	0.00
2. Industrial Processes	**17113.01**	**15656.35**	**12.37**	**100.00**	**-8.51**
A. Mineral industry	4082.45	2855.54	2.26	16.44	-30.05
B. Chemical industry	2944.23	2235.95	1.77	13.44	-24.06
C. Metal industry	9670.32	6479.44	5.12	44.74	-33.00
D. Non-energy products from fuels and solvent use	125.56	142.70	0.11	0.91	13.65
E. Electronic industry	NO,NE	6.72	0.01	0.12	100.00
F. Product uses as ODS substitutes	NO	3641.60	2.88	22.43	100.00
G. Other product manufacture and use	290.46	294.37	0.23	1.93	1.35
H. Other	NO	0.04	NA	NA	100.00
3. Agriculture	**15839.59**	**8432.99**	**6.66**	**100.00**	**-46.76**
A. Enteric fermentation	5600.62	2939.47	2.32	34.14	-47.52
B. Manure management	3315.61	1562.27	1.23	20.97	-52.88
C. Rice cultivation	NO	NO	NA	NO	0.00
D. Agricultural soils	5627.20	3647.93	2.88	40.76	-35.17
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	159.04	0.13	1.92	-86.61
H. Urea application	108.53	124.28	0.10	2.21	14.52
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	**-5225.91**	**-2134.94**	**-1.69**	**100.00**	**-59.15**
A. Forest land	-4617.65	-1618.98	-1.28	91.15	-64.94
B. Cropland	186.26	35.66	0.03	-0.07	-80.86
C. Grassland	-140.23	-378.79	-0.30	8.29	170.13
D. Wetlands	21.73	20.89	0.02	-0.38	-3.84
E. Settlements	1034.95	583.80	0.46	-1.33	-43.59
F. Other land	NO,NA	NO,NA	NA	NA	0.00
G. Harvested wood products	-1712.98	-778.50	-0.62	2.47	-54.55
H. Other	NO	NO	NA	NA	0.00
5. Waste	**3124.51**	**5649.33**	**4.46**	**100.00**	**80.81**
A. Solid waste disposal	1979.27	3720.28	2.94	64.40	87.96
B. Biological treatment of solid waste	NE,IE	713.93	0.56	12.91	100.00
C. Incineration and open burning of waste	21.25	136.08	0.11	2.57	540.27
D. Waste water treatment and discharge	1123.99	1079.03	0.85	20.12	-4.00
E. Other	NO	NO	NA	NA	0.00
Total CO_2 equivalent emissions without land use, land-use change and forestry	**197392.70**	**128675.05**	-	-	**-34.81**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**192166.80**	**126540.11**	**100.00**		**-34.15**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	**199242.03**	**129383.52**	-	-	**-35.06**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	**194016.12**	**127248.59**	-	-	**-34.41**

In 2017, 98 936.38 kt CO_2 eq., that are 78.19% of national total emissions (including 4 Land Use, Land-Use Change and Forestry) arose from 1 Energy; 96.33% of these emissions arise from fuel combustion activities. The most important sub-category of 1 Energy with 52.32% of total sectoral emissions in 2017 is 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction responses for 10.54% and 1.A.3 Transport for 18.86% of total sectoral emissions. From 1990 to 2017 emissions from 1 Energy decreased by 36.23%.

2 Industrial Processes is the second largest category with 12.37% of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2017 (15 656.35 kt CO_2 eq.); the largest sub-category is 2.C Metal Production with 44.74% of sectoral share. From 1990 to 2017 emissions from 2 Industrial Processes decreased by 8.51%.

3 Agriculture is the third largest category in the Czech Republic with 6.66% share of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2017 (8 432.99 kt CO_2 eq.); 40.76% of these emissions arose from 3.D Agricultural Soils. From 1990 to 2017 emissions from 3 Agriculture decreased by 46.76%.

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 2017 by 59.15% to –2 134.94 kt CO_2 eq.

4.46% of the national total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2017 arose from 5 Waste. 87.96% share of GHG emissions arose from 5.A Solid waste disposal. Emissions from 5 Waste increased from 1990 to 2017 by 80.81% to 5 649.33 kt CO_2 eq.

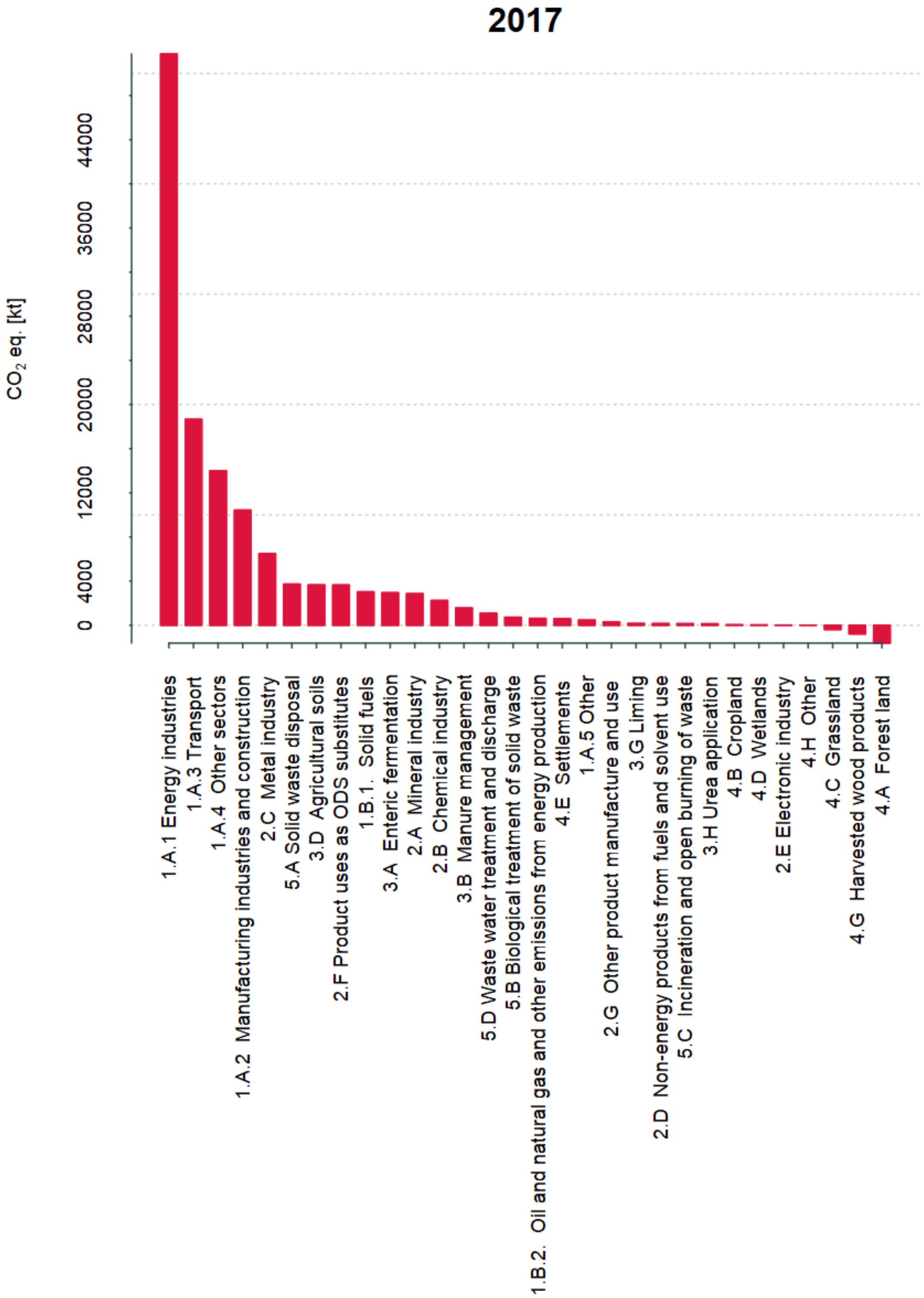


Fig. ES 2 Sources and sinks of greenhouse gases in 2017 (kt CO_2 eq.)

ES 4.2 KP-LULUCF activities

Emission and removals estimates of GHGs for the KP LULUCF activities and HWP contribution for the years 2013-2017 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	2017
A.1. Afforestation and Reforestation						
CO_2 emissions/removals	Gg	-634.49	-699.95	-746.09	-793.13	-851.82
CH_4	Gg	NA	NA	NA	NA	NA
N_2O	Gg	NO	NO	NO	NO	NO
Net CO_2 equivalent emissions/removals	Gg CO_2 eq.	-634.49	-699.95	-746.09	-793.13	-851.82
A.2. Deforestation						
CO_2 emissions/removals	Gg	290.12	287.08	233.46	273.97	300.53
CH_4	Gg	NO	NO	NO	NO	NO
N_2O	Gg	0.00	0.00	0.00	0.00	0.00
Net CO_2 equivalent emissions/removals	Gg CO_2 eq.	290.49	287.41	233.76	274.25	300.77

**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	2017
B.1. Forest Management						
CO_2 emissions/removals	Gg	-5 805.23	-5 740.07	-5 510.69	-4 059.54	-1 788.24
CH_4	Gg	1.00	1.16	1.27	1.31	1.52
N_2O	Gg	0.06	0.06	0.07	0.07	0.08
Net CO_2 equivalent emissions/removals	Gg CO_2 eq.	-5 619.53	-5 514.35	-4 586.33	-4 387.43	-1 725.05

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

Harvested Wood Products	Unit	2013	2014	2015	2016	2017
HWP contribution						
CO_2 emissions/removals	Gg	-126.90	-96.16	-490.14	-940.83	-778.50
CH_4	Gg	NO	NO	NO	NO	NO
N_2O	Gg	NO	NO	NO	NO	NO
Net CO_2 equivalent emissions/removals	Gg CO_2 eq.	-126.90	-96.16	-490.14	-940.83	-778.50

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 2017 are presented in Tab. ES 6.

Tab. ES 6 Indirect GHGs and SO_2 for 1990 to 2017 [kt]

	NO_X	CO	NMVOC	SO_X (as SO_2)
1990	729.98	2 106.04	509.02	1 756.11
1991	694.24	1 987.06	455.18	1 651.74
1992	653.07	1 961.46	434.35	1 383.32
1993	531.47	1 749.41	407.25	1 304.21
1994	438.57	1 678.04	392.61	1 160.71
1995	371.40	1 612.46	356.43	1059.38
1996	352.39	1 676.27	357.39	914.86
1997	323.39	1 538.19	338.33	694.83
1998	304.97	1 308.19	309.99	425.64
1999	280.33	1 163.91	292.03	232.22
2000	281.22	1 112.26	287.30	232.99
2001	285.26	1 096.57	278.94	228.70
2002	279.30	1 059.38	276.68	223.40
2003	281.68	1 087.68	272.44	218.39
2004	282.28	1 068.30	262.77	215.10
2005	277.69	979.85	252.31	208.45
2006	273.04	995.68	253.71	206.75
2007	271.33	1011.75	247.46	212.04
2008	254.75	942.82	242.68	170.08
2009	240.01	951.90	243.08	168.75
2010	233.83	978.06	240.53	163.85
2011	220.70	920.05	229.63	167.59
2012	207.30	908.66	224.11	160.18
2013	191.66	905.63	220.59	145.23
2014	185.24	869.58	213.95	134.49
2015	177.11	854.26	211.62	129.38
2016	167.82	849.89	206.68	115.14
2017	164.63	854.20	207.41	109.96
Trend [%]	-77.45	-59.44	-59.25	-93.74
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 2017: for NO_X by 77.45%, for CO by 59.44%, for NMVOC by 59.25% and for SO_2 by 93.74%. 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 (2019) for the EU contains all the data sets for 1990 - 2017 in the form of the official UNFCCC software called CRF Reporter. Since submission reported in 2015 the CRF Reporter was updated based on the new methodology in scope of different categorization and QWPs. The current version of CRF Reporter is web-based software, which is not considered fully reliable, especially concerning KP LULUCF tables. Additionally, current version of CRF Reporter is adding digits after decimal point during importing of tables, as well as it doesn’t show appropriate notation keys in sum categories. The Party would like to note, that all subcategories are filled up with data, or appropriate notation keys. Since official exported CRF tables are for few categories not calculated correctly, the NIR also contains additional Annex, where the corrected values are displayed.

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

1.2 A description of the national inventory arrangements

1.2.1 Institutional, legal and procedural arrangements

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

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

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

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

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

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

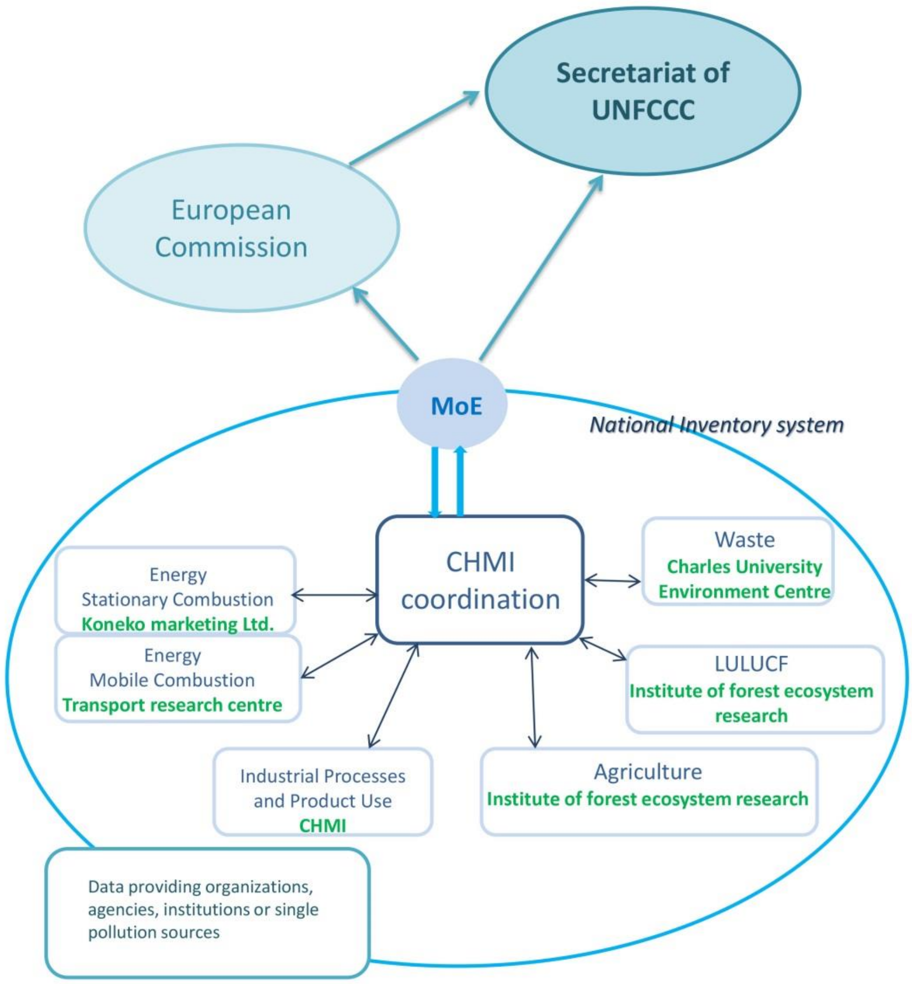


Fig. 1-1 Institutional arrangements of National Inventory System in the Czech Republic

1.2.2 Overview of inventory planning, preparation and management

UNFCCC, the *Kyoto Protocol* and the EU greenhouse gas monitoring mechanism require the Czech Republic to annually submit a *National Inventory Report* (NIR) and *Common Reporting Format* (CRF) tables. The annual submission contains emission estimates for the second but last year, so the 2019 submission contains estimates for the calendar year of 2017. 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.

Annual meetings are held with Slovak National Inventory team in order to discuss the similar difficulties that the both teams are facing while processing their GHG inventories. During the years several general issues were cross-checked, for instance improving the cooperation in the field of QA/QC within the teams. Each year specific sectoral issues are presented and common approach is find to solve them. Since 2017 quatrolateral meetings also with national inventory teams from Hungary and Poland are organised. In 2018 the meeting was focused mainly on Waste issues and was held in Prague.

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

1.2.3.2 Inventory process

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

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

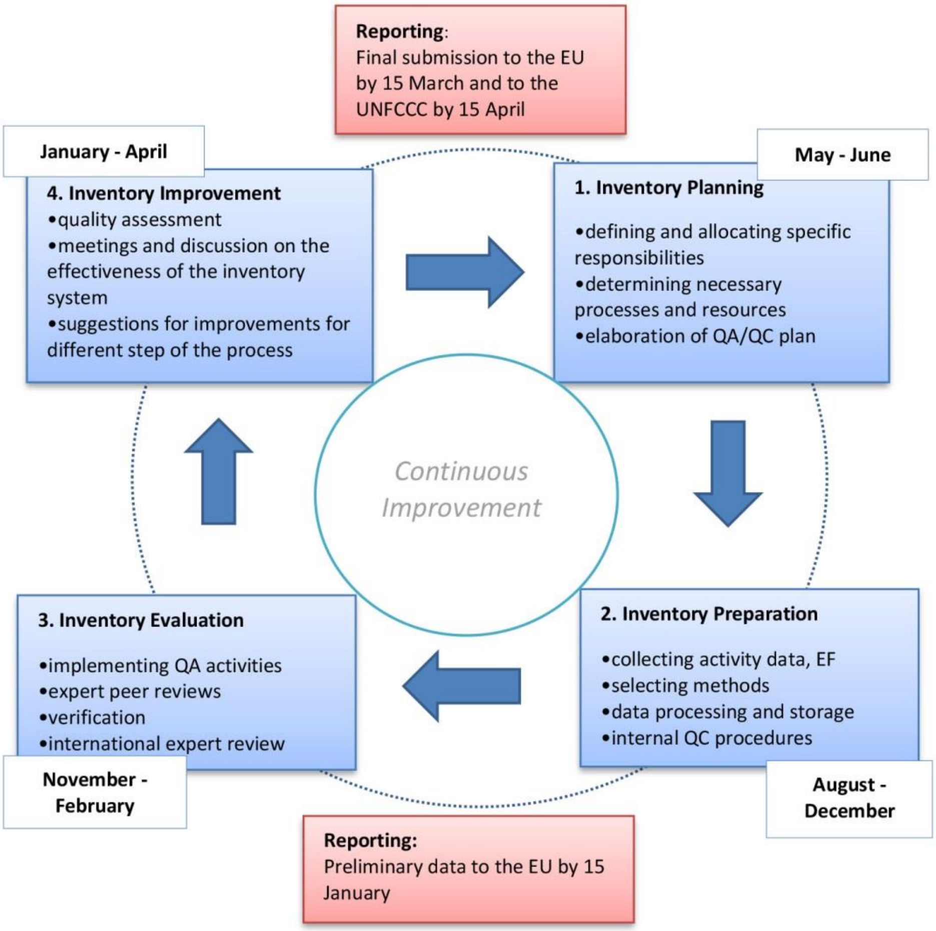


Fig. 1-2 Timeschedule of submissions and QA/QC prodedures

1.2.3.3 Procedures for data acquisition and communication with data suppliers

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

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

The deadline for all data acquisition is 15 November. However, CzSO in some cases carries out data corrections which are presented later. In such cases it is not possible to include corrected data into the output for EU, which is submitted by 15 January and must be considered as a preliminary output of the

Czech national GHG inventory. However, practically all corrected data are incorporated into the final submission for UNFCCC by 15 April (which is also resubmitted to EU).

1.2.3.4 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 Gl., Table 6.1 and IPCC GPG LULUCF 2003, Table 5.5.1) include routine checks of the integrity, correctness and completeness of data, identification of errors and deficiencies and documentation and archiving of inventory data and quality control actions. In addition to general QC checks, category-specific QC checks including technical reviews of the source categories, activity data, emission factors and methods are applied on a case-by-case basis focusing on key categories and on categories where significant methodological and data revisions have taken place.

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

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

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

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

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

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

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

1.2.3.1 Schedule for quality control procedures

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

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

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

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 Gl. and QA/QC plan.

Sectoral administrator, AndreaVeselá:

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

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

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

QC procedures at the Tier 2 are included upon the suggestion of the QA/QC sectoral guarantor after the consultation with the NIS coordinator. They are aimed mainly at the comparison with independent data sources that are not based on data processing from the CzSO energy balance. The relevant independent sources in the Czech Republic are represented by data published and verified within the EU Emission Trading Scheme (ETS) from the national system REZZO, used for the registration of ambient air pollutants, and based mainly on data collection from individual plants. In addition to emission data the REZZO database includes also activity data, independent of CzSO data. The way how to optimally use the above data sources is determined on the basis of systematic research and is covered in the national inventory improvement plan.

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

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

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

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

Person	Activity
Mr. Vladimir Neužil	Sectoral QA/QC guarantor responsible for the compliance of all QA/QC procedures with the IPCC 2006 Gl. and QA/QC plan
Ms. Andrea Veselá	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 Veselá, **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 (Mrs. Vilma Jandová) controls in detail timeliness, completeness, consistency, comparability and transparency.

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

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

Person	Activity
Mr. Roman Ličbínský (Head of the infrastructure and environment department)	Sectoral QA/QC guarantor responsible for the compliance of all QA/QC procedures with the IPCC 2006 Gl. 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 Gl. 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 Veselá:

- 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 (AndreaVeselá) 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 Gl. and the QA/QC plan.
Ms. Andrea Veselá	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 Veselá	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. 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 Gl., 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 Gl. (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 2017 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	33.65	32.88	LA, TA
1.A.3.b Transport - Road transportation	CO_2	46.37	44.53	LA,TA
1.A.4 Other sectors - Gaseous Fuels	CO_2	51.65	66.55	LA, TA
2.C.1 Iron and Steel Production	CO_2	56.50	95.63	LA
5.A Solid Waste Disposal on Land	CH_4	60.58	74.76	LA, TA
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	64.52	84.76	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	67.98	61.61	LA, TA
1.A.4 Other sectors - Solid Fuels	CO_2	70.88	32.88	LA, TA
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	73.69	20.02	LA, TA
3.A Enteric Fermentation	CH_4	75.97	89.76	LA, TA
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	78.23	99.15	LA
1.B.1.a Coal Mining and Handling	CH_4	80.43	70.89	LA, TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	82.45	82.81	LA, TA
2.A.1 Cement Production	CO_2	83.64	98.04	LA
4.A.1 Forest Land remaining Forest Land	CO_2	84.60	80.75	LA, TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	85.55	90.42	LA, TA
5.D Wastewater treatment and discharge	CH_4	86.48	93.67	LA
1.A.4 Other sectors - Liquid Fuels	CO_2	87.35	86.07	LA, TA
4.G Harvested wood products	CO_2	88.19	93.21	LA
5.B Biological treatment of solid waste	CH_4	89.03	87.29	LA, TA
4.E.2 Land converted to Settlements	CO_2	89.82	97.82	LA
3.B Manure Management	N_2O	90.60	95.52	LA
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	97.95	78.24	TA
1.A.4 Other sectors - Solid Fuels	CH_4	95.45	88.11	TA
3.G Liming	CO_2	98.24	88.91	TA

Tab. 1-11 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2017 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	34.93	34.60	LA, TA
1.A.3.b Transport - Road transportation	CO_2	48.13	59.31	LA, TA
1.A.4 Other sectors - Gaseous Fuels	CO_2	53.61	69.82	LA, TA
2.C.1 Iron and Steel Production	CO_2	58.65		LA
5.A Solid Waste Disposal on Land	CH_4	62.88	78.38	LA, TA
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	66.97	86.24	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	70.56	64.62	LA, TA
1.A.4 Other sectors - Solid Fuels	CO_2	73.57	47.02	LA, TA
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	76.49	20.73	LA,TA
3.A Enteric Fermentation	CH_4	78.85	90.55	LA, TA
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	81.20		LA
1.B.1.a Coal Mining and Handling	CH_4	83.49	74.29	LA, TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	85.59	84.15	LA, TA
2.A.1 Cement Production	CO_2	86.82		LA
2.B.8 Petrochemical and Carbon Black Production	CO_2	87.80		LA
5.D Wastewater treatment and discharge	CH_4	88.77		LA
1.A.4 Other sectors - Liquid Fuels	CO_2	89.67	87.58	LA
5.B Biological treatment of solid waste	CH_4	90.54	88.86	LA, TA

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	98.13	81.98	TA
1.A.4 Other sectors - Solid Fuels	CH_4	95.76	89.71	TA

Tab. 1-12 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2017 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	36.25	29.09	LA,TA
1.A.3.b Transport - Road transportation	CO_2	49.94	39.48	LA, TA
1.A.4 Other sectors - Gaseous Fuels	CO_2	55.69	62.62	LA, TA
2.C.1 Iron and Steel Production	CO_2	60.58	58.18	LA, TA
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	64.86	84.05	LA, TA
1.A.4 Other sectors - Solid Fuels	CO_2	67.99	49.51	LA, TA
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	71.01	16.80	LA, TA
5.A Solid Waste Disposal on Land	CH_4	73.83	74.16	LA, TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	76.56	100.00	LA
3.A Enteric Fermentation	CH_4	78.78	94.29	LA, TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	80.98	82.22	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	83.18	77.46	LA, TA
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	85.30	70.81	LA, TA
2.A.1 Cement Production	CO_2	86.61	85.61	LA, TA
1.A.4 Other sectors - Liquid Fuels	CO_2	87.53	88.12	LA, TA
4.A.1 Forest Land remaining Forest Land	CO_2	88.30	66.96	LA, TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	89.06	90.57	LA, TA
5.D Wastewater treatment and discharge	CH_4	89.73	89.86	LA, TA
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	90.37	99.88	LA
3.B Manure Management	N_2O	91.00	87.06	LA, TA
4.G Harvested wood products	CO_2	91.59	91.27	LA, TA
2.B.1 Ammonia Production	CO_2	92.15	91.94	LA, TA
3.B Manure Management	CH_4	92.71	96.92	LA
2.A.2 Lime Production	CO_2	93.22	92.54	LA, TA
4.A.2 Land converted to Forest Land	CO_2	93.72	93.15	LA, TA
5.B Biological treatment of solid waste	CH_4	94.22	93.73	LA, TA
4.E.2 Land converted to Settlements	CO_2	94.66	95.35	LA, TA
1.A.4 Other sectors - Biomass	CH_4	95.10	96.61	LA
1.B.2.b Natural Gas	CH_4	95.53	89.06	LA, TA
1.A.1 Energy industries - Liquid Fuels	CO_2	95.89	94.29	LA
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	97.29	80.37	TA
3.G Liming	CO_2	98.58	94.83	TA
1.A.4 Other sectors - Solid Fuels	CH_4	96.43	95.83	TA

Tab. 1-13 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2017 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	37.25	31.02	LA,TA
1.A.3.b Transport - Road transportation	CO_2	51.32	42.13	LA,TA
1.A.4 Other sectors - Gaseous Fuels	CO_2	57.23	66.53	LA,TA
2.C.1 Iron and Steel Production	CO_2	62.25	61.79	LA,TA
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	66.65	85.99	LA,TA
1.A.4 Other sectors - Solid Fuels	CO_2	69.86	52.59	LA,TA
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	72.97	17.56	LA,TA
5.A Solid Waste Disposal on Land	CH_4	75.87	73.51	LA,TA
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	78.67	100.00	LA
3.A Enteric Fermentation	CH_4	80.96	79.36	LA,TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	83.22	84.00	LA,TA
1.B.1.a Coal Mining and Handling	CH_4	85.47	69.96	LA,TA
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	87.65	82.03	LA,TA
2.A.1 Cement Production	CO_2	89.00	87.64	LA,TA
1.A.4 Other sectors - Liquid Fuels	CO_2	89.95	88.74	LA,TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	90.73	92.93	LA,TA
5.D Wastewater treatment and discharge	CH_4	91.42	90.58	LA,TA
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	92.08	91.38	LA,TA

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
3.B Manure Management	N_2O	92.72	92.18	LA,TA
2.B.1 Ammonia Production	CO_2	93.30	93.64	LA,TA
3.B Manure Management	CH_4	93.87	94.34	LA,TA
2.A.2 Lime Production	CO_2	94.39	94.98	LA,TA
5.B Biological treatment of solid waste	CH_4	94.90	95.60	LA,TA
1.A.4 Other sectors - Biomass	CH_4	95.35	96.92	LA
1.B.2.b Natural Gas	CH_4	95.80	89.73	LA
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	97.61	76.55	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, 33 (Approach 1) and 25 (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	33	25
KC identified by LA	30	22
KC identified by TA	28	18
KC identified by LA + TA concurrently	25	15
KC identified by only LA	5	7
KC identified by only TA	3	3
Key Categories (KC) without LULUCF:	26	20
KC identified by LA	25	18
KC identified by TA	23	14
KC identified by LA + TA concurrently	22	12
KC identified by only LA	3	6
KC identified by only TA	1	2

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, uncertainty in the activity data and emission factors for the individual categories are updated every submission.

Experts from CHMI and all the contributing sectoral organizations are participating 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 relevant subchapters.

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 2017 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 2019 (preparation of 2020 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 4.03%. The corresponding uncertainty in trend is 3.09%. For the case without LULUCF the estimated overall uncertainty in level assessment is 3.7% and 2.34% 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 Gl. are covered (IPCC 2006). 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 2017. 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 1990-2017 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	incl. LULUCF
1990	164203.58	23536.29	9652.77				84.24	199242.03	194016.12
1991	148893.58	21958.59	8310.67				84.08	180813.24	172389.55
1992	144618.05	20626.39	7429.86		NO		85.41	174226.57	164959.49
1993	138636.10	19723.93	6651.99				86.56	166528.47	157663.33
1994	132374.36	18610.78	6524.97				87.66	158971.61	152444.19
1995	131605.98	18184.77	6884.19	27.14	0.01	NO	88.68	158129.08	151133.43
1996	134959.57	18051.69	6672.05	87.51	0.68	NO	98.31	161150.01	153975.21
1997	130729.08	17651.91	6600.01	193.55	1.73	NO	96.10	156515.32	149999.15
1998	125313.44	16953.34	6461.40	264.81	1.66	NO	94.98	150311.11	143709.68
1999	116618.38	16218.18	6270.97	324.77	1.10	NO	95.94	140672.38	133634.26
2000	127059.68	15392.53	6398.81	444.51	4.69	NO	108.40	150494.63	142607.16
2001	126952.46	15151.82	6398.66	561.53	9.75	NO	98.82	150215.36	141987.33
2002	123888.60	14734.68	6143.80	682.36	16.39	NO	121.28	146571.01	138711.07
2003	127376.02	14761.72	5753.65	820.07	8.55	NO	144.69	149809.57	143463.16
2004	128110.18	14334.89	6217.51	921.91	12.81	NO	120.61	150633.08	144112.12
2005	125671.32	14706.39	6041.45	1037.04	14.89	NO	111.84	148549.40	141512.53
2006	126447.34	14951.78	5864.27	1308.41	31.09	NO	105.12	149698.81	144871.75
2007	128260.88	14534.67	5841.03	1716.51	29.00	NO	93.79	151389.49	148825.84
2008	122973.82	14641.79	5970.61	2009.94	39.76	NO	88.67	146644.93	140811.55
2009	115223.65	14285.90	5574.71	2090.49	45.44	NO	89.05	138175.33	131268.68
2010	117459.82	14489.36	5372.34	2381.07	48.04	0.15	82.76	140702.10	135163.23
2011	115005.47	14492.03	5568.04	2639.20	8.24	0.59	88.64	138701.26	131849.77
2012	110904.82	14478.16	5511.41	2757.66	6.19	0.89	92.44	134603.55	127913.10
2013	106376.58	13893.61	5473.34	2906.60	4.08	1.41	83.04	129496.54	123521.28
2014	104014.52	13894.91	5713.45	3104.77	3.02	2.37	79.90	127560.13	121640.15
2015	104786.44	13958.29	5691.57	3317.83	1.93	2.15	78.27	128564.93	123482.61
2016	106599.14	13734.03	5939.00	3462.58	1.44	2.15	78.63	130508.90	125350.87
2017	105607.27	13548.91	5868.20	3640.80	1.37	2.75	74.31	129383.52	127248.59
% [2)]	-35.69	-42.43	-39.21	13316.64	15390.29	NA	-11.79	-35.06	-34.41

	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
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, 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 158 000 kt CO_2 eq. and continues fluctuating ever since (see Fig. 2-1). From 2010 to 2017 the total GHG emissions (incl. indirect emissions and incl. LULUCF) decreased by approximately 6% or -7 914.64 kt CO_2 eq. resulting in total emissions of 127 248.59 kt CO_2 eq. The decrease was caused by CO_2, CH_4, PFCs emissions and SF_6 emissions (decreased by 10%; 6%; 97%; and 10%) despite increase in HFCs emissions and N_2O emissions (raised by 53%; 9%) compared to previous year (excl.LULUCF).

The total GHG emissions and removals in 2017 were -34% below the base year level incl. LULUCF and indirect emissions and -35%, when excl. LULUCF.

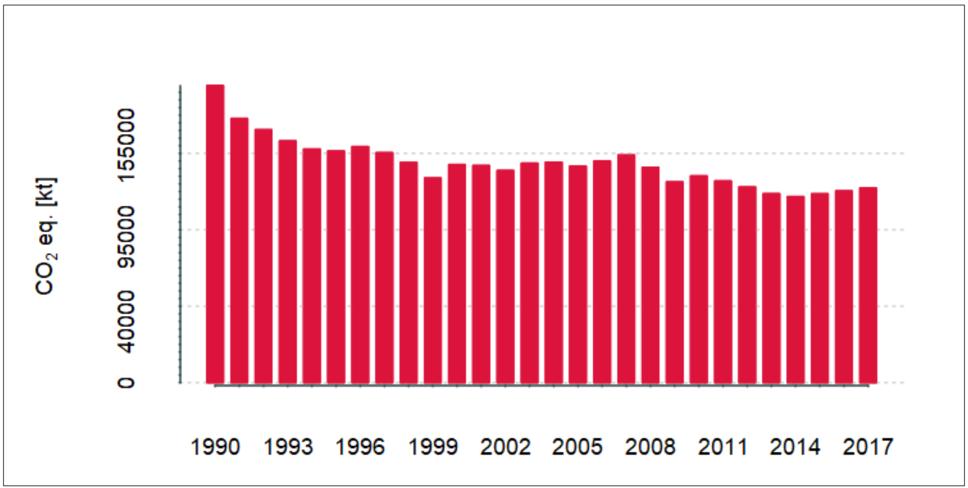


Fig. 2-1 Total trend of GHG emissions, [kt CO_2 eq.]

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.

2.2 Description and interpretation of emission trends by sector

2.2.1 Description and interpretation of emission trends by gas

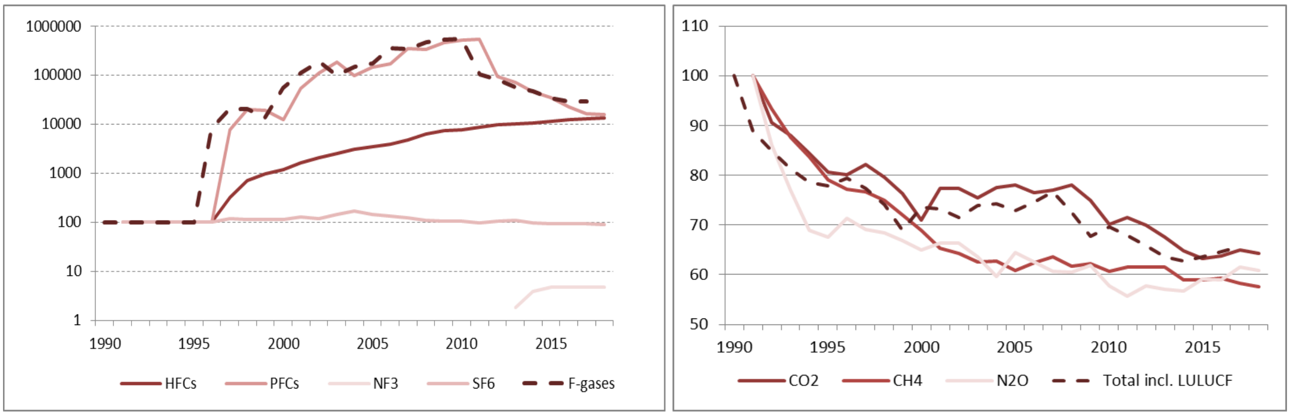


Fig. 2-2 Trend in CO_2, CH_4 and N_2O emissions 1990 - 2017 in index form (base year = 100%) and Trend in HFCs, PFCs (1995 – 2017) and SF_6 (1990 – 2017) actual emissions in index form (base year = 100%)

The major greenhouse gas in the Czech Republic is CO_2, which represents 82% of total GHG emissions and removals in 2017, compared to 83% in the base year (excl. indirect emissions, excl. LULUCF). It is followed by CH_4 (10% in 2017, 12% in the base year), N_2O (5% in 2017, 5% in the base year) and F-gases (3% in 2017, 0.04% in 1990). 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 2017 by 10% results the total decrease of 36% from 1990 to 2017. Quoting in absolute figures, CO_2 emissions and removals decreased from 164 203.58 to 105 607.27 kt CO_2 in the period from 1990 to 2017, 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).

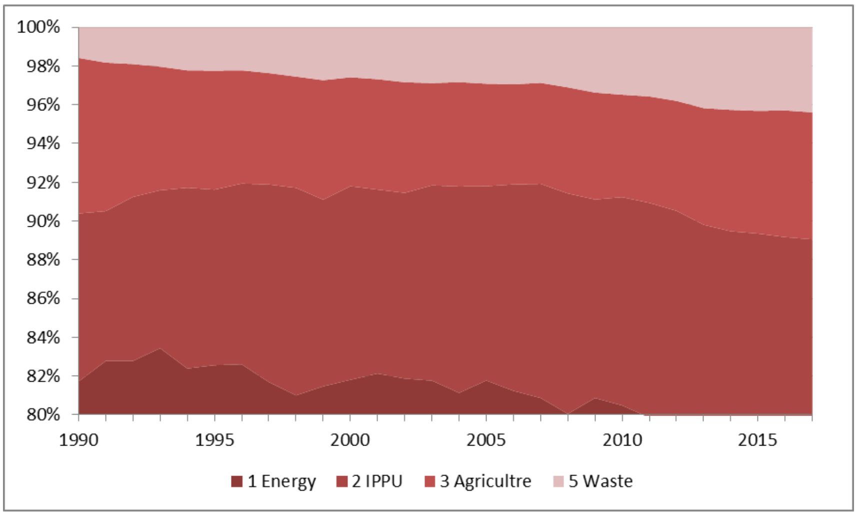


Fig. 2-3 Percentual share of GHGs (Y-axis begins at 80% - part of CO_2 share is hidden)

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 2017 from the 1.A.3 Transport category from 11, 218.46 to 18, 418.22 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 2017 CH_4 emissions were 42% 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% over this period and then shows slow decreasing trend with inter-annual fluctuation. N_2O emissions decreased between 1990 and 2017 from 9 652.77 to 5 868.20 kt CO_2 eq (incl. LULUCF). In 2017 N_2O emissions were 39% 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 2017 from 27.14 to 3 640.80 kt CO_2 eq. The rapid increase of emissions was driven mainly by increased consumption of HFCs in subcategory 2.F.1 Refrigeration and Air Conditioning. In 2017, HFCs emissions were more than 134-times higher than in the base year 1995.

The main sources of HFCs emissions are 2.F Product Uses as ODS substitutes (specifically above mentioned subcategory 2.F.1 Refrigeration and Air Conditioning). HFCs and PFCs have not been imported and used before 1995.

PFCs

PFCs emissions rapidly increased between 1995 and 2010. Since 2010, PFCs emissions are decreasing to current level 1.37 kt CO_2 eq. Rapid decrease of emissions is caused by reduced consumption of PFCs.

The main sources of PFCs emissions are 2.E Semiconductor Manufacture and 2.F.1 Refrigeration and Air Conditioning equipment.

SF_6

SF_6 emissions in 1995 accounted for 88.68 kt CO_2 eq. Between 1995 and 2017 they inter-annually fluctuated with maximum of 144.69 kt CO_2 eq. In 2017 SF_6 reached amount of 74.31 kt, the level was 16% 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 2017 the emissions of NF_3 equalled to 2.75 kt CO_2 eq.

2.2.2 Description and interpretation of emission trends by category

Fig. 2-4 presents a summary of GHG emissions by categories for the period from 1990 to 2017:

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

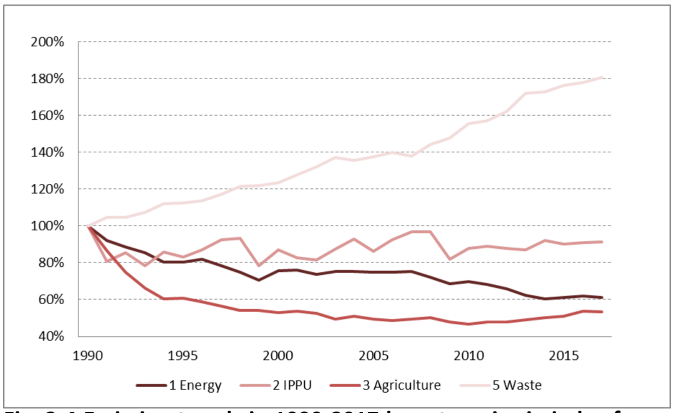


Fig. 2-4 Emission trends in 1990-2017 by categories in index form (base year = 100)

The dominant category is the 1 Energy sector, which caused for 77% of total GHG emissions in 2017 (82% in 1990) excl. LULUCF and indirect emissions, followed by the categories 2 Industrial Processes and Product Use and 3 Agriculture, which caused for 12% and 7% of total GHG emissions in 2017 (9% and 8% in 1990, resp.), 5 Waste category covered 4 % and 4 LULUCF category removed 2 134.94 kt CO_2 eq. which represents share of 2% of all GHG emissions.

The trend of GHG emissions by categories is presented in Fig. 2-4 (indexed relative to the base year).

Tab. 2-2 Summary of GHG emissions by category 1990-2017 [kt CO_2 eq.]

	1 Energy	2 IPPU	3 Agriculture	4 LULUCF	5 Waste
1990	161315.59	17113.01	15839.59	-5225.91	3124.51
1991	148334.86	13847.99	13732.22	-8423.69	3266.79
1992	142963.34	14609.67	11838.17	-9267.08	3275.76
1993	137686.90	13451.41	10523.14	-8865.14	3356.73
1994	129784.15	14690.24	9539.83	-6527.42	3503.45
1995	129387.75	14202.28	9616.63	-6995.65	3510.88
1996	131980.34	14903.04	9337.48	-7174.80	3549.21
1997	126749.69	15822.55	8921.83	-6516.18	3665.98
1998	120701.98	15949.40	8554.82	-6601.43	3792.03
1999	113611.61	13431.38	8599.40	-7038.12	3806.09
2000	122170.35	14916.43	8393.28	-7887.46	3853.46
2001	122455.72	14153.58	8494.36	-8228.03	3993.32
2002	119132.82	13939.64	8306.07	-7859.94	4126.98
2003	121633.74	14989.07	7850.92	-6346.41	4285.11
2004	121399.88	15925.09	8064.87	-6520.96	4234.83
2005	120608.01	14790.38	7801.18	-7036.87	4294.58
2006	120719.51	15828.73	7679.47	-4827.06	4371.05
2007	121583.10	16604.19	7835.16	-2563.65	4314.32
2008	116565.26	16565.03	7972.44	-5833.38	4511.55
2009	110966.55	14054.54	7572.38	-6906.65	4621.05
2010	112462.86	15022.88	7386.47	-5538.87	4861.48
2011	110014.66	15253.97	7567.38	-6851.49	4917.13
2012	106004.88	15029.48	7585.97	-6690.45	5077.39
2013	100676.98	14896.85	7744.22	-5975.26	5373.05
2014	97662.04	15752.16	7940.86	-5919.98	5403.39
2015	98771.14	15402.41	8092.55	-5082.32	5511.73
2016	100133.52	15573.79	8482.36	-5158.03	5567.01
2017	98936.38	15656.35	8432.99	-2134.94	5649.33
[1]%	-1.20	0.53	-0.58	-58.61	1.48
[2]%	-38.67	-8.51	-46.76	-59.15	80.81
[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	2017
Total (net emissions)	192166.80	149721.89	141446.06	140457.28	134194.82	122695.51	126540.11
1. Energy	161315.59	129387.75	122170.35	120608.01	112462.86	98771.14	98936.38
A. Fuel combustion (sectoral approach)	149454.08	120082.74	115044.29	114198.89	106671.34	94383.39	95300.97
1. Energy industries	56855.14	61762.46	62061.95	63165.65	62122.33	53690.07	51764.51
2. Manufacturing industries and construction	47113.14	24468.30	23425.64	18844.64	12112.38	9751.37	10423.08
3. Transport	11484.14	10472.53	12129.34	17368.53	16803.37	17489.10	18658.56
4. Other sectors	33807.41	23162.56	17247.42	14546.59	15304.12	13072.02	13989.97
5. Other	194.26	216.88	179.95	273.47	329.14	380.81	464.84
B. Fugitive emissions from fuels	11861.51	9305.01	7126.06	6409.12	5791.51	4387.76	3635.42
1. Solid fuels	10779.39	8468.06	6249.66	5513.41	4894.36	3774.33	3023.02
2. Oil and natural gas and other emissions from energy production	1082.12	836.95	876.40	895.71	897.15	613.43	612.40
2. Industrial Processes	17113.01	14202.28	14916.43	14790.38	15022.88	15402.41	15656.35
A. Mineral industry	4082.45	3019.09	3633.37	3345.75	3048.42	2594.89	2855.54
B. Chemical industry	2944.23	2808.20	2937.08	2837.88	2371.07	2070.59	2235.95
C. Metal industry	9670.32	7949.20	7435.43	7103.10	6752.62	6975.84	6479.44
D. Non-energy products from fuels and solvent use	125.56	103.75	146.75	133.66	115.27	137.40	142.70
E. Electronic industry	NO,NE	NO,NE	11.17	6.64	41.95	5.30	6.72
F. Product uses as ODS substitutes	NO	27.15	446.61	1046.42	2388.88	3319.35	3641.60
G. Other product manufacture and use	290.46	294.90	306.04	316.93	304.69	299.04	294.37
H. Other	NO	NO	NO	NO	NO	NO	0.04
3. Agriculture	15839.59	9616.63	8393.28	7801.18	7386.47	8092.55	8432.99
A. Enteric fermentation	5600.62	3505.93	2989.01	2798.72	2656.89	2828.21	2939.47
B. Manure management	3315.61	2304.96	2041.46	1835.89	1581.15	1552.07	1562.27
D. Agricultural soils	5627.20	3585.21	3201.99	3027.90	2975.19	3360.75	3647.93
G. Liming	1187.63	111.26	113.21	64.51	61.97	164.41	159.04
H. Urea application	108.53	109.27	47.61	74.17	111.27	187.10	124.28
4. Land use, land-use change and forestry	-5225.91	-6995.65	-7887.46	-7036.87	-5538.87	-5082.32	-2134.94
A. Forest land	-4617.65	-6937.12	-7075.50	-5941.79	-4000.27	-4753.19	-1618.98
B. Cropland	186.26	212.69	174.17	191.97	112.41	70.19	35.66
C. Grassland	-140.23	-364.05	-464.14	-476.37	-537.56	-436.70	-378.79
D. Wetlands	21.73	9.34	27.39	21.75	35.09	25.59	20.89
E. Settlements	1034.95	915.57	727.14	612.64	497.91	500.80	583.80
F. Other land	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
G. Harvested wood products	-1712.98	-833.54	-1277.73	-1446.15	-1647.57	-490.14	-778.50
5. Waste	3124.51	3510.88	3853.46	4294.58	4861.48	5511.73	5649.33
A. Solid waste disposal	1979.27	2404.98	2798.38	3058.11	3462.42	3653.77	3720.28
B. Biological treatment of solid waste	NE,IE	NE,IE	NE,IE	60.90	202.65	678.57	713.93
C. Incineration and open burning of waste	21.25	64.92	57.88	124.12	127.29	121.59	136.08
D. Waste water treatment and discharge	1123.99	1040.98	997.20	1051.44	1069.12	1057.79	1079.03
Memo items:							
International bunkers	528.22	562.83	593.83	978.92	965.41	895.11	1082.89
Aviation	528.22	562.83	593.83	978.92	965.41	895.11	1082.89
CO_2 emissions from biomass	6445.39	5790.70	6666.40	8667.97	12379.65	16258.72	16718.07
Long-term storage of C in waste disposal sites	15558.30	19691.70	24677.97	30258.81	36422.71	41586.48	43541.66
Indirect N_2O	1062.85	551.23	418.73	414.69	354.96	276.15	258.71
Indirect CO_2	1849.32	1411.54	1161.11	1055.26	968.41	787.10	708.48
Total CO_2 equivalent emissions without LULUCF	197392.70	156717.54	149333.52	147494.14	139733.69	127777.83	128675.05
Total CO_2 equivalent emissions with LULUCF	192166.80	149721.89	141446.06	140457.28	134194.82	122695.51	126540.11
Total CO_2 equivalent emissions, including indirect CO_2, without LULUCF	199242.03	158129.08	150494.63	148549.40	140702.10	128564.93	129383.52
Total CO_2 equivalent emissions, including indirect CO_2, with LULUCF	194016.12	151133.43	142607.16	141512.53	135163.23	123482.61	127248.59

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 2017 is 39%. Between 2016 to 2017 emissions from category 1 Energy slightly decreased by 1%.

From the total 98 936.38 kt CO_2 eq. in 2017 96% 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 26% of all CH_4 emissions in 2017. 33% of all CH_4 emissions in 2017 originated from Energy category.

CO_2 emissions from fossil fuels combustion (category 1.A Energy) are the main source in Czech Republic's inventory with a share of 89% in total emissions from Energy sector. CO_2 emissions from category 1 Energy contributes for 73% to total GHG emissions, CH_4 for 4% and N_2O for 1% in 2017 (excl. LULUCF).

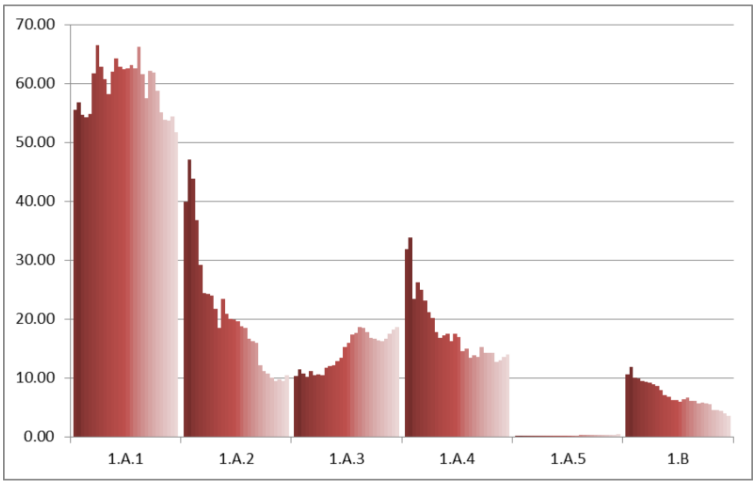


Fig. 2-5 Trends in Energy by categories 1990-2017 (Tg CO_2 eq.)

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 2017. 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 2017, emissions from this category decreased by 9%. In 2017 emissions amounted for 15 656.35 kt CO_2 eq.

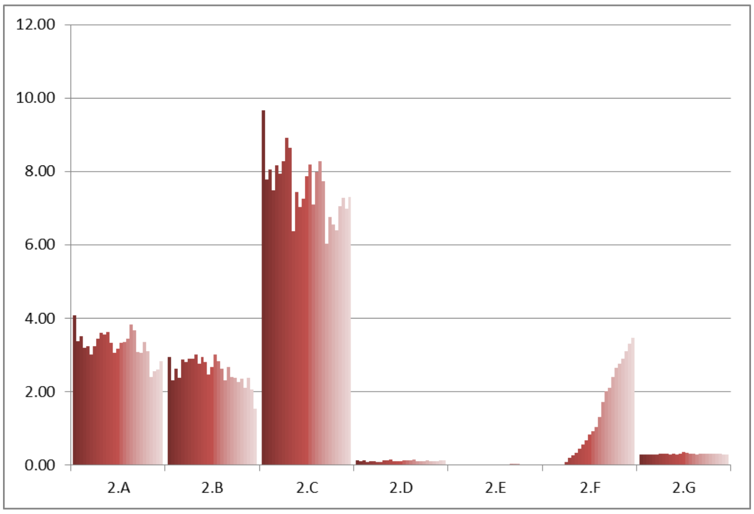


Fig. 2-6 Trends in IPPU by categories 1990-2017 (Tg CO_2 eq.)

The main categories in the 2 Industrial Processes and Product Use category are 2.C Metal Industry (41%), 2.F Product Uses as ODS substitutes (23%), 2.A Mineral Industry (18%) and 2.B Chemical Industry (14%) of the sectoral emissions in 2017 (Fig. 2-6).

The most important GHG of the 2 Industrial Processes and Product Use category was CO_2 with 73% of sectoral emissions, followed by F-gases (24%).

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 % below the base year level.

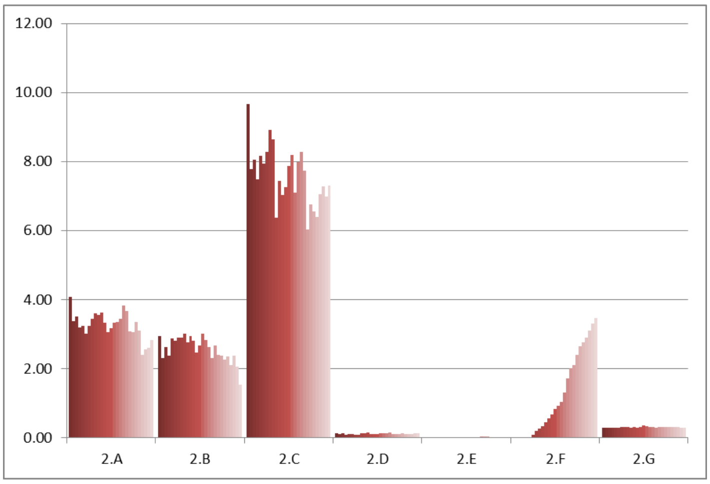


Fig. 2-7 Trends in Agriculture by categories 1990-2017 (Tg CO_2 eq.)

Agriculture amounted to 8 432.99 kt CO_2 eq. in 2017 which corresponds to 7% of national total emissions (excl. indirect emissions, excl. LULUCF). The most important sub-category 3.D Agricultural Soils (N_2O emissions) contributed by 43% to sectoral total in 2017, followed by the 3.A Enteric Fermentation (CH_4 emissions, 35%).

3 Agriculture is the largest source for N_2O and second largest source for CH_4 emissions (77% of total emissions of N_2O and 27% of total emissions of CH_4, excl. 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 maximum of -9267.08 kt CO_2 eq. in 1992 and minimum in 2017.

Emissions and removals amounted to -2134.94 kt CO_2 eq. in 2017, which corresponds to 2% 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 -2203.50 kt CO_2 eq. in 2017. CH_4 emissions amounted to 38.08 kt CO_2 eq., N_2O to 30.48 kt CO_2 eq. Trends of the sub-categories in LULUCF sector are presented in Fig. 2-8.

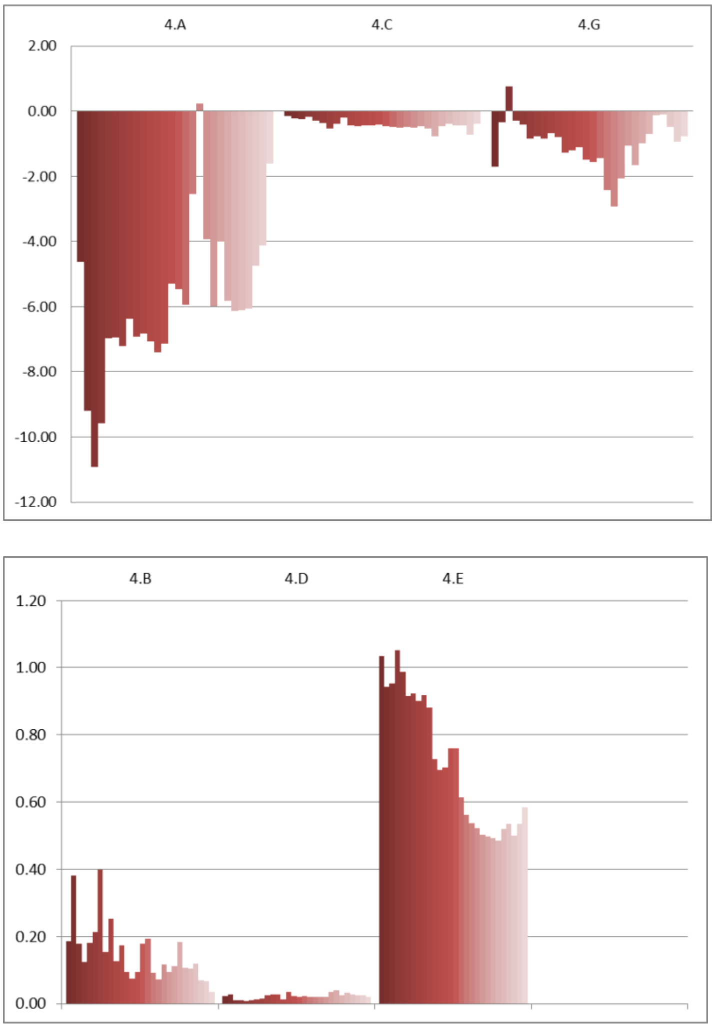


Fig. 2-8 Trends in LULUCF by separate source and sink categories 1990 – 2017 (Tg CO_2 eq.)

Waste (IPCC Category 5)

GHG emissions from category 5 Waste substantially increased during the whole period. In 2017 emissions amounted for 5 649.33 kt CO_2 eq., which is 81% 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% in 2017.

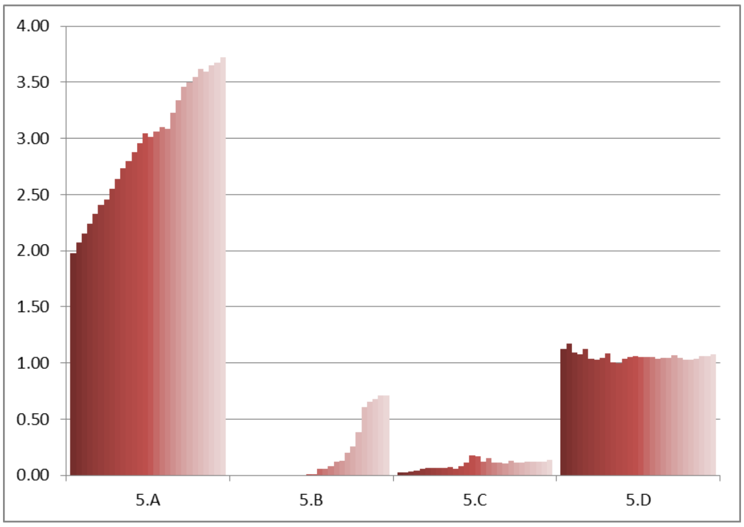


Fig. 2-9 Trends in Waste by categories 1990-2017 (Tg CO_2 eq.)

The main source is solid 5.A Solid Waste Disposal, which accounted for 66% of sectoral emissions in 2017, followed by 5.D Wastewater Treatment and Discharge (19%) and 5.B Biological treatment of solid waste (13%). Trends of the separate sub-categories in Waste sector can be observed on Fig. 2-9.

93% of all emissions from Waste category are CH_4 emissions; CO_2 contributes by 2% and N_2O by 5%.

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

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

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

Of the qualifying KP LULUCF activities, emission removals from Forest Management dominate for all years in the reported period from 2013 to 2017. There removals are enhanced by the estimates for Afforestation/Reforestation activities and by the contribution from changes in carbon pools associated with Harvested Wood Products (HWP). On the contrary, Deforestation represents emissions for all years (Tab. 2-4).

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

Year	Article 3.3 activities		Article 3.4 activities		HWP
	Afforestation and Reforestation	Deforestation	Forest Management	Other Art. 3.4 activities	HWP contribution
2013	-634.49	290.49	-5619.53	NA	-126.9
2014	-699.95	287.41	-5514.35	NA	-96.16
2015	-746.09	233.76	-4586.33	NA	-490.14
2016	-793.13	274.25	-4387.43	NA	-940.83
2017	-851.82	300.77	-1725.05	NA	-778.5
Total*	-3725.48	1386.68	-21832.7	NA	-2432.53

**) 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 emission sources. 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 parts 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 out extensive updates of activity data, which resulted in an increased number of recalculations in this submission. In particular, in April 2017 CzSO carried out extensive updates of net caloric values of some Solid Fuels, which resulted in recalculations in most of categories. This submission is the first one that can respond to these updates.

Default emission factors from the IPCC 2006 Gl. (IPCC 2006) for key categories have been gradually replaced by country specific emission factors.

Inventories of CO_2, CH_4 and N_2O emissions in subsector 1.A.3 Transport were performed using COPERT model starting with this submission.

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, where data are missing or insufficient.

3.1.1 Key categories in sector 1 Energy

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

Altogether, 16 key sources have been identified in sector 1, the most important of which are the first four 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 mostly corresponds to the direct production of heat for buildings in the private and public sector and for households. Consequently, increased attention is paid to this area.

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 the 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 the 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 in the latest assessment. Moreover, identifiers placed this category just over the borderline between key and non-key categories.

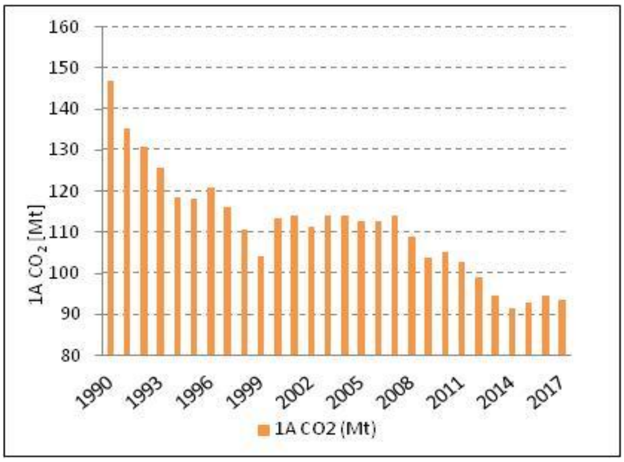
Tab. 3-1 Overview of key categories in 1 Energy (2017)

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	37.61	36.99
1.A.3.b Transport - Road transportation	CO_2	LA, TA	LA,TA	yes	yes	yes	Yes	14.21	13.98
1.A.4 Other sectors - Gaseous Fuels	CO_2	LA, TA	LA, TA	yes	yes	yes	Yes	5.97	5.87
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	LA, TA	LA, TA	yes	yes	yes	Yes	4.45	4.37
1.A.4 Other sectors - Solid Fuels	CO_2	LA, TA	LA, TA	yes	yes	yes	Yes	3.24	3.19
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	LA, TA	LA, TA	yes	yes	yes	Yes	3.14	3.09
1.B.1.a Coal Mining and Handling	CH_4	LA, TA	LA, TA	yes	yes	yes	Yes	2.28	2.24
1.A.1 Energy industries - Gaseous Fuels	CO_2	LA, TA	LA, TA	yes	yes	yes	Yes	2.28	2.25
1.A.4 Other sectors - Liquid Fuels	CO_2	LA, TA	LA, TA	yes	yes	yes	Yes	0.96	0.94
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	TA	TA	yes	yes	yes	Yes	0.21	0.21
1.A.4 Other sectors - Solid Fuels	CH_4	TA	TA	yes		yes	Yes	0.25	0.25
1.A.4 Other sectors - Biomass	CH_4	LA		yes	yes			0.45	0.45
1.B.2.b Natural Gas	CH_4	LA, TA		yes	yes			0.45	0.45
1.A.1 Energy industries - Liquid Fuels	CO_2	LA		yes				0.45	0.44

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

3.1.2 Emissions Trends

CO_2 emissions from the 1.A sector decreased by 36% from 147 Mt CO_2 in 1990 to 94 Mt CO_2 in 2017. Furthermore CO_2 emissions from the 1.B sector decreased by 72% from 458 kt in 1990 to 127 kt in 2017, as well as CH_4 emissions from 1.B sectors decreased by 69% from 456 kt in 1990 to 140 kt in 2017. Fig. 3-1Fig. 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



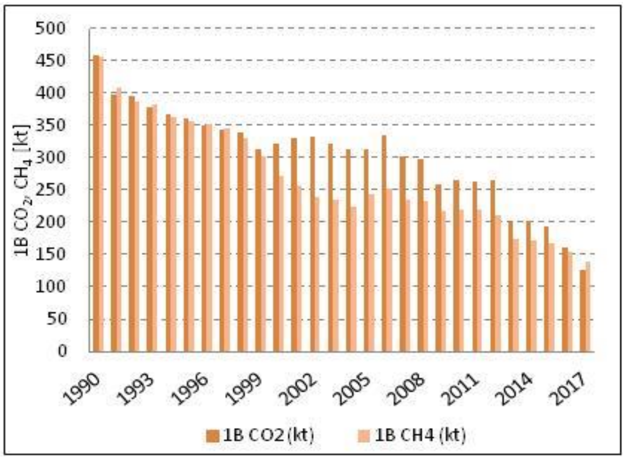


Fig. 3-1 Trend total CO_2 (Sectoral Approach) in 1.A and trend of CO_2 and CH_4 from 1.B sector in period 1990 – 2017

Tab. 3-2 Emissions of greenhouse gases and their trend from 1990 – 2017 from IPCC Category 1 Energy

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]
1990	147 240.01	531.02	2.68
1991	135 652.62	477.92	2.46
1992	131 019.37	449.17	2.40
1993	125 998.03	440.06	2.31
1994	118 686.52	416.92	2.26
1995	118 536.71	406.85	2.28
1996	121 226.86	402.61	2.31
1997	116 263.27	392.51	2.26
1998	110 794.39	369.83	2.22
1999	104 545.46	336.33	2.21
2000	113 785.13	307.23	2.36
2001	114 501.25	292.71	2.14
2002	111 651.49	273.73	2.14
2003	114 201.14	271.04	2.20
2004	114 218.85	260.55	2.24
2005	113 016.61	276.86	2.25
2006	112 883.32	286.12	2.29
2007	114 169.97	268.69	2.33
2008	109 199.79	267.17	2.30
2009	103 949.00	254.42	2.20
2010	105 334.39	258.82	2.21
2011	102 907.44	257.78	2.22
2012	99 104.61	249.95	2.19
2013	94 665.00	214.87	2.15
2014	91 740.02	211.08	2.16
2015	92 941.13	206.90	2.21
2016	94 614.95	194.02	2.24
2017	93 746.13	180.84	2.24
Trend 1990/2017	**-36%**	**-66%**	**-16%**

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 2017.

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 11 Tg CO_2 in 1990 to 18 Tg in 2007. A slight decrease has been apparent since 2008, while between

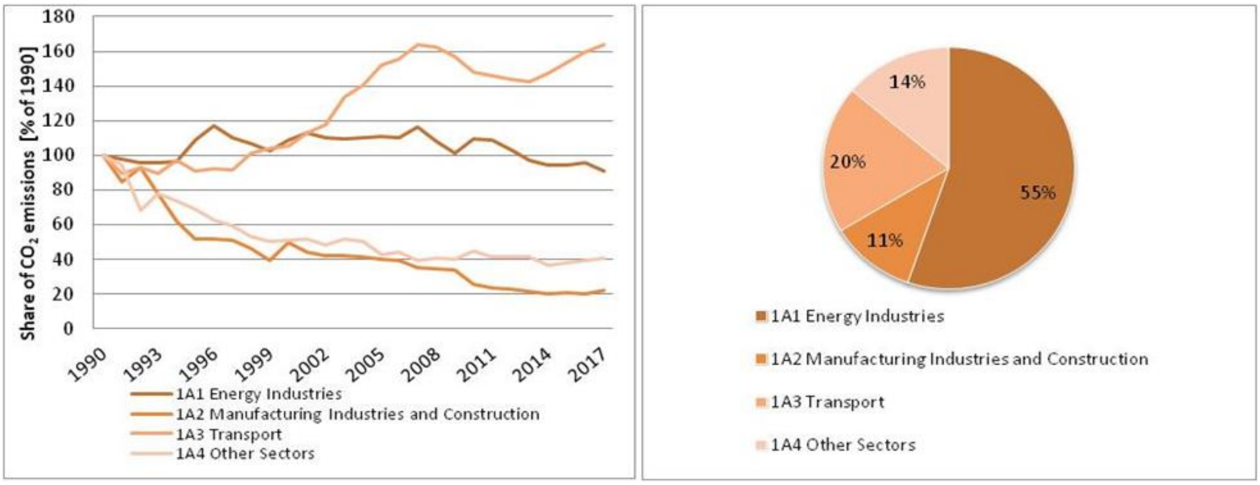


Fig. 3-2 Share and development of CO_2 emissions from 1990 - 2017 in individual sub-sectors; share of CO_2 emissions in individual subsectors in 2017 [kt]

Increase by 1.9 Tg is apparent between 2014 and 2017. 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 47 and 33 Tg CO_2 in 1990 to 10 and 14 Tg CO_2 in 2017, respectively.

Fig. 3-3 demonstrate that the fugitive emissions from Solid fuels also indicate substantial decrease in the whole time-series, i.e. 73% for CO_2 emission and 72% for CH_4 emissions. Fugitive CH_4 emissions from Oil and Natural Gas also indicate decrease for 44% 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.

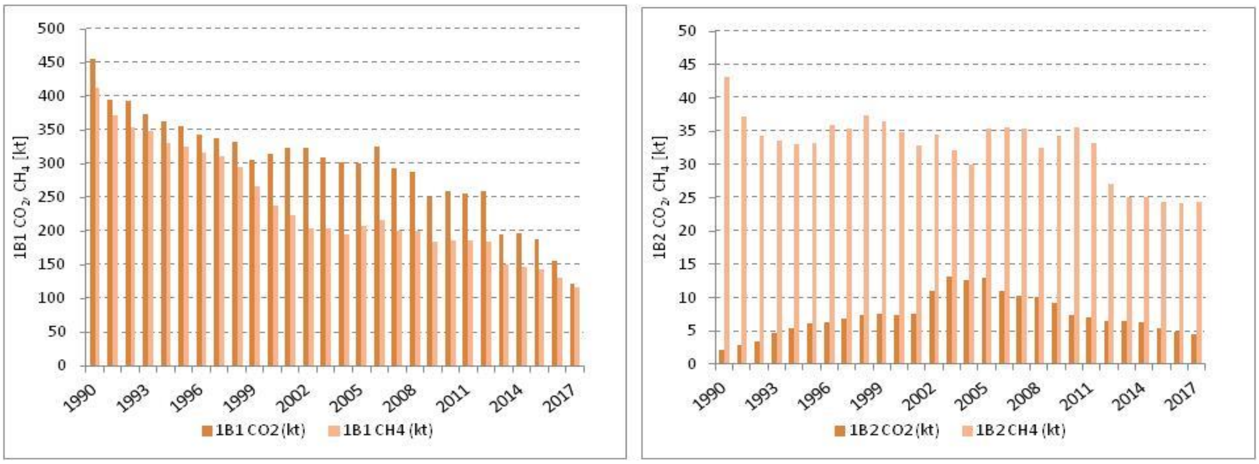


Fig. 3-3 **CO_2 and CH_4 trend from the sector Fugitive Emissions from Solid Fuels and from the sector Fugitive Emissions from Oil and Natural Gas**

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

Tab. 3-3 Total GHG emissions in [kt CO_2 equivalent] from 1990 – 2017 by subcategories 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	161 316	149 454	56 855	47 113	11 484	33 807	194	11 862	10 779	1 082
1991	148 335	137 706	55 476	39 860	10 306	31 909	156	10 628	9 698	931
1992	142 963	132 873	54 650	43 897	10 720	23 406	201	10 090	9 227	863
1993	137 687	127 754	54 321	36 752	10 253	26 239	188	9 933	9 088	845
1994	129 784	120 340	54 842	29 186	11 165	24 933	214	9 444	8 612	832
1995	129 388	120 083	61 762	24 468	10 473	23 163	217	9 305	8 468	837
1996	131 980	122 826	66 518	24 253	10 661	21 183	211	9 155	8 250	905
1997	126 750	117 758	62 809	24 061	10 536	20 154	198	8 991	8 099	892
1998	120 702	112 066	60 678	21 705	11 694	17 816	173	8 636	7 696	940
1999	113 612	105 731	58 225	18 506	12 003	16 829	167	7 881	6 959	922
2000	122 170	115 044	62 062	23 426	12 129	17 247	180	7 126	6 250	876
2001	122 456	115 703	64 245	20 879	12 901	17 517	161	6 752	5 925	828
2002	119 133	112 828	62 799	19 999	13 478	16 310	242	6 305	5 431	873
2003	121 634	115 419	62 449	19 937	15 269	17 519	245	6 215	5 399	816
2004	121 400	115 452	62 568	19 569	16 032	17 010	273	5 947	5 186	762
2005	120 608	114 199	63 166	18 845	17 369	14 547	273	6 409	5 513	896
2006	120 720	114 084	62 615	18 544	17 711	14 956	259	6 635	5 735	900
2007	121 583	115 400	66 264	16 659	18 626	13 504	347	6 183	5 287	897
2008	116 565	110 429	61 533	16 197	18 458	13 863	377	6 136	5 312	825
2009	110 967	105 238	57 462	15 945	17 831	13 636	364	5 729	4 861	868
2010	112 463	106 671	62 122	12 112	16 803	15 304	329	5 792	4 894	897
2011	110 015	104 258	61 884	11 138	16 620	14 229	387	5 756	4 917	839
2012	106 005	100 465	58 755	10 810	16 347	14 236	316	5 540	4 856	684
2013	100 677	96 106	55 168	10 085	16 217	14 325	309	4 571	3 937	634
2014	97 662	93 148	53 790	9 561	16 724	12 755	319	4 514	3 882	632
2015	98 771	94 383	53 690	9 751	17 489	13 072	381	4 388	3 774	613
2016	100 134	96 103	54 456	9 482	18 161	13 596	407	4 031	3 421	610
2017	98 936	95 301	51 765	10 423	18 659	13 990	465	3 635	3 023	612
Total Trend 1990 - 2017	**-39%**	**-36%**	**-9%**	**-78%**	**62%**	**-59%**	**139%**	**-69%**	**-72%**	**-43%**

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), commonly used for determination of greenhouse gas emissions from sector 1.A, the IPCC 2006 Gl. (IPCC 2006) also requires the performance of 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 large amount 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 the 2015 submission onward, it has been required that the Reference Approach be used in accordance with the IPCC 2006 Gl. (IPCC 2006). The 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 basis of the apparent domestic consumption (Apparent consumption, AC) is deducted the “excluded carbon”. This is mainly the case of carbon contained in fossil fuels used: (i) as raw materials for further treatment in industry (feedstocks), (ii) as reductants and (iii) as non-energy products.

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

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

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

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

In the Czech national inventory, the inclusion of above-mentioned “excluded carbon” is being considered for the following substances:

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

Tab. 3-5 and Tab. 3-6 report the values set by the reference approach for 1990, 2000, 2005, 2010, 2011, 2012, 2013, 2014, 2015, 2016 and 2017 and also comparison between the reference and sectoral approach for the same years. Tab. 3-7 summarizes comparison for the whole time period. In the majority of cases, the relative differences are less than 2%.

Tab. 3-5 Activity data in energy units (PJ), 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	358.56	71.77	286.79	298.26	-3.84
	Solid Fuels	1 315.08	86.73	1 228.36	1 179.22	4.17
	Gaseous Fuels	219.91		219.91	205.43	7.05
	Other Fuels	0.39		0.26	0.26	0.00

Year	Type of fossil fuels	Apparent Consumption (PJ)	Carbon excluded (PJ)	Reference approach (PJ)	Sectoral approach (PJ)	(RA-SA)/SA (%)
	Total	**1 893.94**	**158.49**	**1 735.32**	**1 683.18**	**3.10**
1995	Liquid Fuels	321.29	96.96	224.33	233.08	-3.75
	Solid Fuels	937.64	71.03	904.15	866.61	4.33
	Gaseous Fuels	274.74		274.74	260.80	5.35
	Other Fuels	0.98		0.65	0.65	0.00
	Total	**1 534.65**	**167.99**	**1 403.87**	**1 361.14**	**3.14**
2000	Liquid Fuels	311.43	87.58	223.84	238.42	-6.12
	Solid Fuels	901.78	66.29	835.48	822.67	1.56
	Gaseous Fuels	314.52		314.52	305.05	3.10
	Other Fuels	1.91		1.28	1.28	0.00
	Total	**1 529.64**	**153.87**	**1 375.12**	**1 367.43**	**0.56**
2005	Liquid Fuels	387.46	111.37	276.15	291.96	-5.42
	Solid Fuels	847.06	75.47	771.58	762.94	-1.12
	Gaseous Fuels	323.04		323.04	318.87	-1.29
	Other Fuels	2.37		5.69	5.69	0.00
	Total	**1 559.94**	**186.84**	**1 376.46**	**1 379.46**	**-0.22**
2010	Liquid Fuels	370.03	99.60	270.31	277.33	-2.53
	Solid Fuels	780.51	71.50	709.01	702.25	0.96
	Gaseous Fuels	338.55	3.80	334.75	309.77	8.06
	Other Fuels	2.94		5.89	5.89	0.00
	Total	**1 492.02**	**174.90**	**1 319.96**	**1 295.25**	**1.91**
2011	Liquid Fuels	358.01	92.58	265.37	273.27	-2.89
	Solid Fuels	765.68	70.81	694.87	691.32	0.51
	Gaseous Fuels	285.66	3.99	281.67	282.48	-0.29
	Other Fuels	3.34		6.78	6.78	
	Total	**1 412.69**	**167.37**	**1 248.69**	**1 253.85**	**-0.41**
2012	Liquid Fuels	353.13	95.17	257.99	267.86	-3.69
	Solid Fuels	718.15	70.99	647.16	659.25	-1.83
	Gaseous Fuels	287.60	4.07	283.53	278.31	1.88
	Other Fuels	3.50		5.78	5.78	0.00
	Total	**1 362.39**	**170.23**	**1 194.47**	**1 211.21**	**-1.38**
2013	Liquid Fuels	340.79	90.07	250.83	258.20	-2.86
	Solid Fuels	717.84	73.70	644.14	620.53	3.80
	Gaseous Fuels	291.43	3.88	287.55	282.81	1.68
	Other Fuels	3.53		4.67	4.67	0.00
	Total	**1 353.59**	**167.65**	**1 187.19**	**1 166.22**	**1.80**
2014	Liquid Fuels	362.09	100.59	261.68	271.20	-3.51
	Solid Fuels	663.52	76.57	586.95	598.20	-1.88
	Gaseous Fuels	259.39	3.97	255.42	250.40	2.01
	Other Fuels	3.77		5.76	5.76	0.00
	Total	**1 288.76**	**181.12**	**1 109.81**	**1 125.57**	**-1.40**
2015	Liquid Fuels	354.50	81.87	272.71	278.85	-2.20
	Solid Fuels	682.81	75.36	607.45	595.68	1.98
	Gaseous Fuels	272.03	4.02	268.01	263.19	1.83
	Other Fuels	3.72		7.07	7.07	0.00
	Total	**1 313.07**	**161.25**	**1 155.25**	**1 144.80**	**0.91**
2016	Liquid Fuels	330.80	52.81	278.07	278.89	-0.29
	Solid Fuels	685.73	78.26	607.46	598.47	1.50
	Gaseous Fuels	294.46	4.21	290.25	285.65	1.61
	Other Fuels	4.08		7.78	7.78	0.00
	Total	**1 315.07**	**135.28**	**1 183.56**	**1 170.79**	**1.09**
2017	Liquid Fuels	381.44	104.10	279.75	286.85	-2.47
	Solid Fuels	648.59	69.18	579.41	577.85	0.27
	Gaseous Fuels	302.19	4.59	293.10	294.27	-0.40
	Other Fuels	4.11		8.63	8.63	0.00
	Total	**1 336.33**	**177.87**	**1 160.89**	**1 167.61**	**-0.57**

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

Year	Type of fossil fuels	Apparent Consumption (kt CO_2)	Carbon excluded (kt CO_2)	Reference approach (kt CO_2)	Sectoral approach (kt CO_2)	(RA-SA)/SA (%)
1990	Liquid Fuels	26 351.41	5 392.00	20 959.41	22 196.19	-5.57
	Solid Fuels	127 096.39	9 280.00	117 816.39	113 360.35	3.93
	Gaseous Fuels	11 990.17	0.00	11 990.17	11 200.98	7.05
	Other Fuels	24.04		24.04	24.04	0.00
	Total	**165 462.01**	**14 672.00**	**150 790.01**	**146 781.57**	**2.73**
1995	Liquid Fuels	23 432.31	7 197.00	16 235.31	17 178.70	-5.49
	Solid Fuels	90 469.99	7 600.00	82 869.99	86 592.46	-4.30
	Gaseous Fuels	15 110.10	0.00	15 110.10	14 343.44	5.34
	Other Fuels	59.83		59.83	59.83	0.00
	Total	**129 072.22**	**14 797.00**	**114 275.22**	**118 174.44**	**-3.30**
2000	Liquid Fuels	22 666.97	6 481.00	16 185.97	17 460.45	-7.30
	Solid Fuels	87 187.25	7 093.00	80 094.25	79 108.45	1.25
	Gaseous Fuels	17 297.22	0.00	17 297.22	16 776.79	3.10
	Other Fuels	117.00		117.00	117.00	0.00
	Total	**127 268.45**	**13 574.00**	**113 694.45**	**113 462.70**	**0.20**
2005	Liquid Fuels	40 081.24	20 040.62	20 040.62	21 485.89	-6.73
	Solid Fuels	147 828.20	73 914.10	73 914.10	73 180.71	1.00
	Gaseous Fuels	35 529.01	17 764.51	17 764.51	17 535.52	1.31
	Other Fuels	500.73		500.73	500.73	0.00
	Total	**223 939.18**	**111 719.23**	**112 219.95**	**112 702.84**	**-0.43**
2010	Liquid Fuels	27 089.51	7 394.00	19 695.51	19 960.81	-1.33
	Solid Fuels	74 899.24	7 296.00	67 603.24	67 468.09	0.20
	Gaseous Fuels	18 717.12	210.00	18 507.12	17 126.77	8.06
	Other Fuels	512.00		512.00	512.00	0.00
	Total	**223 939.18**	**111 719.23**	**112 219.95**	**112 702.84**	**-0.43**
2011	Liquid Fuels	26 203.77	6 883.00	19 320.77	19 667.49	-1.76
	Solid Fuels	73 817.14	7 238.00	66 579.14	66 778.20	-0.30
	Gaseous Fuels	15 785.36	220.00	15 565.36	15 610.45	-0.29
	Other Fuels	588.91		588.91	588.91	0.00
	Total	**116 395.18**	**14 341.00**	**102 054.18**	**102 645.04**	**-0.58**
2012	Liquid Fuels	25 873.87	7 072.00	18 801.87	19 265.37	-2.41
	Solid Fuels	69 222.81	7 215.00	62 007.81	63 671.28	-2.61
	Gaseous Fuels	15 876.20	225.00	15 651.20	15 363.47	1.87
	Other Fuels	538.51		538.51	538.51	0.00
	Total	**111 511.38**	**14 512.00**	**96 999.38**	**98 838.63**	**-1.86**
2013	Liquid Fuels	24 942.45	6 691.00	18 251.45	18 576.00	-1.75
	Solid Fuels	68 994.60	7 487.00	61 507.60	59 833.85	2.80
	Gaseous Fuels	16 117.10	215.00	15 902.10	15 640.46	1.67
	Other Fuels	413.34		413.34	413.34	0.00
	Total	**110 467.49**	**14 393.00**	**96 074.49**	**94 463.66**	**1.71**
2014	Liquid Fuels	26 541.53	7 460.00	19 081.53	19 478.43	-2.04
	Solid Fuels	63 781.28	7 632.00	56 149.28	57 688.93	-2.67
	Gaseous Fuels	14 358.31	220.00	14 138.31	13 859.80	2.01
	Other Fuels	509.73		509.73	509.73	0.00
	Total	**105 190.85**	**15 312.00**	**89 878.85**	**91 536.89**	**-1.81**
2015	Liquid Fuels	26 062.34	6 134.00	19 928.34	20 044.28	-0.58
	Solid Fuels	65 569.49	7 471.00	58 098.49	57 501.66	1.04
	Gaseous Fuels	15 060.49	223.00	14 837.49	14 586.54	1.72
	Other Fuels	614.72		614.72	614.72	0.00
	Total	**107 307.04**	**13 828.00**	**93 479.04**	**92 747.21**	**0.79**
2016	Liquid Fuels	24 274.34	3 980.15	20 294.19	20 113.69	0.90
	Solid Fuels	65 785.08	7 825.99	57 959.09	57 782.89	0.30
	Gaseous Fuels	16 312.40	233.15	16 079.25	15 854.22	1.42
	Other Fuels	702.75		702.75	702.75	0.00
	Total	**107 074.57**	**12 039.29**	**95 035.27**	**94 453.55**	**0.62**
2017	Liquid Fuels	27 920.06	7 490.45	20 429.61	20 661.09	-1.12
	Solid Fuels	62 481.11	6 920.02	55 561.09	55 982.90	-0.75

Year	Type of fossil fuels	Apparent Consumption (kt CO_2)	Carbon excluded (kt CO_2)	Reference approach (kt CO_2)	Sectoral approach (kt CO_2)	(RA-SA)/SA (%)
	Gaseous Fuels	16 759.76	229.49	16 530.27	16 321.10	1.28
	Other Fuels	654.02		654.02	654.02	0.00
	Total	**107 814.95**	**14 639.96**	**93 174.99**	**93 619.11**	**-0.47**

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

Year	Appar. cons. (PJ)	Carbon excluded (PJ)	Reference approach (PJ)	Sectoral approach (PJ)	(RA-SA)/SA (%)	Activity data (kt CO_2)	Carbon excluded (kt CO_2)	Reference approach (kt CO_2)	Sectoral approach (kt CO_2)	(RA-SA)/SA (%)
1990	1 841.63	158.49	1 735.32	1 683.14	3.10	161 556	10 766	150 790	146 782	2.73
1991	1 667.94	114.01	1 588.59	1 553.94	2.23	148 743	10 766	137 978	135 255	2.01
1992	1 640.94	120.19	1 519.86	1 520.75	-0.06	140 875	11 327	129 548	130 623	-0.82
1993	1 574.11	108.30	1 470.91	1 465.81	0.35	135 237	10 250	124 986	125 620	-0.50
1994	1 520.94	130.62	1 380.45	1 390.32	-0.71	128 479	12 125	116 354	118 319	-1.66
1995	1 566.61	167.99	1 366.33	1 398.62	-2.31	129 072	14 797	114 275	118 174	-3.30
1996	1 622.42	174.02	1 402.47	1 448.40	-3.17	131 038	15 311	115 727	120 877	-4.26
1997	1 566.47	171.18	1 419.21	1 395.28	1.71	132 874	15 251	117 623	115 919	1.47
1998	1 510.76	167.22	1 372.23	1 343.54	2.14	127 423	14 935	112 488	110 454	1.84
1999	1 428.28	149.05	1 273.55	1 279.22	-0.44	115 772	12 876	102 896	104 232	-1.28
2000	1 521.30	153.87	1 375.12	1 367.42	0.56	127 269	13 574	113 694	113 463	0.20
2001	1 538.34	151.23	1 402.52	1 387.11	1.11	128 327	13 262	115 065	114 170	0.78
2002	1 514.63	158.85	1 377.93	1 355.78	1.63	126 760	14 023	112 737	111 318	1.28
2003	1 555.31	167.48	1 389.28	1 387.83	0.10	128 571	14 871	113 700	113 878	-0.16
2004	1 588.74	195.67	1 330.44	1 393.07	-4.50	124 993	17 064	107 928	113 904	-5.25
2005	1 566.29	186.84	1 376.46	1 379.45	-0.22	128 252	16 032	112 220	112 703	-0.43
2006	1 575.70	196.82	1 394.37	1 378.88	1.12	130 843	17 090	113 754	112 548	1.07
2007	1 574.61	187.37	1 403.89	1 387.24	1.20	131 914	16 424	115 489	113 867	1.43
2008	1 527.93	192.37	1 339.89	1 335.56	0.32	125 705	16 524	109 181	108 902	0.26
2009	1 427.40	158.87	1 250.31	1 268.54	-1.44	115 281	13 513	101 768	103 690	-1.85
2010	1 470.13	174.90	1 319.96	1 295.23	1.91	121 217	14 899	106 318	105 068	1.19
2011	1 421.21	167.37	1 248.69	1 253.83	-0.41	116 396	14 342	102 054	102 645	-0.58
2012	1 381.42	170.23	1 194.47	1 211.19	-1.38	111 512	14 512	96 999	98 839	-1.86
2013	1 333.86	167.65	1 187.19	1 166.20	1.80	110 468	14 393	96 074	94 464	1.71
2014	1 306.65	181.12	1 109.81	1 125.52	-1.40	105 235	15 356	89 879	91 537	-1.81
2015	1 305.96	161.25	1 155.25	1 144.71	0.92	107 358	13 879	93 479	92 747	0.79
2016	1 306.00	135.28	1 183.56	1 170.73	1.10	107 060	12 025	95 035	94 454	0.62
2017	1 344.87	177.87	1 160.89	1 167.01	-0.52	107 815	14 640	93 175	93 619	-0.47

In 1990, 1995, 1996 and 2004, the difference between the reference and sectoral approaches is much larger than 2%. These differences are mainly caused by statistical differences (SD) and distribution losses (DL), see Tab. 3-8.

Tab. 3-8 Explanation of high differece between reference and sectoral approach

Years	(RA-SA)/SA (%)	Statistical diffrences (SD) [TJ]	Distribution losses (DL) [TJ]	SD+DL [TJ]	Share DL+DS from sectoral approach (%)	(RA-SA)/SA without DS+DL (%)
1990	2.73	68 003.29	0.00	68 003.29	3.91	-1.18
1995	-3.30	-16 708.24	439.32	-16 268.92	-1.16	-2.14
1996	-4.26	-26 629.76	631.39	-25 998.36	-1.80	-2.46
2004	-5.25	-36 609.64	578.67	-36 030.97	-2.60	-2.65

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 a marine fleet.

Basic activity data are available in the CzSO energy balance (CzSO, 2018). 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**	**2017**
[TJ/ year]	13 062	13573	14070	14763	15664	14287	13387	13272	12367	11931	12248	12413	13250	15016

3.2.3 Feedstocks and non-energy use of fuels

IPCC 2006 Gl. clearly defines the borderlines between the sectors of Energy and Industrial Processes and Product Use (IPPU) (IPCC 2006). Compared to the previous version of the methodology (IPCC 1997), emissions from non-energy use of fuels are 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 degree, 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 the 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 fixed for a long time in the products and the larger part of the carbon is oxidized during the reduction process. A typical example of a 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 as lubricants (lubricating oils and petrolatum), diluents and solvents, bitumen (for covering roads and roofs) and paraffin. In this IPPU category, there are only limited emissions of CO_2 and other GHG (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 the 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.

In accordance with the Regulation No 1099/2008 of the European Parliament and of the Council on energy statistics, the energy balance of the Czech Republic distinguishes various types of fuels in their use for energy and non-energy purposes. Below are listed the various 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. These consist primarily of naphtha, for which CzSO has reported since 2001 that virtually the entire amount is consumed for non-energy purposes in the chemical industry, mainly as petrochemicals (2.B). The non-energy use of LPG is less significant. Since Naphtha is a major feedstock, emissions from sector 2.B.8 Petrochemical and Carbon Black Production are 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 a variety of chemical production processes and the specific amount is not known.

Another important type of liquid fuels consumed for non-energy purposes is a group denoted as Other Oils. Their most significant share is Other Petroleum Products, which are employed in the production of hydrogen by partial oxidation with steam for subsequent production of ammonia and another part is also categorised as Solvent Use. In 2017, the consumption of Other Petroleum Products for non-energy purposes (particularly in sub-sectors 2.B, 2.D) corresponded to 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 for non-energy use is processed under Solvents. Following the IPCC 2006 Gl., no CO_2 is produced from Solvent Use (2.D.3) (IPCC 2006).

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

The liquid fuels, used especially for non-energy purposes, also include bitumen, whose consumption in 2017 was 16 PJ and lubricants with consumption of 8 PJ in 2017. While the use of bitumen yields are no emissions of CO_2 (Stored carbon), annually a portion of lubricants is oxidized to CO_2 (Reported in 2.D.1) Consequently, CO_2 reported in Table 1.A(d) under Lubricants is the CO_2 formed in 2.D.1.

Solid fuels for non-energy purposes are mainly used as reductants. These include coke (Coke Oven Coke), of which 47 PJ were used in the production of iron and steel (2.C.1) in 2017. Consequently, CO_2 reported in Table 1.A(d) under Coke Oven Coke is the CO_2 which formed in 2.C.1 from Metallurgical coke use. In the Other bituminous coal category in 2017, 8 PJ were used for non-energy purposes. Further bituminous coal was also used as reductant in 2.C.1.

In many countries, natural gas (NG) is also used as a feedstock. In the Czech Republic, it was not used this way until recently; since 2008 CzSO has reported 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 the 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	EF
	[GJ/kt]	[t CO_2/TJ]
LPG	43 800	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	29 418[2)]	107.00

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

3.2.4 Methodological issues

The chapter describes procedures which are employed 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, 2018), 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 reported in thousand m^3 and the consumption in TJ is also tabulated; however, this value is calculated using the gross caloric value. The Energy balance in mass units (kt p.a.) for the last reported year (2016) is given in Annex 4, Tables A4-1 – A4-7.

Since the 2012 submission, net calorific values for Liquid Fuels have been available for the whole time series. These are now assumed to be correct (agreed by CzSO) and therefore are used for conversion of activity data from natural units to energy units. Except for 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 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 data 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.

If EU ETS data are used, the original forms are stored in the archive of the national inventory system coordinator, as well as officially at the 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. An interconnected system of excel files was used to create a computational model for emission estimates from the stationary sources in the 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 chronological order
- the source of the data
- 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 fuel are used, and 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 the entire computational approach for estimation of CO_2, CH_4 and N_2O emissions, which includes the following steps:

- complete division of data on the consumption of each kind of fuel from the Energy balance provided by CzSO into the structure compatible with the CRF Reporter (for the purposes of the 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

The outputs from the computational model are datasets, which can be imported into the CRF Reporter. All the computational sheets are managed in whole time-series and units of input and output values are also recorded.

3.2.4.3 Calculations of emissions

Original activity data are provided in kilotons. Thus, it is necessary to convert these values to energy units – terajoules. The calorific values listed in Annex 5 are used for this conversion.

Coke Oven Gas, Gas Works Gas and biofuels are given directly in terajoules in the CzSO Questionnaires (CzSO, 2018); 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 coefficient NCV/GCV = 0.9 for the conversion between the gross and net calorific values. In 2014, research was carried out to develop a methodology for determination of the precise values of this coefficient. Details concerning the research and methodology of determination of coefficient NCV/GCV are provided in Annex 5.

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

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

where NCV and GCV are expressed in MJ/m^3 at the reference temperatures of 15 ˚C (i.e. trade conditions). However, improved values of the NCV/GCV ratio are not far from the IPCC default value of 0.9 (IPCC 2006). For example, NCV = 34.424 MJ/m^3 given in Tab. 3-10 corresponds to the ratio NVC/GCV = 0.9019 calculated from the equation above. This equation was used for calculation of NCV from GCV for all the time periods.

CO_2 emissions are calculated using the emission factors, which are either provided in the IPCC 2006 Gl. (IPCC 2006) or which were determined as country-specific emission factors. Since CO_2 emission factors depend on the quality of the specific fuel, the values of the emission factors are listed in the specific chapters below. Default emission factors from the IPCC 2006 Gl. (IPCC 2006) for key categories have been gradually substituted by country-specific emission factors. Moreover, for the CO_2 emission factors from lignite (brown coal) and bituminous coal, the previous country-specific emission factors were refined in this submission by using up-to-date national data. Description of the employed country-specific emission factors including means 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, in contrast to the CO_2 emission factors, default values from the IPCC 2006 Gl. (IPCC 2006) are always used for the CH_4 and N_2O emission factors. The 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. Regarding the fact that the values in the following table are used by Czech emission trading facilities that are obliged to report their emissions to the Emission Trade System – EU ETS (which is a market-based approach to controlling pollution by providing economic incentives for achieving reductions in the emissions of pollutants), values of country specific EF are expressed as a 5-year mean i.e. mean for 2013 – 2017. This adjustment decreases inaccuracies in emission reporting to EU ETS, which are caused by time discrepancies (companies will use the values for the reporting year 2018).

Tab. 3-11 Net calorific values (NCV), CO_2 emission factors and oxidation factors used in the Czech GHG inventory – 2017

Fuel (IPCC 2006 Gl. definitions)	NCV [TJ/kt]	CO_2 EF [a] [t CO_2/TJ]	Oxidation Factor	CO_2 EF [b] [t CO_2/TJ]
Crude Oil	42.400	73.30	1	73.30
Gas/Diesel Oil	42.600	74.10	1	74.10
Residual Fuel Oil	39.500	77.40	1	77.40
LPG [d]	45.945	65.86	1	65.86
Naphtha	43.600	73.30	1	73.30
Bitumen	40.193	80.70	1	80.70
Lubricants	40.193	73.30	1	73.30
Petroleum Coke	39.400	97.50	1	97.50
Other Oil	39.203	73.30	1	73.30
Coking Coal [d]	29.580	93.53	1	93.53
Other Bituminous Coal [d]	25.484	94.70	0.9707	91.93
Lignite (Brown Coal) [d]	13.698	99.41	0.9846	97.88
Brown Coal Briquettes	23.292	97.50	0.9846[d]	96.00
Coke Oven Coke	29.418	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]	48.707	55.46	1	55.46
Natural Gas (TJ/mill. m^3) [d]	34.627	55.46	1	55.46

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 sources of expert judgement provided for uncertainty analysis for each category.

Activity data

Information on fuel consumption is taken from CzSO (CzSO, 2018).

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 the uncertainty of the Solid Fuels activity data, since the Natural Gas data is measured more accurately than, 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 the whole 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

Calculations were carried out using

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

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

Time - series consistency

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

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

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

Example:

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

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

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

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

The time series comes from two data sources – time-series was reproduced by MIT and data about current incineration comes from ISOH (Information system of waste management). There are no country-specific uncertainties yet, as all the factors but activity data used in the equations are default IPCC factors (IPCC 2006).

3.2.6 QA/QC and verification

The general QA/QC plan was formulated since the last submission and is presented in Chapter 1.2.3. The QA/QC procedures employed in 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 devoted 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 the QC procedure
- validates verification procedures and is responsible for their implementation
- is responsible for submission of all the documents and data files for storing in the coordinating institution and suggests external experts for the QA procedure
- provides for data input in the CRF Reporter
- carries out auto-control – control of the input data and primary computations
- provides for 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 QA/QC experts that are familiar with the topic (Andrea Veselá, new external employee of KONEKO). At this control level, the individual steps are checked according the official QA/QC methodology (IPCC 2006). To minimize technical errors in both CRF and NIR we set up automatic connecttion for value transcription. In this way, we interconnect the files of CzSO, all the computation files, the QA/QC files and files for creation of tables for NIR.

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

Verification procedures are included at the suggestion of the QA/QC sectoral guarantor after consultation with the NIS coordinator. They are aimed mainly at 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 also includes activity data, independent of CzSO data. It is necessary to determine the best way to optimally use the above data sources on the basis of systematic research and this will be encompassed in the national inventory improvement plan.

An external employee of KONEKO (Andrea Veselá) is familiar with the assessed topic and participates in the QC procedures. The cooperation is based on ad hoc contracts validated by the QA/QC sectoral guarantor. As already mentioned above, experts from CzSO who cooperate closely with CHMI and KONEKO also take part in the control procedures.

The QA procedures are planned as described in the general part of the QA/QC plan, i.e. approximately once every three years. The 2015 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, the reported data is summarized in category CRF 1.A.1.a.i in this submission.

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

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

1.A.1.a.i, 2017								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	Data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**	**[-]**	**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
Rafinery Gas	828.41	55.08	1	45.63	1	0.00083	0.1	0.00008
LPG	321.62	65.86	1	21.18	1	0.00032	0.1	0.00003
Heating and Other Gasoil	85.20	74.10	1	6.31	3	0.00026	0.6	0.00005
Fuel Oil - Low Sulphur	592.50	77.40	1	45.86	3	0.00178	0.6	0.00036
Fuel Oil - High Sulphur	118.50	77.40	1	9.17	3	0.00036	0.6	0.00007
Other Bituminous Coal	61 238.09	95.79*)	0,9707*)	5 694.21	1	0.06124	1.5	0.11620
Brown Coal + Lignite	361 363.64	101.28*)	0,9846*)	36 036.39	1	0.36136	1.5	0.09186
Coke	0.52	107.00	1	0.06	1	0.00000	1.5	0.54205
Coal Tars	106.39	80.70	1	8.59	1	0.00011	1.5	0.00016
Brown Coal Briquets	8.36	97.50	0.9846*)	0.80	1	0.00001	1.5	0.00001
Coke Oven Gas	5 887.28	44.40	1	261.40	1	0.00589	0.1	0.00059
Natural Gas	48 415.63	55.46*)	1	2 685.19	1	0.04842	0.1	0.00484
Waste - fossil fraction	2 741.11	91.70	1	251.36	30	0.08223	4	0.01096
Waste - biomass fraction	4 111.66	100.00	1	411.17	30	0.12335	4	0.01645
Wood/Wood Waste	20 619.34	112.00	1	2 309.37	30	0.61858	4	0.08248
Gaseous Biomass	1 686.65	54.60	1	92.09	1	0.00169	0.1	0.00017
Total year 2017	**508 124.90**			**44 814.79**		**0.48056**		**0.64010**
Total year 2016	531 814.42			47 149.69		0.50679		0.6800
Index 2017/2016	0.96			0.95		0.95		0.94

1.A.1.a.i, 2017								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	Data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**	**[-]**	**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
Total year 1990	569 177.27			54 625.24		0.5989		0.8090
Index 2017/1990	0.89			0.82		0.80		0.79

*) *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.

2017							
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 55 % in 2017 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 by public power stations.

This category encompasses all the facilities that produce electrical 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 ČEZ Inc., 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 2017, the fraction of CO_2 emissions in subsector 1.A.1.a equalled 88% of total CO_2 emissions in sector 1.A.1 .

Of the total installed capacity of electricity generation of 20.30 GWe in 2017, 11.58 GWe are accounted for by thermal power plants:

Nuclear	4 290	MWe
Hydro	2 081	MWe
Solar photovoltaic	2 070	MWe
Wind	308	MWe
Combustible fuels	11 582	MWe
Total capacity	**20 331**	**MWe**

In the final energy balance of CzSO (CzSO, 2018), 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)	**87 055**
Main activity producer electricity plants	42 563
Main activity producer CHP plants	35 375
Autoproducer electricity plants	638
Autoproducer CHP plants	8 474
Heat production (TJ)	**122 952**
Main activity producer CHP plants	87 414
Main activity producer heat plants	18 431
Autoproducer CHP plants	8 205
Autoproducer heat plants	17 107

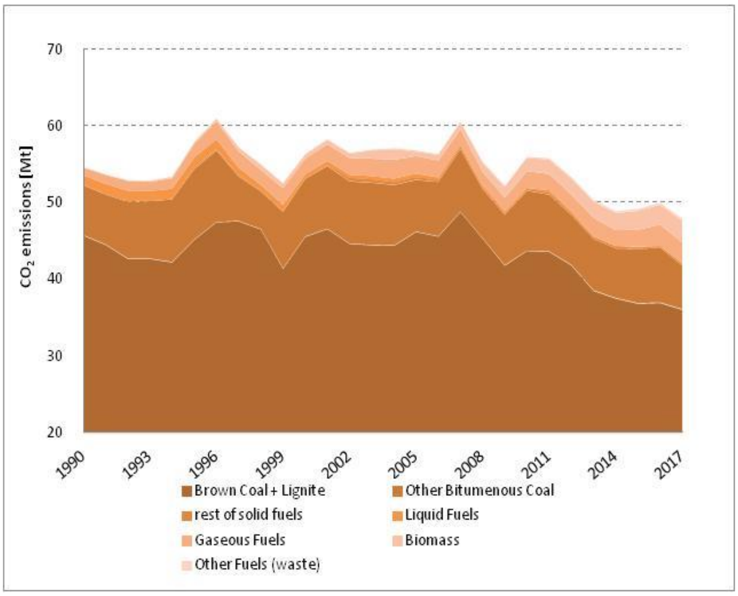


Fig. 3-4 Development of CO_2 emissions in 1.A.1.a category

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. It is clear from the figure that 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 439 PJ, corresponding to 43 355 kt CO_2/year on an average for the entire 1990 – 2017 period. The second largest consumption corresponds to Other Bituminous Coal, with an average consumption of 78 PJ, corresponding to 7 235 kt CO_2/year on an average for the whole 1990 – 2017 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 26.97 t C/TJ; a country-specific emission factor equal to 25.79 t C/TJ for Other Bituminous Coal and Coking Coal has been used to calculate CO_2 emissions. In 2015, research was conducted to update these emission factors. A 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 the 2014, submission, country-specific oxidation factors for Other Bituminous Coal, Brown Coal and Lignite and Brown Coal Briquettes were employed. A 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. The use of NG does not exhibit a substantially oscillating trend. At the beginning of the period, it exhibits an 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

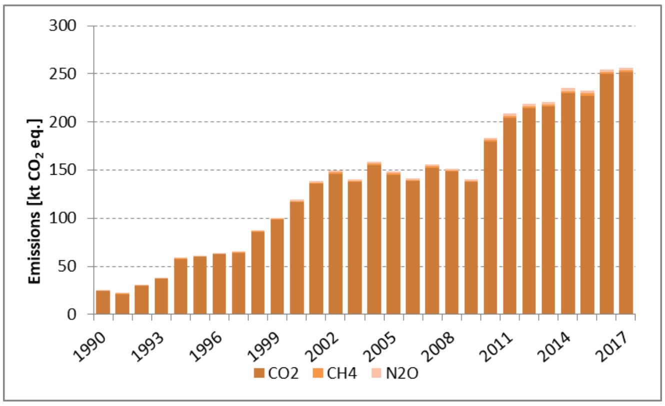


Fig. 3-5 trend of GHG emissions from waste incineration for energy

This category consists of emissions resulting from incineration of municipal solid waste for energy purposes. Originally this chapter was part of 5.C Waste Incineration but, based on a suggestion in ICR (in-country review), this chapter was moved under the energy sector. This chapter is still prepared by CUEC (Charles University Environment Centre) – 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, 2017

Incinerator (city)	Capacity (kt) 2017
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.

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, a good correlation can be seen between the total fuel consumption and the gross energy production. There are minor fluctuations, caused by variations in the ratio between the electricity and the amount of heat produced.

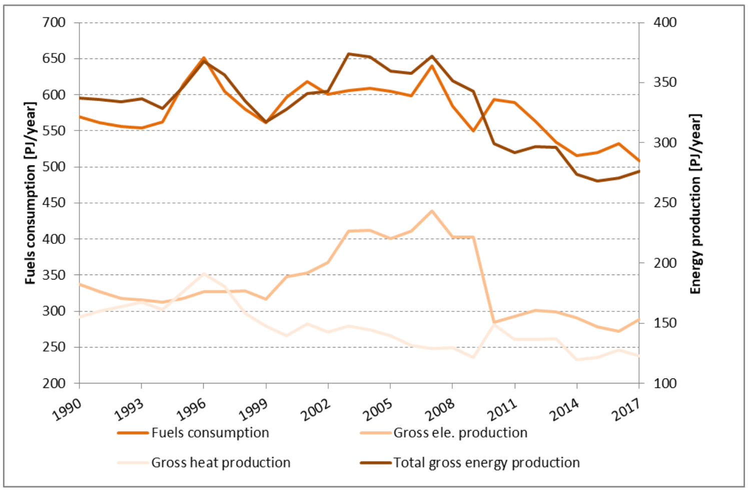


Fig. 3-6 The ratio between the total consumption of fuels from the heat sources in the category 1.A1.a and overall energy production

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 sector but it is still managed in NIS under the waste sector and, for this particular chapter, all the 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 for Liquid fuels. The following table describes the change caused by these recalculations.

Liquid fuels

Tab. 3-14 Recalculations caused by change in activity data for Liquid fuels in submission 2019-2017

Fuel consumption	Units	1990	1991	1992	1994	1995	1996	1997	1998
Submission 2018-2016	TJ	15 991.19	17 338.82	18 041.29	16 598.50	17 427.46	16 229.31	13 115.62	9 298.23
Submission 2019-2017	TJ	15 173.96	16 482.69	17 298.97	15 970.05	16 981.09	15 900.58	12 809.91	9 278.70
Difference	TJ	-817.23	-856.13	-742.31	-628.45	-446.38	-328.73	-305.71	-19.53
	%	-5.11	-4.94	-4.11	-3.79	-2.56	-2.03	-2.33	-0.21
CO_2 emission	**Units**	**1990**	**1991**	**1992**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	1234.1	1338.1	1392.5	1281.8	1346.9	1253.4	1012.9	719.5
Submission 2019-2017	kt	1173.5	1274.7	1337.5	1235.2	1313.9	1229.0	990.3	718.1
Difference	kt	-60.6	-63.4	-55.0	-46.6	-33.1	-24.4	-22.7	-1.4
	%	-4.91	-4.74	-3.95	-3.63	-2.46	-1.94	-2.24	-0.20
CH_4 emission	**Units**	**1990**	**1991**	**1992**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.04797	0.05202	0.05412	0.04980	0.05228	0.04869	0.03935	0.02789
Submission 2019-2017	kt	0.04552	0.04945	0.05190	0.04791	0.05094	0.04770	0.03843	0.02784
Difference	kt	-0.00245	-0.00257	-0.00223	-0.00189	-0.00134	-0.00099	-0.00092	-0.00006
	%	-5.11	-4.94	-4.11	-3.79	-2.56	-2.03	-2.33	-0.21
N_2O emission	**Units**	**1990**	**1991**	**1992**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.00959	0.01040	0.01082	0.00996	0.01046	0.00974	0.00787	0.00558

Submission 2019-2017	kt	0.00910	0.00989	0.01038	0.00958	0.01019	0.00954	0.00769	0.00557
Difference	kt	-0.00049	-0.00051	-0.00045	-0.00038	-0.00027	-0.00020	-0.00018	-0.00001
	%	-5.11	-4.94	-4.11	-3.79	-2.56	-2.03	-2.33	-0.21

Recalculations based on QA/QC procedures – Biomass

The recalculation of Biomass in 1.A.1.a.i was caused by computation error. Table 3-15 depicts the comparison of original and updated values.

Tab. 3-15 Recalculations caused by computation error in Biomass

Fuel consumption		2014	2015	2016
Submission 2018-2016	TJ	20 424.87	22 863.00	23 383.00
Submission 2019-2017	TJ	20 577.76	23 011.87	23 893.02
Difference	TJ	152.90	148.87	510.02
	%	0.75	0.65	2.18
CO_2 emission		2014	2015	2016
Submission 2018-2016	Kt	2 191.65	2 454.24	2 513.34
Submission 2019-2017	Kt	2 206.94	2 469.13	2 564.34
Difference	Kt	15.29	14.89	51.00
	%	0.70	0.61	2.03
CH_4 emission		2014	2015	2016
Submission 2018-2016	Kt	0.58618	0.65379	0.66982
Submission 2019-2017	Kt	0.59077	0.65825	0.68512
Difference	Kt	0.00459	0.00447	0.01530
	%	0.78	0.68	2.28
N_2O emission		2014	2015	2016
Submission 2018-2016	Kt	0.07813	0.08713	0.08927
Submission 2019-2017	Kt	0.07874	0.08773	0.09131
Difference	Kt	0.00061	0.00060	0.00204
	%	0.78	0.68	2.29

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

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

Therefore, for the next submission, attention will be paid to the distribution of fuels in the specific 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, the employed emission factors and emissions of individual greenhouse gases are shown in the following outline.

1.A.1.b, 2017								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O /TJ]	[kt]
Refinery Gas	5 844.92	55.08*)	1	321.91	1	0.00584	0.1	0.00058
Natural Gas	3 906.92	55.46*)	1	216.68	1	0.00391	0.1	0.00039
Total year 2017	9 751.84			538.60		0.00975		0.00098
Total year 2016	7 339.23			405.60		0.00734		0.00073
Index 2017/2016	1.33			1.33		1.33		1.33
Total year 1990	8 705.45			492.56		0.01017		0.00124
Index 2017/1990	1.12			1.09		0.96		0.79

*) *Country specific data*

The origin of the data, employed emission factors and the method for calculating the emissions for each gas are shown in detail in the following outline.

2017							
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
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 constituted approximately 2% of the total amount in 2017. 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 Česká rafinérská Inc. in the Czech Republic. Fugitive CH_4 emissions are included in category 1.B.2.a Fugitive Emissions from Fuels - Oil.

The fraction of CO_2 emissions in subsector 1.A.1.b in CO_2 emissions in sector 1.A.1 equalled 1% in 2017. It contributed 0.6% to the CO_2 emissions in the whole Energy sector.

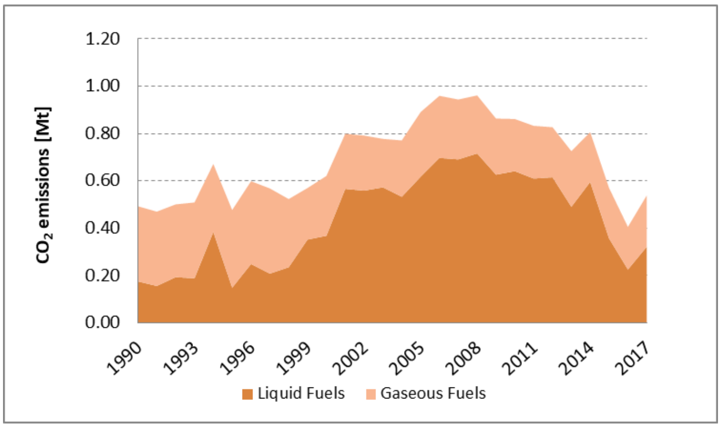


Fig. 3-7 Development of CO_2 emissions in 1.A.1.b category

In the CzSO Questionnaire (CzSO, 2018), the consumption of the individual kinds of fuels in this sector is reported under the items:

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

Starting with the submission reported in 2013, the greenhouse gas emissions from the combustion of refinery gas have been estimated using the country-specific emission factor. A 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 also used for Natural Gas – see the outlines at the beginning of each subchapter.

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

No consumption of Solid Fuels occurred in this category.

Liquid Fuels are of the greatest importance and exhibit an increasing trend over the whole period. The fluctuations that occurred over the years can be explained as resulting from differences in production quantities (see also Fig. 3-8). 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 levels of 357 kt CO_2 in 2015 and 322 kt CO_2 in 2017.

Natural gas plays the second greatest role, with emissions in the range between 205 kt CO_2 in 2003 and 360 kt CO_2 in 1997 and ending with 217 kt CO_2 in 2017.

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)

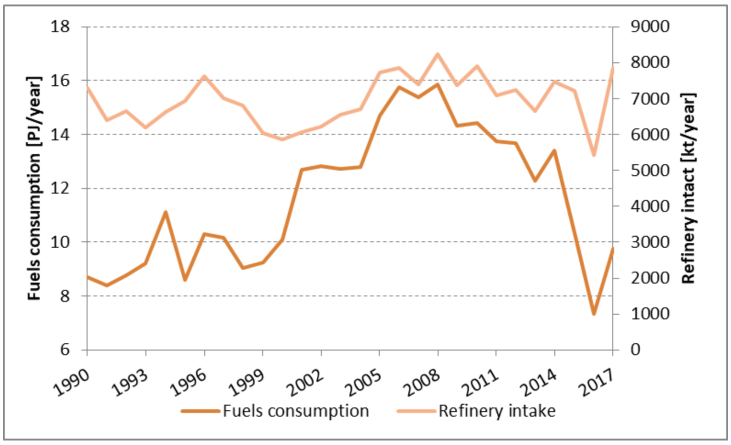


Fig. 3-8 Comparison of fuel consumption in the sector 1.A.1.b and amount of crude oil processed

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.

It is apparent from the figure that since 2000, the relation between the amount of crude oil processed and the amount of fuel used are in accordance. In the period from 1990 to 2000, it is clear that the specific energy consumption for processing crude oil was lower than at the present time, and underwent certain fluctuations. These values were driven by the fact that, in this period, the production capacities 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 1990s).

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)

Minor recalculations were carried out in this subcategory as a result of uploading of the activity data for Liquid fuels. The following table describes the change caused by these recalculations.

Tab. 3-16 Recalculations caused by change in activity data for Liquid fuels in submission 2019

Fuel consumption		1994	1997	1998
Submission 2018-2016	TJ	5 857.77	3 608.12	3 821.62
Submission 2019-2017	TJ	5 528.58	3 569.91	3 626.33
Difference	TJ	-329.19	-38.21	-195.28
	%	-5.62	-1.06	-5.11
CO_2 emission		1994	1997	1998
Submission 2018-2016	Kt	408.70	211.02	249.72
Submission 2019-2017	Kt	384.31	208.19	235.25
Difference	Kt	-24.39	-2.83	-14.47
	%	-5.97	-1.34	-5.79
CH_4 emission		1994	1997	1998
Submission 2018-2016	Kt	0.01371	0.00475	0.00751
Submission 2019-2017	Kt	0.01272	0.00463	0.00692
Difference	Kt	-0.00099	-0.00011	-0.00059
	%	-7.20	-2.41	-7.80
N_2O emission		1994	1997	1998
Submission 2018-2016	Kt	0.00255	0.00065	0.00130
Submission 2019-2017	Kt	0.00235	0.00062	0.00119
Difference	Kt	-0.00020	-0.00002	-0.00012
	%	-7.75	-3.55	-8.99

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

No further improvements are currently planned in this subcategory.

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 no precise data are available for more detailed classification, the data is reported in this submission as a summary in category CRF 1.A.1.c.ii. Production of briquettes, which would fall under 1.A.1.c.i has been terminated in the Czech Republic and in terms of the share of the emissions from this production, it was negligible and further accurate data on fuel consumption in this category are now difficult to access.

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, 2017								
Structure of Fuels	**Activity**		**CO_2**		**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
Heating and Other Gasoil	255.60	74.10	1	18.94	3	0.00077	0.6	0.00015

1.A.1.c, 2017								
Structure of Fuels	Activity		CO_2		CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
Brown Coal + Lignite	40 570.11	101.28*)	0.9846*)	4 045.79	1	0.04057	1.5	0.06086
Gas Works Gas	14 154.5	99.26*)	1	1 504.22	1	0.01515	0.1	0.00152
Coke Oven Gas	6 961.7	44.40	1	309.10	1	0.00696	0.1	0.00070
Natural Gas	82.1	55.46*)	1	4.56	1	0.00008	0.1	0.00001
Total year 2017	62 686.29			5 859.10		0.06269		0.06307
Total year 2016	67 215.13			6 307.42		0.06722		0.06816
Index 2017/2016	0.93			0.93		0.93		0.93
Total year 1990	26 735.70			1 351.58		0.02674		0.00689
Index 2017/1990	2.34			4.34		2.34		9.15

*) *Country specific data*

The table shows that, while the index of fuel consumption for 2017/1990 is 0.91, the same index is significantly higher for CO_2 emissions. This is caused by the high proportion of coke oven gas, which has a relatively low emission factor, in the fuel structure in 1990. Later, part of the coke oven gas was reallocated to other subsectors (1.A.1.a and 1.A.2.a). The high proportion of coke oven gas, combined with relatively low emission factor, compared to other fuels, led to an even greater change in N_2O emissions.

The origin of the data, the employed emission factors and the method of calculating the level of emissions for each gas are presented in detail in the following outline.

2017							
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 the facilities that process Solid Fuels from mining through coking processes to the production of secondary fuels, such as Brown-Coal Briquettes, Coke Oven Gas or Generator Gas. It also includes fuels for the production of electrical energy and heat for internal consumption (reported by companies as "own use").

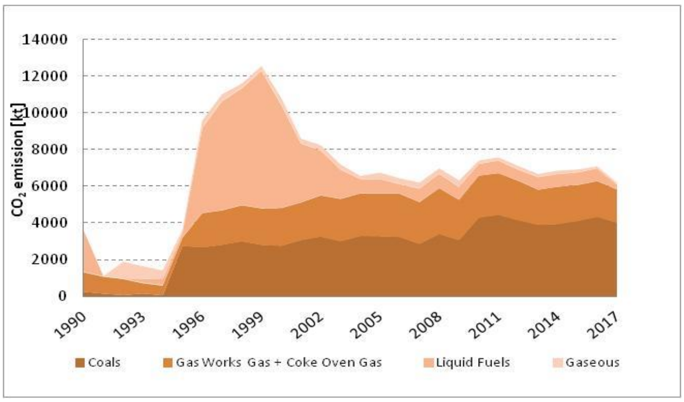


Fig. 3-9 Development of CO_2 emissions in 1.A.1.c.ii category

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

The fraction of CO_2 emissions in subsector 1.A.1.c in CO_2 emissions in sector 1.A.1 equalled 12% in 2017. It contributed only 6% to CO_2 emissions in the whole Energy sector 1.A.

In the CzSO Questionnaire (CzSO, 2018), the consumption of the individual kinds of fuels in this sector is reported in the 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 an increase in emissions in 1995 – 2012. The use of Coal predominated in the whole period, followed by the consumption of Gas Works Gas and Coke Oven Gas. The use of Liquid Fuels and Natural Gas in this category is very low.

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 combination ended in 1974 when this facility was moved under the Hnědouhelné doly a briketárny company. Together with this step, the Vřesová Fuel combine cycle was established. This new combined-cycle power station came into operation in 1996 (http://www.suas.cz).

Between 1990 and 1995, the production of Coal Gas, which was distributed in the Czech Republic by the Vřesová Gas Works, was gradually phased out. Fig. 3-9 shows a decline in the production of Coal Gas and the start of production of Gas Works Gas for the production of electricity and heat supplies. Pipelines used to distribute Coal 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 in operation.

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

Fuel consumption in the Vřesová Fuel combine cycle 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 synthesic gas is then purified to remove acidic components (CO_2 and H_2S) and is used for power generation and heat supplies. 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). So as 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 Works Gas in the model by coal, which is used in 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 the 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. 3-17.

Tab. 3-17 Consumption of Lignite for production of technological steam in Fuel combine Vřesová 1995 – 2017

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
Year	**2017**										
Lignite [kt/year]	2 140										

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

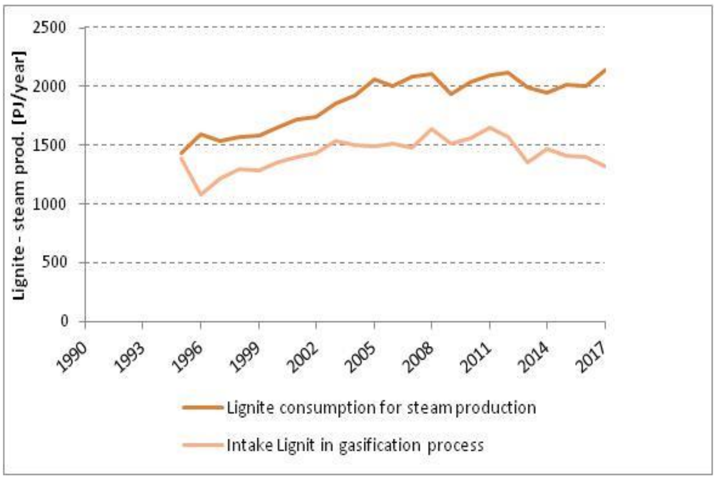


Fig. 3-10 Comparison of lignite consumption for steam production and gasification

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 1995-2017.

Apart from the early years, when combined cycle operations were starting to reach full power (1995 to 1998), the trends in 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 so that its consumption also depends on the average annual temperatures.

The internal expertise of experts from the Department of Emissions and Sources at CHMI were used as in the QA/QC procedure for this part of the calculations. 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 recalculations were carried out in this submission due to uploads of activity data for Liquid fuels (1994-1998) and computation errors (2011-2013). The following table describes the change caused by these recalculations.

Tab. 3-18 Changes after recalculation in 1.A.1.c.ii for Liquid Fuels

Fuel consumption		1994	1995	1996	1997	1998	2011	2012	2013
Submission 2018-2016	TJ	1057.50	972.42	5104.75	6392.08	6801.32	766.80	639.00	724.20
Submission 2019-2017	TJ	309.35	239.08	4628.10	5952.63	6371.70	681.60	596.40	681.60
Difference	TJ	-748.15	-733.33	-476.65	-439.46	-429.62	-85.20	-42.60	-42.60
	%	-70.75	-75.41	-9.34	-6.88	-6.32	-11.11	-6.67	-5.88
CO_2 emission		1994	1995	1996	1997	1998	2011	2012	2013
Submission 2018-2016	kt	78.36	72.06	390.35	491.00	521.74	56.82	47.35	53.66
Submission 2019-2017	kt	22.92	17.72	355.03	458.44	489.90	50.51	44.19	50.51
Difference	kt	-55.44	-54.34	-35.32	-32.56	-31.84	-6.31	-3.16	-3.16
	%	-70.75	-75.41	-9.05	-6.63	-6.10	-11.11	-6.67	-5.88
CH_4 emission		1994	1995	1996	1997	1998	2011	2012	2013
Submission 2018-2016	kt	0.00317	0.00292	0.01531	0.01918	0.02040	0.00230	0.00192	0.00217
Submission 2019-2017	kt	0.00093	0.00072	0.01388	0.01786	0.01912	0.00204	0.00179	0.00204
Difference	kt	-0.00224	-0.00220	-0.00143	-0.00132	-0.00129	-0.00026	-0.00013	-0.00013
	%	-70.75	-75.41	-9.34	-6.88	-6.32	-11.11	-6.67	-5.88
N_2O emission		1994	1995	1996	1997	1998	2011	2012	2013
Submission 2018-2016	kt	0.00063	0.00058	0.00306	0.00384	0.00408	0.00046	0.00038	0.00043
Submission 2019-2017	kt	0.00019	0.00014	0.00278	0.00357	0.00382	0.00041	0.00036	0.00041
Difference	kt	-0.00045	-0.00044	-0.00029	-0.00026	-0.00026	-0.00005	-0.00003	-0.00003
	%	-70.75	-75.41	-9.34	-6.88	-6.32	-11.11	-6.67	-5.88

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, the employed emission factors and emissions of the individual greenhouse gases are shown in the following outline.

1.A.2.a, 2017								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O /TJ]	[kt]
Anthracite	1 566.56	98.30	1	153.99	10	0.01567	1.5	0.00235
Other Bituminous Coal	18.28	94.32*)	0.9707*)	1.67	10	0.00018	1.5	0.00003
Brown Coal + Lignite	236.10	99.26*)	0.9846*)	23.07	10	0.00236	1.5	0.00035
Coke	11 001.02	107.00	1	1 177.11	10	0.11001	1.5	0.01650
Coke Oven Gas	4 736.98	44.40	1	210.32	1	0.00474	0.1	0.00047
Natural Gas	11 322.37	55.46*)	1	627.95	1	0.01132	0.1	0.00113
Wood/Wood Waste	1.01	112.00	1	0.11	30	0.00003	4.0	0.00000

1.A.2.a, 2017								
Structure of Fuels	**Activity**		**CO_2**			**CH_4**		**N_2O**
	data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O /TJ]**	**[kt]**
Total year 2017	**28 882.30**			**2 194.12**		**0.14428**		**0.02084**
Total year 2016	24 440.85			1 802.31		0.11731		0.01689
Index 2017/2016	1.18			1.22		1.23		1.23
Total year 1990	155 319.22			14 860.68		1.39496		0.20941
Index 2017/1990	0.19			0.15		0.10		0.10

*) *Country specific data*

The origin of the data, the employed emission factors and the method of calculating the level of emissions for each gas are shown in detail in the following outline.

2017							
Structure of Fuels	**Source of**		**Emission factors**			**Method used**	
	Activity data	**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
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, 2018), the consumption of the individual kinds of fuels in this sector is reported in the Industry Sector under the item: Iron and Steel. This included the fuels of the economic part according to NACE Rev. 2 Iron and steel: NACE Divisions 24.1 – 24.3 and 24.51, 24.52.

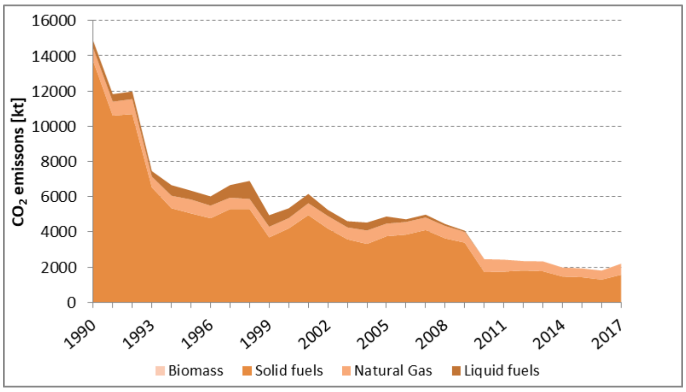


Fig. 3-11 Development of CO_2 emissions in source category 1.A.2.a

The fraction of CO_2 emissions in subsector 1.A.2.a in total CO_2 emissions in sector 1.A.2 equalled 21% in 2017. It contributed only 2% to CO_2 emissions in the whole Energy sector.

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

The graph in Fig. 3-11 shows a marked sharp decline in emissions in the early 90s, mainly due to the loss of markets, following the substantial political changes in this 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 protection of the environment is reflected in the decrease in emissions after about 1998. The competition of metallurgical plants in countries outside of Europe caused an impact on emissions after 2000. Minor fluctuations are caused by market demand and, to a lesser extent, the necessary restructuring undertaken in individual companies.

Further, from Fig. 3-11 that the main fraction of the CO_2 emissions is caused by the use of fossil fuels, which are completely dominant in this sector.

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 exactly identify the amounts 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 this approach, no CO_2 emissions from blast furnace and converter gas are included in the calculation.

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 because of their high energy intensity. Fig. 3-12 shows the relationship between fuel consumption and total production of sinter and iron in mil. tons.

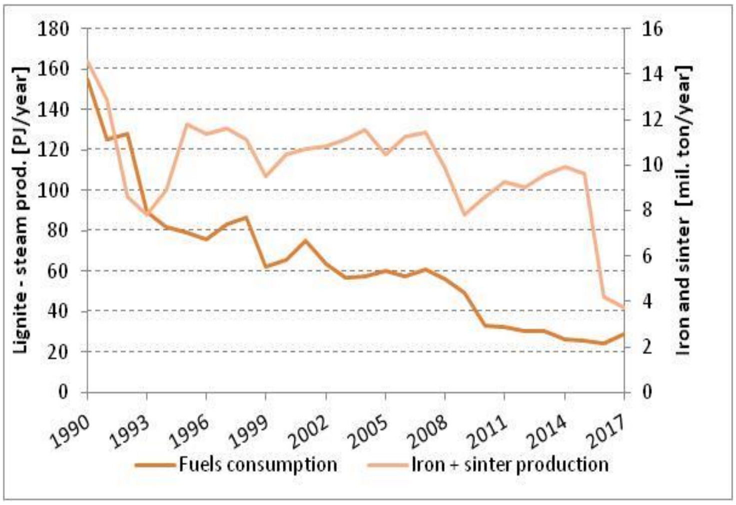


Fig. 3-12 The trend in the manufacture of agglomerates of iron ore and iron, in comparison with the development of fuel consumption in the sector 1.A.2.a

It is clear from the graph in Fig. 3-12 that the fuel consumption decreases faster than the production. This is due to the gradual reduction in the overall energy intensity throughout the metallurgical industry. This trend is particularly evident in the early 90s, when there was a major restructuring of production. After the decline in 1990 and 1993, this restructuring enabled a return to 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 then evident until the end of the period.

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

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

Quite extensive recalculations were carried out in this submission as a result of uploads of activity data for Liquid fuels (1994-1998) and for Solid fules (2016). The following tables describe the change caused by these recalculations.

Tab. 3-19 Changes after recalculation in 1.A.2.a for Solid Fuels

Fuel consumption		2016	CH_4 emission		2016
Submission 2018-2016	TJ	14453.53	**Submission 2018-2016**	kt	0.10355
Submission 2019-2017	TJ	15182.25	**Submission 2019-2017**	kt	0.10806

Difference	TJ	728.72	**Difference**	kt	0.00451
	%	4.80		%	4.17
CO_2 emission		**2016**	**N_2O emission**		**2016**
Submission 2018-2016	kt	1234.04	**Submission 2018-2016**	kt	0.01530
Submission 2019-2017	kt	1288.51	**Submission 2019-2017**	kt	0.01597
Difference	kt	54.47	**Difference**	kt	0.00066
	%	4.23		%	4.14

Tab. 3-20 Changes after recalculation in 1.A.2.a for Liquid Fuels

Fuel consumption		1994	1995	1996	1997	1998
Submission 2018-2016	TJ	7909.19	6651.60	7069.65	9474.45	13501.55
Submission 2019-2017	TJ	7788.69	6522.45	6803.16	9243.97	13267.21
Difference	TJ	-120.51	-129.15	-266.49	-230.48	-234.34
	%	-1.55	-1.98	-3.92	-2.49	-1.77
CO_2 emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	611.61	514.27	544.40	731.11	1042.28
Submission 2019-2017	kt	602.68	504.70	524.65	714.03	1024.92
Difference	kt	-8.93	-9.57	-19.75	-17.08	-17.36
	%	-1.48	-1.90	-3.76	-2.39	-1.69
CH_4 emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.02373	0.01995	0.02112	0.02833	0.04032
Submission 2019-2017	kt	0.02337	0.01957	0.02032	0.02764	0.03962
Difference	kt	-0.00036	-0.00039	-0.00080	-0.00069	-0.00070
	%	-1.55	-1.98	-3.93	-2.50	-1.77
N_2O emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.00475	0.00399	0.00422	0.00566	0.00805
Submission 2019-2017	kt	0.00467	0.00391	0.00406	0.00552	0.00791
Difference	kt	-0.00007	-0.00008	-0.00016	-0.00014	-0.00014
	%	-1.55	-1.98	-3.94	-2.50	-1.78

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

We are planning to obtain data that make it possible to identify the amounts of both blast furnace and converter gases 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, the employed emission factors and emissions of the individual greenhouse gases are shown in the following outline.

1.A.2.b, 2017								
Structure of Fuels	**Activity**		**CO_2**			**CH_4**		**N_2O**
	data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O /TJ]**	**[kt]**
Coke	144.68	107.00	1	15.48	10	0.00145	1.5	0.00022
Brown Coal Briquets	0.68	97.50	0.9846*)	0.06	10	0.00001	1.5	0.00000
Natural Gas	2 320.17	55.46*)	1	128.68	1	0.00232	0.1	0.00023
Wood/Wood Waste	5.76	112.00	1	0.65	30	0.00017	4	0.00002
Total year 2017	**2 471.30**			**144.23**		**0.00377**		**0.00045**
Total year 2016	2 336.59			135.40		0.00335		0.00039
Index 2017/2016	1.06			1.07		1.16		1.19
Total year 1990	1 476.34			101.96		0.00572		0.00081

1.A.2.b, 2017								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O /TJ]	[kt]
Index 2017/1990	1.67			1.42		0.69		0.58

*) *Country specific data*

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

2017							
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
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

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, 2018), the consumption of the individual kinds of fuels in this sector is reported in the 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

Kovohutě Příbram is an important facility in this category. The fraction of CO_2 emissions in subsector 1.A.2.b in total CO_2 emissions in sector 1.A.2 equalled 1% in 2017. It contributed only 0.1% to CO_2 emissions in the whole Energy sector.

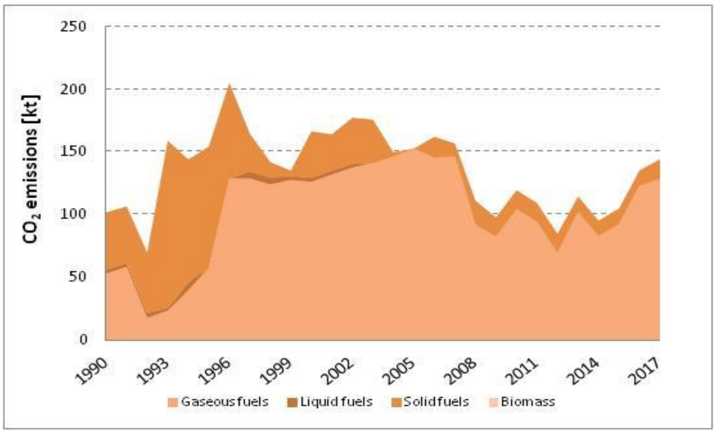


Fig. 3-13 Development of CO_2 emissions in source category 1.A.2.b

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

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

The trend in CO_2 emissions corresponds to the trend of consumption of individual types of fuels. After a decline in the early 90s, is apparent a sharp increase in emissions, which was caused by recovery in the industry. The industry in this sector has recovered, especially as a result of the increase in demand for components made of ferrous metals in the emerging automotive industry. The decrease in emissions at the end of the period was caused by the financial crisis between 2008 and 2012, as well as the reduction of the energy intensity of production. This is also related to 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 recalculations were carried out in this submission as a result of uploading of activity data for Liquid fuels.

Tab. 3-21 Changes after recalculation in 1.A.2.b for Liquid Fuels

Fuel consumption		1994	1995	1996	1997	1998
Submission 2018-2016	TJ	173.75	198.11	414.05	92.87	92.31
Submission 2019-2017	TJ	83.37	0.00	0.00	73.66	72.78
Difference	TJ	-90.38	-198.11	-414.05	-19.21	-19.53
	%	-108.41	-100.00	-100.00	-26.07	-26.83
CO_2 emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	13.03	15.33	32.05	7.05	7.01
Submission 2019-2017	kt	6.33	0.00	0.00	5.62	5.56
Difference	kt	-6.70	-15.33	-32.05	-1.42	-1.45
	%	-105.81	-100.00	-100.00	-25.30	-26.03
CH_4 emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.00052	0.00059	0.00124	0.00028	0.00028
Submission 2019-2017	kt	0.00025	0.00000	0.00000	0.00022	0.00022
Difference	kt	-0.00027	-0.00059	-0.00124	-0.00006	-0.00006
	%	-108.41	-100.00	-100.00	-26.07	-26.83
N_2O emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.00010	0.00012	0.00025	0.00006	0.00006
Submission 2019-2017	kt	0.00005	0.00000	0.00000	0.00004	0.00004
Difference	kt	-0.00005	-0.00012	-0.00025	-0.00001	-0.00001
	%	-108.41	-100.00	-100.00	-26.07	-26.83

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, the employed emission factors and emissions of the individual greenhouse gases are shown in the following outline.

1.A.2.c, 2017								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission

	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
LPG	361.82	65.86	1	23.83	1	0.00036	0.1	0.00004
Fuel Oil - Low Sulphur	87.78	77.40	1	6.79	3	0.00026	0.6	0.00005
Other Oil	1 176.09	73.30	1	86.21	3	0.00353	0.6	0.00071
Other Bituminous Coal	1 037.98	94.32*)	0.9707*)	95.04	10	0.01038	1.5	0.00156
Brown Coal + Lignite	11 065.50	99.26*)	0.9846*)	1 081.43	10	0.11066	1.5	0.01660
Coal Tars	154.56	80.70	1	12.47	10	0.00155	1.5	0.00023
Natural Gas	10 734.31	55.46*)	1	595.34	1	0.01073	0.1	0.00107
Wood/Wood Waste	23.28	112.00	1	2.61	30	0.00070	4.0	0.00009
Gaseous Biomass	639.23	54.60	1	34.90	1	0.00064	0.1	0.00006
Total year 2017	25 280.56			1 901.11		0.13747		0.02025
Total year 2016	17 602.77			1 361.79		0.10164		0.01492
Index 2017/2016	1.44			1.40		1.35		1.36
Total year 1990	33 576.71			2 996.37		0.2648001		0.039753
Index 2017/1990	0.75			0.63		0.52		0.51

*) *Country specific data*

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

2017							
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
Coal Tars	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 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, s.r.o.) and in Kralupy (Synthos Kralupy a.s.). 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) along with a number of factories for manufacturing 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, 2018), 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 18% in 2017. It contributed 2% to CO_2 emissions in the whole Energy sector.

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

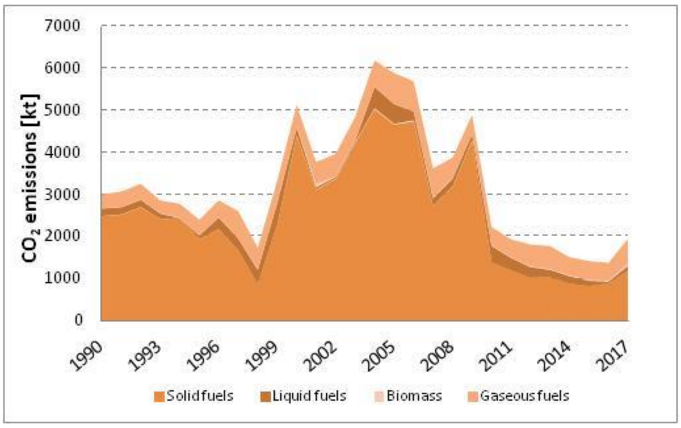


Fig. 3-14 Development of CO_2 emissions in source category 1.A.2.c

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

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

An updated approach is used in IPCC 2006 Gl. (IPCC 2006) for the allocation of feedstocks and non-energy use of fuels in IPPU. The new distribution of liquid fuels is considered as a category-specific methodological issue. This methodological approach is simultaneously based on the new reallocation of fuel consumption for energy and non-energy use in the questionnaire from CzSO (2018). The reallocation of feedstocks and non-energy use of fuels in IPPU is described in detail in chapter 3.2.3.

Other methodological approaches were employed 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)

No specific QA/QC procedures were used in this category. Given that the fuel consumption in this sector, reported directly, is not related to the produced volume of chemicals, relevant comparison with specific commodities is not possible.

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)

Some updates were provided in activity data of Solid fules by CzSO, which resulted in recalculation of this category.

Tab. 3-22 Changes after recalculation in 1.A.2.c for Solid Fuels

Fuel consumption		2013	2014	2015	2016
Submission 2018-2016	TJ	10641.52	9054.28	8365.66	9057.13
Submission 2019-2017	TJ	10680.40	9137.23	8544.93	9245.98
Difference	TJ	38.88	82.94	179.27	188.85
	%	0.36	0.91	2.10	2.04
CO_2 emission		**2013**	**2014**	**2015**	**2016**
Submission 2018-2016	kt	1033.18	877.07	812.44	880.19
Submission 2019-2017	kt	1036.32	883.76	826.94	891.65

Fuel consumption		2013	2014	2015	2016
Difference	kt	3.14	6.69	14.49	11.46
	%	0.30	0.76	1.75	1.29
CH_4 emission		2013	2014	2015	2016
Submission 2018-2016	kt	0.10642	0.09054	0.08366	0.09057
Submission 2019-2017	kt	0.10680	0.09137	0.08545	0.09246
Difference	kt	0.00039	0.00083	0.00179	0.00189
	%	0.36	0.91	2.10	2.04
N_2O emission		2013	2014	2015	2016
Submission 2018-2016	kt	0.01596	0.01358	0.01255	0.01359
Submission 2019-2017	kt	0.01602	0.01371	0.01282	0.01387
Difference	kt	0.00006	0.00012	0.00027	0.00028
	%	0.36	0.91	2.10	2.04

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, the employed emission factors and emissions of the individual greenhouse gases are shown in the following outline.

1.A.2.d, 2017								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
Fuel Oil - Low Sulphur	87.78	77.40	1	6.79	3	0.00026	0.6	0.00005
Other Bitumenous Coal	2.51	94.32*)	0.9707*)	0.23	10	0.00003	1.5	0.00000
Brown Coal + Lignite	1 284.68	99.26*)	0.9846*)	125.55	10	0.01285	1.5	0.00193
Natural Gas	4 826.68	55.46*)	1	267.69	1	0.00483	0.1	0.00048
Wood/Wood Waste	16 636.50	112.00	1	1 863.29	30	0.49910	4.0	0.06655
Gaseous Biomass	7 099.34	54.60	1	387.62	1	0.00710	0.1	0.00071
Total year 2017	**29 937.51**			**400.27**		**0.01796**		**0.00247**
Total year 2016	30 973.07			404.05		0.02029		0.06980
Index 2017/2016	0.97			0.99		0.89		0.87
Total year 1990	25 900.78			2 285.33		0.18784		0.02890
Index 2017/1990	1.16			0.18		0.10		0.09

*) *Country specific data*

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

2017							
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
Other Bitumenous 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
Gaseous Biomass	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

This subcategory includes all the 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 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, 2018), the consumption of the individual kinds of fuels in this sector is reported in the Industry Sector section under the item:

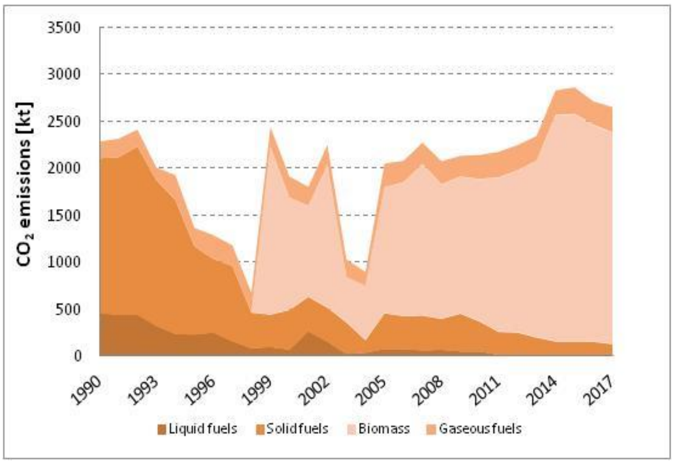


Fig. 3-15 Development of CO_2 emissions in source category 1.A.2.d

Paper, Pulp and Printing

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

Pulp, paper and print: NACE Divisions 17 and 18

The fraction of CO_2 emissions in subsector 1.A.2.d in total CO_2 emissions in sector 1.A.2 equalled 4% in 2017. It contributed 0.4% to CO_2 emissions in the whole Energy sector.

It is clear from the graph in Fig. 3-15 that there was significant substitution at the end of the 1990s, with formerly used fossil fuels (primarily lignite) being replaced by wood and later biogas. Both biofuels represent waste products from the production of paper and pulp at 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. Fig. 3-15 depicts 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 employed 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 recalculations were carried out in this submission as a result of uploads of activity data for Liquid fuels (1994-1998) and Biomass (2016).

Tab. 3-23 Changes after recalculation in 1.A.2.d for Liquid Fuels

Fuel consumption		1994	1995	1996	1997	1998
Submission 2018-2016	TJ	3166.98	3054.20	3317.18	2141.40	1219.40

Submission 2019-2017	TJ	3106.72	2989.63	3283.87	2083.78	1141.29
Difference	TJ	-60.25	-64.57	-33.31	-57.62	-78.11
	%	-1.94	-2.16	-1.01	-2.77	-6.84
CO_2 emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	244.84	236.11	256.47	165.32	93.82
Submission 2019-2017	kt	240.38	231.33	254.00	161.05	88.03
Difference	kt	-4.46	-4.78	-2.47	-4.27	-5.79
	%	-1.86	-2.07	-0.97	-2.65	-6.57
CH_4 emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.00950	0.00916	0.00995	0.00642	0.00366
Submission 2019-2017	kt	0.00932	0.00897	0.00985	0.00625	0.00342
Difference	kt	-0.00018	-0.00019	-0.00010	-0.00017	-0.00023
	%	-1.94	-2.16	-1.01	-2.77	-6.84
N_2O emission		**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.00190	0.00183	0.00199	0.00128	0.00073
Submission 2019-2017	kt	0.00186	0.00179	0.00197	0.00125	0.00068
Difference	kt	-0.00004	-0.00004	-0.00002	-0.00003	-0.00005
	%	-1.94	-2.16	-1.01	-2.77	-6.84

Tab. 3-24 Changes after recalculation in 1.A.2.d for Biomass

Fuel consumption		**2016**	**CH_4 emission**		**2016**
Submission 2018-2016	TJ	26 381.42	**Submission 2018-2016**	kt	0.54888
Submission 2019-2017	TJ	24 898.03	**Submission 2019-2017**	kt	0.50438
Difference	TJ	-1 483.39	**Difference**	kt	-0.04450
	%	-5.96		%	-8.82
CO_2 emission		**2016**	**N_2O emission**		**2016**
Submission 2018-2016	kt	2 474.62	**Submission 2018-2016**	kt	0.07291
Submission 2019-2017	kt	2 308.48	**Submission 2019-2017**	kt	0.06697
Difference	kt	-166.14	**Difference**	kt	-0.00593
	%	-7.20		%	-8.86

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

Currently no improvements are planned in this category.

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

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

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

1.A.2.e, 2017								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
LPG	103.38	103.38	1	6.81	1	0.00010	0.1	0.00001
Heating and Other Gasoil	59.64	74.10	1	4.42	3	0.00018	0.6	0.00004
Fuel Oil - Low Sulphur	87.78	77.40	1	6.79	3	0.00026	0.6	0.00005
Other Bituminous Coal	555.89	94.32*)	0.9707*)	50.90	10	0.00556	1.5	0.00083
Brown Coal + Lignite	1 294.43	99.26*)	0.9846*)	126.50	10	0.01294	1.5	0.00194
Coke	208.99	107.00	1	22.36	10	0.00209	1.5	0.00031
Natural Gas	14 654.37	55.46*)	1	812.75	1	0.01465	0.1	0.00147
Wood/Wood Waste	143.55	112.00	1	16.08	30	0.00431	4.0	0.00057

Gaseous Biomass	9 685.32	54.60	1	528.82	1	0.00969	0.1	0.00097
Total year 2017	**26 793.34**			**1 030.53**		**0.03579**		**0.00465**
Total year 2016	25 946.97			1 021.11		0.03691		0.00486
Index 2017/2016	1.03			1.01		0.97		0.96
Total year 1990	37 616.46			2 988.18		0.21342		0.03226
Index 2017/1990	0.71			0.34		0.17		0.14

*) *Country specific data*

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

		2017					
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Heating and Other Gasoil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - Low Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other 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 products. The subcategory also includes fuel consumption in the tobacco industry. The nature of the production processes permitted the use of a relatively high fraction of biofuels, especially towards the end of the period.

In the CzSO Questionnaire (CzSO, 2018), the consumption of the individual kinds of fuels in this sector is reported in the Industry Sector section 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 total CO_2 emissions in sector 1.A.2 equalled 10% in 2017. It contributed 1 % to CO_2 emissions in the whole Energy sector.

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

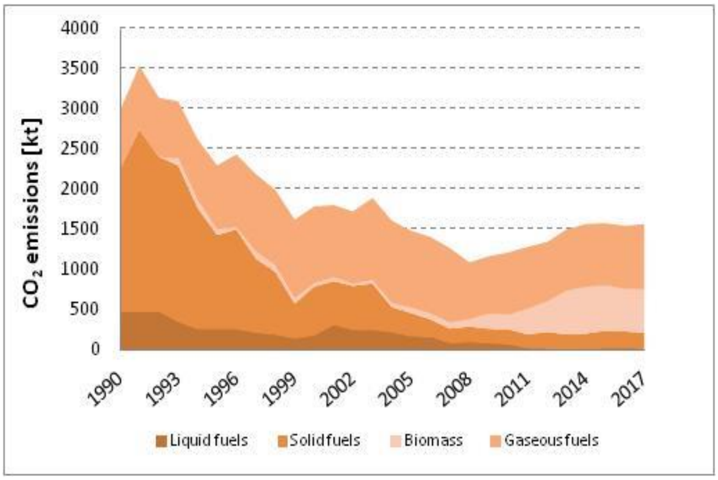


Fig. 3-16 Development of CO_2 emissions from fossil fuels combustion in source category 1.A.2.e

It is obvious from the graph in Fig. 3-16 that natural gas is the predominant fuel over the entire time series, with quite balanced consumption. The large share of fossil fuels at the beginning of the period reduced continuously, 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 compensated by increasing consumption of biofuels, in response to the development of the financial crisis in the period at the end of the first decade of the 21st century.

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

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

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

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

See chapter 3.2.5.

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

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

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

Quite extensive recalculations were carried out in this submission as a result of uploads of activity data for Liquid fuels (1994-1998).

Tab. 3-25 Changes after recalculation in 1.A.2.e for Liquid Fuels

Fuel consumption		1994	1995	1996	1997	1998
Submission 2018-2016	TJ	4434.23	3818.48	3380.74	4080.68	3807.41
Submission 2019-2017	TJ	3379.81	3398.75	3364.08	2851.45	2557.59
Difference	TJ	-1054.42	-419.73	-16.66	-1229.22	-1249.82
	%	-31.20	-12.35	-0.50	-43.11	-48.87
CO_2 emission		1994	1995	1996	1997	1998
Submission 2018-2016	kt	338.29	293.18	261.53	306.86	285.76
Submission 2019-2017	kt	260.16	262.08	260.29	215.78	193.15
Difference	kt	-78.13	-31.10	-1.23	-91.09	-92.61
	%	-30.03	-11.87	-0.47	-42.21	-47.95
CH_4 emission		1994	1995	1996	1997	1998
Submission 2018-2016	kt	0.01330	0.01136	0.01014	0.01224	0.01142
Submission 2019-2017	kt	0.01014	0.01010	0.01009	0.00855	0.00767
Difference	kt	-0.00316	-0.00126	-0.00005	-0.00369	-0.00375
	%	-31.20	-12.46	-0.50	-43.11	-48.87
N_2O emission		1994	1995	1996	1997	1998
Submission 2018-2016	kt	0.00266	0.00227	0.00203	0.00245	0.00228
Submission 2019-2017	kt	0.00203	0.00202	0.00202	0.00171	0.00153
Difference	kt	-0.00063	-0.00025	-0.00001	-0.00074	-0.00075
	%	-31.20	-12.49	-0.50	-43.11	-48.87

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

Currently there are no planned improvements in this category.

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

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

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

1.A.2.f, 2017								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
LPG	103.38	65.86	1	6.8	1	0.00010	0.1	0.00001
Fuel Oil - Low Sulphur	43.89	77.40	1	3.4	3	0.00013	0.6	0.00003
Fuel Oil - High Sulphur	118.50	77.40	1	9.2	3	0.00036	0.6	0.00007
Antracit	94.18	98.30	1.0	9.3	10	0.00094	1.5	0.00014
Other Bituminous Coal	5 459.91	94.32*)	0.9707*)	499.9	10	0.05460	1.5	0.00819
Brown Coal + Lignite	71.42	99.26*)	0.9846*)	7.0	10	0.00071	1.5	0.00011
Coke	1 286.25	107.00	1	137.6	10	0.01286	1.5	0.00193
Coal Tars	583.49	80.70	1	47.1	10	0.00583	1.5	0.00088
Brown Coal Briquets	875.22	97.50	0.9846*)	84.0	10	0.00875	1.5	0.00131
Cove Oven Gas	66.04	44.40	1	2.9	1	0.00007	0.1	0.00001
Natural Gas	25 022.02	55.46*)	1	1 387.8	1	0.02502	0.1	0.00250
Other fuels - liquid	585.89	78.13*)	1	45.8	30	0.01758	4	0.00234
Other fuels - solid	5 304.98	67.27*)	1	356.9	30	0.15915	4	0.02122
Wood/Wood Waste	104.56	112.00	1	11.7	30	0.00314	4	0.00042
Total year 2017	**39 719.73**			**2 597.60**		**0.28611**		**0.03874**
Total year 2015	37 870.43			2 549.29		0.25014		0.03382
Index 2016/2015	1.05			1.02		1.14		1.15
Total year 1990	59 962.36			4 527.12		0.29373		0.04487
Index 2016/1990	0.66			0.57		0.97		0.86

*) *Country specific data*

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

2017							
Structure of Fuels	Source of Activity data	Emission factors CO_2	CH_4	N_2O	Method used 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
Brown Coal Briquets	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 the industrial processes for the treatment of non-mineral 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. 1.A.2.g includes the remaining sources of greenhouse gases in the "Manufacturing industries and construction" category.

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

In the CzSO Questionnaire (CzSO, 2018), the consumption of the individual kinds of fuels in this sector is reported in the Industry Sector section 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 total CO_2 emissions in sector 1.A.2 equalled 25% in 2017. It contributed 3% to CO_2 emissions in the whole Energy sector.

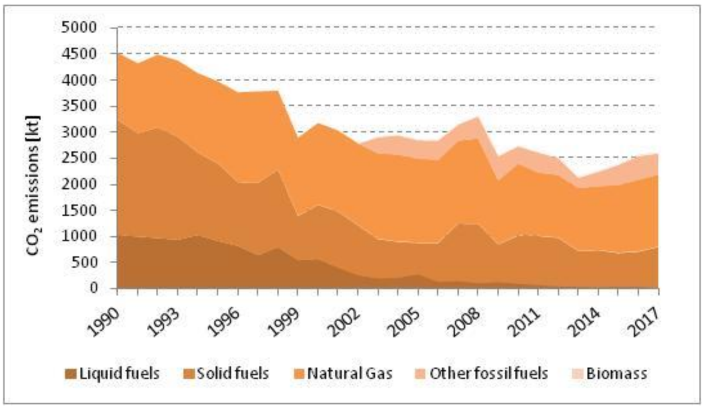


Fig. 3-17 Development of CO_2 emissions in source category 1.A.2.f

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

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

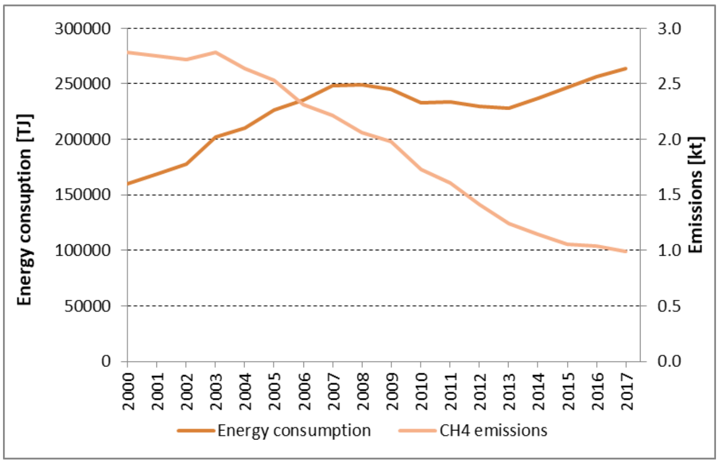


Fig. 3-18 Comparison of energy consumption and CH_4 emissions from road transport

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, which 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 slowly declined and, from 2002, liquid fuels were gradually replaced by alternative fuels (Other fuels). The increase in fuel consumption between 2005 and 2008 was interrupted by the economic crisis and, after a slight recovery in 2010-2011, was followed by another decline. A slight increase has been recorded since 2014.

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

The category of Non-Metallic Minerals reports consumption of alternative fuels (Other fuels). The compilation consumption balance and the determination of the emission factors are different from the procedures used for other fuels, as described in section 3.2.4. The basic source of information is the ETS database, where the emission factors for different types of alternative fuels are available. At the same time, data from the REZZO national emission database are used, where data are available on the consumption of alternative fuels in the whole time series since 2003. The resulting processed data on consumption of alternative fuels is further corrected according to the data on the server of the Union of cement and lime manufacturers (www.svcement.cz). Alternative fuel consumption is shown in Tab. 3-26.

Tab. 3-26 Consumption of alternative fuels in sector 1.A.2.f

[TJ/year]	2003	2004	2005	2006	2007	2008	2009	2010
Solid fuels	2 424	3 200	3 517	3 398	3 726	5 037	5 537	3 224
Liquid fuels	1 266	1 156	589	1 014	240	557	682	708
Total	3 690	4 356	4 105	4 412	3 966	5 594	6 219	3 932
[TJ/year]	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	
Solid fuels	3 885	3 055	1 137	3 234	3 576	3 035	5 305	
Liquid fuels	661	394	1 181	18	1 017	2 021	586	
Total	4 546	3 449	2 318	3 252	4 593	5 056	5 891	

Emission factors for calculating CO_2 emissions vary according to the composition of the individual types of fuel (solid, liquid fuels). Solid alternative fuels consist of a variety of sorted waste, used tires, animal meal, etc. Alternative liquid fuels include mainly used oils, waste petroleum products, or even rendered fats. The resulting emission factor corresponds to the relative representation of individual types of fuels. Tab. 3-27 gives an overview of emission factors used for solid and liquid alternative fuels in different years.

Tab. 3-27 CO_2 emission factors used in the consumption of alternative fuels in sector 1.A.2.f

[t CO_2/TJ]	2003	2004	2005	2006	2007	2008	2009	2010
Solid fuels	95.48	87.63	44.20	77.21	17.52	40.07	44.04	57.46
Liquid fuels	212.19	279.87	311.37	287.24	291.60	381.19	419.03	274.81
[t CO_2/TJ]	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	
Solid fuels	51.18	30.50	91.90	1.33	80.65	255.75	356.88	
Liquid fuels	333.26	293.80	105.52	278.19	306.54	197.39	45.78	

The calculation of CH_4 and N_2O emissions was based on default emission factors in accordance with the IPCC 2006 Gl. for the entire 2003-2017 time series (Tab. 3-28).

Tab. 3-28 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

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

See chapter 3.2.5.

3.2.15.4 Category-specific QA/QC and verification (CRF 1.A.2.f)

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

A basic indicator for verification of fuel consumption in the sector of production of pig iron and steel is considered to correspond to indicators of the overall production of basic goods, such as cement, lime, clay tiles and roof tiling or glass and fine ceramics. These are relatively large mass flows, which also exhibit high energy demands (Fig. 3-19). Comparison of total production and total fuel consumption in sub sector 1.A.2.f is shown in n Fig. 3-19.

The basic trend flow of production of mineral products in total corresponds well to the total fuel consumption. Given that this is a rough comparison, it might be that the minor variations are caused by different specific energy intensities of the individual kinds of mineral products.

Other QA/QC procedures are set out in section 3.2.6.

3.2.15.5 Category-specific recalculations (CRF 1.A.2.f)

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

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

Fuel consumption		2009	2010	2011	2012	2013	2014	2015	2016
Submission 2018-2016	TJ	7731.43	9538.15	9738.42	9641.28	7152.16	7423.37	6653.93	7128.12
Submission 2019-2017	TJ	7729.17	9780.49	10129.94	10035.35	7444.15	7680.46	6978.97	7256.48
Difference	TJ	-2.26	242.34	391.51	394.07	291.99	257.09	325.04	128.37
	%	-0.03	2.48	3.86	3.93	3.92	3.35	4.66	1.77
CO_2 emission		2009	2010	2011	2012	2013	2014	2015	2016
Submission 2018-2016	kt	724.56	895.97	903.15	890.34	659.93	685.07	614.94	662.61
Submission 2019-2017	kt	724.32	919.21	941.16	928.50	688.00	709.87	646.39	672.72
Difference	kt	-0.24	23.24	38.01	38.16	28.07	24.80	31.45	10.11
	%	-0.03	2.53	4.04	4.11	4.08	3.49	4.87	1.50
CH_4 emission		2009	2010	2011	2012	2013	2014	2015	2016
Submission 2018-2016	kt	0.07682	0.09497	0.09688	0.09584	0.07095	0.07367	0.06596	0.07070
Submission 2019-2017	kt	0.07680	0.09740	0.10080	0.09978	0.07387	0.07624	0.06921	0.07202
Difference	kt	-0.00002	0.00243	0.00392	0.00394	0.00292	0.00257	0.00325	0.00132
	%	-0.03	2.49	3.88	3.95	3.95	3.37	4.70	1.83
N_2O emission		2009	2010	2011	2012	2013	2014	2015	2016
Submission 2018-2016	kt	0.01152	0.01424	0.01453	0.01437	0.01064	0.01105	0.00989	0.01060
Submission 2019-2017	kt	0.01152	0.01461	0.01512	0.01496	0.01108	0.01143	0.01038	0.01080
Difference	kt	0.00000	0.00036	0.00059	0.00059	0.00044	0.00039	0.00049	0.00020
	%	-0.03	2.49	3.88	3.95	3.95	3.37	4.70	1.83

Tab. 3-30 Changes after recalculation in 1.A.2.f for Liquid Fuels in years 1994-1998 and 2016

Fuel consumption		1994	1995	1996	1997	1998	2016
Submission 2018-2016	TJ	13921.69	12246.30	11161.08	8769.89	10739.39	603.68

Submission 2019-2017	TJ	13379.42	11891.14	10694.73	8385.76	10368.35	588.37
Difference	TJ	-542.27	-355.16	-466.35	-384.13	-371.04	-15.32
	%	-4.05	-2.99	-4.36	-4.58	-3.58	-2.60
CO_2 emission		**1994**	**1995**	**1996**	**1997**	**1998**	**2016**
Submission 2018-2016	kt	1075.01	946.31	859.91	673.24	827.00	44.48
Submission 2019-2017	kt	1034.83	919.99	825.35	644.77	799.51	43.47
Difference	kt	-40.18	-26.32	-34.56	-28.46	-27.49	-1.01
	%	-3.88	-2.86	-4.19	-4.41	-3.44	-2.32
CH_4 emission		**1994**	**1995**	**1996**	**1997**	**1998**	**2016**
Submission 2018-2016	kt	0.04177	0.03674	0.03348	0.02631	0.03222	0.00148
Submission 2019-2017	kt	0.04014	0.03567	0.03208	0.02516	0.03111	0.00158
Difference	kt	-0.00163	-0.00107	-0.00140	-0.00115	-0.00111	0.00010
	%	-4.05	-2.99	-4.36	-4.58	-3.58	6.53
N_2O emission		**1994**	**1995**	**1996**	**1997**	**1998**	**2016**
Submission 2018-2016	kt	0.00835	0.00735	0.00670	0.00526	0.00644	0.00031
Submission 2019-2017	kt	0.00803	0.00713	0.00642	0.00503	0.00622	0.00031
Difference	kt	-0.00033	-0.00021	-0.00028	-0.00023	-0.00022	0.00000
	%	-4.05	-2.99	-4.36	-4.58	-3.58	-0.50

Tab. 3-31 Changes after recalculation in 1.A.2.f for Biomass in 2016

Fuel consumption		**2016**	**CH_4 emission**		**2016**
Submission 2018-2016	TJ	23 061	**Submission 2018-2016**	kt	0.0231
Submission 2019-2017	TJ	24 863	**Submission 2019-2017**	kt	0.0249
Difference	TJ	1 802	**Difference**	kt	0.0018
	%	7.25		%	7.25
CO_2 emission		**2016**	**N_2O emission**		**2016**
Submission 2018-2016	kt	1 278	**Submission 2018-2016**	kt	0.0023
Submission 2019-2017	kt	1 380	**Submission 2019-2017**	kt	0.0025
Difference	kt	102	**Difference**	kt	0.0002
	%	7.42		%	7.25

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

Currently there no improvements are planned in this category.

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

3.2.16.1 Category description (CRF 1.A.2.g)

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

1.A.2.g, 2017								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
LPG	671.95	65.86	1	44.25	1	0.00067	0.1	0.00007
Heating and Other Gasoil	238.56	74.10	1	17.68	3	0.00072	0.6	0.00014
Fuel Oil - Low Sulphur	482.78	77.40	1	37.37	3	0.00145	0.6	0.00029
Fuel Oil - High Sulphur	118.50	77.40	1	9.17	3	0.00036	0.6	0.00007
Anthracite	41.28	98.30	1	4.06	10	0.00084	1.5	0.00006
Other Bitumenous Coal	84.44	94.32*)	0.9707*)	7.73	10	0.00707	1.5	0.00013
Brown Coal + Lignite	707.38	99.26*)	0.9846*)	69.13	10	0.00220	1.5	0.00106

1.A.2.g, 2017								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
Coke	219.85	107.00	1	23.52	10	0.00076	1.5	0.00033
Brown Coal Briquets	75.75	97.50	0.9846*)	7.27	10	0.00002	1.5	0.00011
Natural Gas	33 134.62	55.46*)	1	1 837.69	1	0.03313	0.1	0.00331
Wood/Wood Waste	9 782.42	112.00	1	1 095.63	30	0.29347	4	0.03913
Total year 2017	**45 557.52**			**3 153.50**		**0.34070**		**0.04471**
Total year 2016	46 979.98			3 286.22		0.36032		0.04744
Index 2017/2016	0.97			0.96		0.95		0.94
Total year 1990	246 233.69			20 623.94		1.8069733		0.2661874
Index 2017/1990	0.19			0.15		0.19		0.17

*) *Country specific data*

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

2017							
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
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
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

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 a high energy-demand branch with diverse fuel consumption, such as by the textile and leather industry, wood processing and subsequent production processes, the entire machine industry, incl. production of means of transport and the construction industry.

In the CzSO Questionnaire (CzSO, 2018), the consumption of the individual kinds of fuels in this sector is reported in the Industry Sector section under the items:

- Transport Equipment
- Machinery
- Mining (excluding fuels) and Quarrying
- Wood and Wood Products
- Construction
- Textiles and Leather
- Non-specified (Industry)

This includes the fuels of the 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 total CO_2 emissions in sector 1.A.2 equalled 20% in 2017. It contributed 2% 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 constantly decreased until 2017. Liquid fuels also constantly decreased in importance since 1990. Natural Gas is also an important fuel in this category.

The graph in Fig. 3-20 shows that the beginning of the period in this category was characterised by highly energy-intensive types of industrial processes. Social changes occurring in the Czech Republic in the early 1990s resulted in the introduction of energy-saving measures by newly privatized enterprises. Together, these influences led to an end to inefficient production and reduction of consumption, particularly of fossil fuels, which were the predominant fuels at the beginning of the period and had 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 in a decline in the CO_2 emissions (and other greenhouse gases). This is the category with the largest relative decrease in CO_2 emissions between 1990 and 2017 (90% decrease).

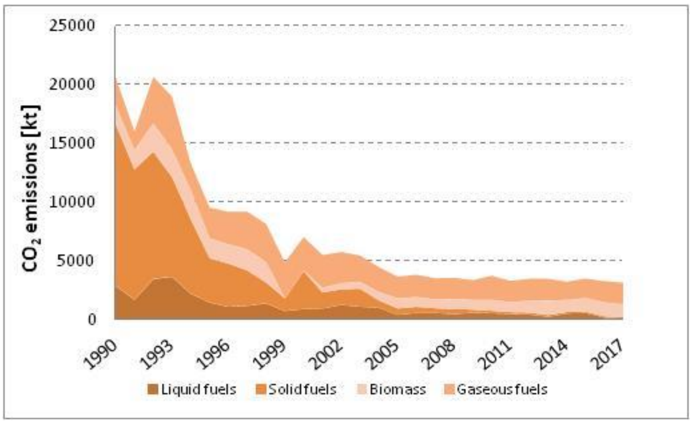


Fig. 3-20 Development of CO_2 emissions in source category 1.A.2.g

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

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

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

See chapter 3.2.5.

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

See chapter 3.2.6.

3.2.16.5 Category-specific recalculations (CRF 1.A.2.g)

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

Tab. 3-32 Changes after recalculation in 1.A.2.g for Solid Fuels in years 2010-2013 and 2015-2016

Fuel consumption		2010	2011	2012	2013	2015	2016
Submission 2018-2016	TJ	2264.89	1620.77	1517.36	1506.68	1172.61	1154.82
Submission 2019-2017	TJ	2247.70	1627.13	1561.63	1540.77	1167.34	1202.00
Difference	TJ	-17.19	6.36	44.27	34.09	-5.27	47.17
	%	-0.76	0.39	2.83	2.21	-0.45	3.92
CO_2 emission		2010	2011	2012	2013	2015	2016
Submission 2018-2016	kt	200.53	152.60	147.41	147.67	115.22	113.36
Submission 2019-2017	kt	199.19	153.57	152.02	151.34	114.66	117.53
Difference	kt	-1.35	0.96	4.61	3.67	-0.56	4.17
	%	-0.68	0.63	3.03	2.42	-0.49	3.55
CH_4 emission		2010	2011	2012	2013	2015	2016
Submission 2018-2016	kt	0.01917	0.01502	0.01468	0.01473	0.01144	0.01132
Submission 2019-2017	kt	0.01900	0.01508	0.01512	0.01507	0.01139	0.01180
Difference	kt	-0.00017	0.00006	0.00044	0.00034	-0.00005	0.00047
	%	-0.90	0.42	2.93	2.26	-0.46	4.00
N_2O emission		2010	2011	2012	2013	2015	2016
Submission 2018-2016	kt	0.00286	0.00225	0.00220	0.00221	0.00171	0.00170
Submission 2019-2017	kt	0.00283	0.00226	0.00227	0.00226	0.00171	0.00177
Difference	kt	-0.00003	0.00001	0.00007	0.00005	-0.00001	0.00007
	%	-0.91	0.42	2.93	2.26	-0.46	4.00

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

Fuel consumption		2016	CH_4 emission		2016
Submission 2018-2016	TJ	34230.94	**Submission 2018-2016**	kt	0.03423
Submission 2019-2017	TJ	32429.19	**Submission 2019-2017**	kt	0.03243
Difference	TJ	-1801.75	**Difference**	kt	-0.00180
	%	-5.56		%	-5.56
CO_2 emission		2016	N_2O emission		2016
Submission 2018-2016	kt	1896.39	**Submission 2018-2016**	kt	0.00342
Submission 2019-2017	kt	1799.89	**Submission 2019-2017**	kt	0.00324
Difference	kt	-96.50	**Difference**	kt	-0.00018
	%	-5.36		%	-5.56

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

Currently there no improvements are planned in this category.

3.2.17 Transport (1.A.3)

The type of transport modes and vehicle categories for the calculation of greenhouse gases emissions are differentiated according individual types of vehicles. An individual category consists of the transport mode, the fuel used and the type of emission standard the particular vehicle must meet (in the road transport). The vehicle categories are not as detailed for non-road transport.

For road transport, the activity data (AD) are calculated using a combination of the Czech Car Registry (CCR) and the Database of Technical Control stations (TCS). This results in the average traffic performance for each category per year in vehicle kilometers. These data are entered to the COPERT 5 calculation program (see chapter 3.2.17.3.).

The data required for calculations in other categories (aviation, railway, navigation) are primarily fuel consumption statistics, which 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 the Czech Statistical Office (CzSO).

The categories of mobile sources are as follows:

Domestic Aviation (CRF 1.A.3.a)

- airplanes fueled by aviation gasoline
- airplanes fueled by jet kerosene

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

- motorcycles conventional, EURO 1 – EURO 5 – gasoline
- passenger cars (PCs) conventional, EURO 1 – EURO 6 – gasoline, diesel, LPG Bifuel, CNG bifuel, Petrol Hybrid
- light duty vehicles (LDVs) conventional, EURO 1 – EURO 6 – gasoline, diesel
- heavy duty diesel vehicles conventional (HDVs), EURO I – EURO VI – gasoline, diesel
- buses conventional, EURO I – EURO VI – diesel, CNG

Railways (CRF 1.A.3.c)

- diesel and steam locomotives

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

- ships with diesel engines

3.2.17.1 Methodological issues

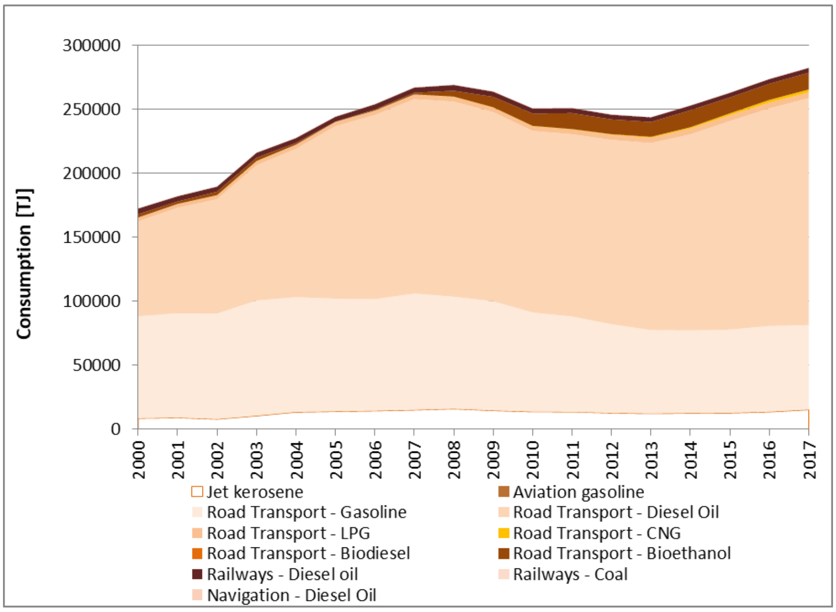


Fig. 3-21 Annual fuel consumption by all modes of transport

Since 2018, the methodology for road transport in the Czech Republic has been based on the COPERT 5 methodology (see 3.2.17.3). Other sectors employ with emission factors in [g.kg^{-1}] of fuel and not in [g.TJ^{-1}] of energy, because the country-specific measured data of every greenhouse gas or pollutant in the internal database are expressed in this unit. The ADs calculated for the CRF Reporter in TJ are affected by the CS calorific value of a particular fuel (which differs in different years). The fuel consumption entered in the CRF Reporter must be converted from weight to energy units (using the calorific value). Thus, the time series of IEF depends partly on the trend in calorific values and primarily on EF in [g.kg^{-1}]. Emission factors for the individual transport subsectors are always given for the current submission year. All the calorific values used for the calculations in the transport sector are presented in Chapter 3 (Energy).

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

Tab. 3-34 Fuel consumption by all modes of transport

Year	Aviation		Road Transport					Railways		Navigation
	Aviation gasoline	Jet kerosene	Gasoline	Diesel oil	LPG	CNG	Biomass	Diesel oil	Coal	Diesel oil
	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
2000	44	8256	79848	74321	2849	97	2590	4440	NO	213
2001	88	8774	81707	82491	2895	97	1924	4066	NO	335
2002	131	7576	82569	89451	2941	243	2701	3942	NO	168
2003	131	10187	90183	105859	2986	243	2590	3857	NO	168
2004	131	13097	89875	116053	3124	146	1332	3810	NO	251
2005	88	13610	88227	134995	3216	146	111	3848	14	209
2006	88	14116	87326	144125	3308	146	757	4107	15	257
2007	88	14808	91067	152062	3538	195	1258	4061	13	214
2008	88	15674	87701	152633	3676	244	4602	4501	14	171
2009	88	14332	85501	148036	3400	293	8154	4083	14	215
2010	88	13423	77634	142059	3538	343	9682	3959	15	172
2011	44	13293	74619	142633	3584	392	12566	3869	15	129
2012	88	12384	69515	144172	3951	489	11525	3737	15	215
2013	88	11950	65325	146334	4089	736	11602	3652	16	86
2014	88	12261	64671	153490	4503	1033	13264	3697	43	129
2015	131	12427	65190	163143	4503	1528	12415	3607	43	129
2016	131	13261	67188	170200	4549	2081	12607	3651	41	172
2017	131	15025	66139	177544	4411	2328	13141	3737	41	172

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

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

3.2.17.2.1 Methodological issues

Aircraft emissions were estimated on the basis of overall fuel consumption in aviation. It is very important to separate domestic and international flights. CzSO provides fuel consumption for these two categories separately. These are the numbers for “fuel sold” not “fuel used”. Every year CDV makes its own estimate of fuel used by domestic Aviation in the Czech Republic. Emission estimates are made on the basis of 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 consists of:

- Aviation gasoline considered to be used entirely by domestic flights

- Jet kerosene 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 important step is to define the ratio between fuel consumption during the LTO and Cruise phases of flights (see Tab. 3-35). 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. 3-35 Ratio of fuel use between LTO and 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

The activity data are obtained from CzSO and are divided between the LTO and Cruise flight mode according to a ratio which is given in Tab. 3-36. 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). The jet kerosene consumption, as well as the relevant emissions from the Army, Industry, Commercial and Public Services categories, are not reported in the CRF tables in Transport sector 1A3, but in sectors 1A5b, 1A2f and 1A4a, respectively. Other two categories (Civil Aviation and International Aviation) are divided on the basis of expert judgment in the whole time period where the main criteria are the combination of transport performance of air passengers transport (only a small number of domestic lines among Czech main airports) and transport performance of air freight transport (MoT, 2017). Regular domestic flights (9 TJ) using kerosene correspond to a very small percentage in the Czech Republic compared to international flights (15 016 TJ). The IEA data (2 295 TJ) also include, in the Domestic Aviation category, kerosene consumption reported to IEA by CzSO (divided in CRF into the categories of Army, Industry, Commercial and Public Services not used for aviation or transport). Tab. 3-36 (based 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 following table, total sums for kerosene (CRF vs. IEA) are mostly identical. Tab. 3-37 lists jet kerosene consumption according to the flight mode.

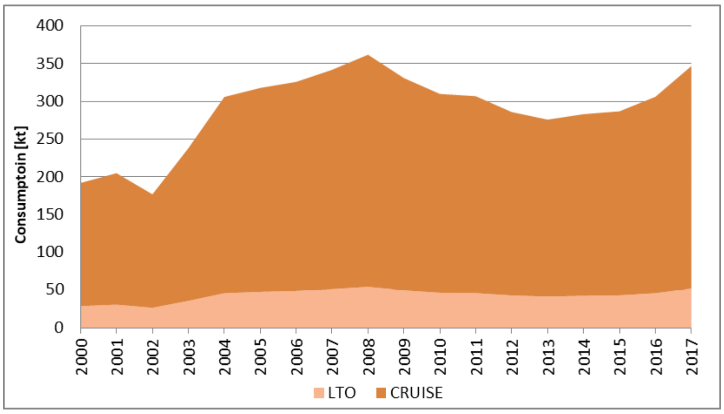


Fig. 3-22 Annual jet kerosene consumption in aviation

Tab. 3-36 Distribution of 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

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
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	7 557	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	15 934	14 462	1 472	15 934
2008	31	15 644	1 083	16 757	14 895	1 862	16 757
2009	45	14 288	1 169	15 501	14 246	1 256	15 501
2010	36	13 387	866	14 289	13 120	1 169	14 289
2011	22	13 271	1 516	14 809	12 990	1 819	14 809
2012	17	12 367	736	13 120	12 297	823	13 120
2013	20	11 931	650	12 600	11 864	736	12 600
2014	12	12 248	686	12 947	12 254	693	12 974
2015	15	12 412	1 386	13 813	12 341	1 472	13 813
2016	11	13 250	1 634	14 895	13 250	1 645	14 895
2017	9	15 016	2 122	17 147	14 852	2 295	17 147

Tab. 3-37 Jet kerosene consumption according to the flight mode

Jet kerosene consumption	Domestic Flights LTO	International Flights LTO	Domestic Flights Cruise	International Flights Cruise
	kt	**kt**	**kt**	**kt**
2000	0.08	28.72	0.43	162.77
2001	0.08	30.67	0.47	173.78
2002	0.07	26.48	0.38	150.08
2003	0.08	35.62	0.47	201.84
2004	0.12	45.78	0.69	259.40
2005	0.13	47.57	0.73	269.56
2006	0.16	48.74	0.90	276.20
2007	0.16	51.14	0.90	289.80
2008	0.11	54.19	0.60	307.09
2009	0.16	49.49	0.88	280.47
2010	0.12	46.38	0.70	262.80
2011	0.07	45.97	0.42	260.52
2012	0.06	42.84	0.34	242.77
2013	0.07	41.33	0.38	234.21
2014	0.04	42.43	0.24	240.44
2015	0.05	43.00	0.29	243.66
2016	0.04	45.90	0.22	260.10
2017	0.03	52.02	0.18	294.77

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 2006 Gl. for aviation).

Tab. 3-38 Emission factors of CO_2, N_2O and CH_4 for 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

CO_2 emissions from domestic air transport make a very small contribution to overall emissions from aviation (about 1%) as this 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 fueled mainly by jet kerosene, while the consumption of aviation gasoline and CO_2 emissions from aviation gasoline are limited to small aircraft used in agriculture and in sports and recreational activities

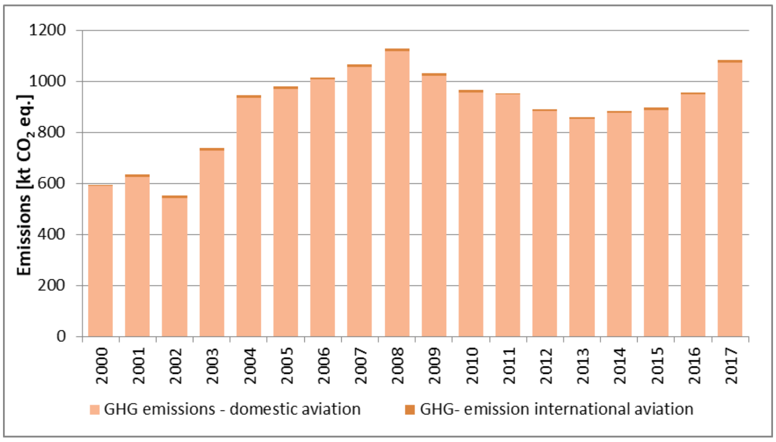


Fig. 3-23 Emissions of CO2, N2O and CH4 from aviation

The total consumption by military and domestic transport (estimated on the basis of the number of flights, distances between destinations and specific consumption of fuels per unit distance in the LTO regime and the Cruise regime) was subtracted from the total kerosene consumption. The remaining kerosene consumption is related to international air transport. Fig.3-23 shows emissions of GHG from aviation in the Czech Republic.

3.2.17.2.2 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 has been evaluated for the whole time series (1990 – 2017) and both flight stages. Combined uncertainties of national emissions within aviation for particular pollutants are given in Tab. 3-39.

Tab. 3-39 Uncertainty data for aviation from uncertainty analysis

IPCC Source Category	Gas	Base year emissions (1990)	2017 year emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
		kt	kt	%	%	%
1A3aii Civil Aviation-Aviation Gasoline	CO_2	138.08	9.20	4.0	3.9	5.6
1A3aii Civil Aviation-Jet Kerosene	CO_2	1.36	0.64	4.0	3.2	5.1
1D1a International Aviation-Jet Kerosene	CO_2	523.72	1073.65	4.0	3.2	5.1
1A3aii Civil Aviation-Aviation Gasoline	CH_4	0.0010	0.0001	4.0	78.5	78.7

1A3aii Civil Aviation-Jet Kerosene	CH_4	0.000009	0.000004	4.0	78.5	78.6
1D1a International Aviation-Jet Kerosene	CH_4	0.00	0.01	4.0	78.5	78.6
1A3aii Civil Aviation-Aviation Gasoline	N_2O	0.0039	0.0003	4.0	110.0	110.1
1A3aii Civil Aviation-Jet Kerosene	N_2O	0.00004	0.00002	4.0	110.0	110.1
1D1a International Aviation-Jet Kerosene	N_2O	0.01	0.03	4.0	110.0	110.1

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

This category covers all GHG emissions from motor road traffic in the Czech Republic, including 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 these vehicle categories: passenger cars (PCs), light duty vehicles (LDVs), heavy duty vehicles (HDVs), buses and motorcycles. For the purpose of calculation, the vehicle categories were broken down by type of fuel and EURO standards.

3.2.17.3.1 Methodological issues

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

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

The methodology for the calculation of emissions from road transport was improved in 2018, with the introduction of COPERT 5. In addition, the national H:C and O:C ratios have been calculated on the basis of laboratory analysis (Černý, 2018). These changes improved the calculation method for CO_2 to Tier 2 and for N_2O and CH_4 to Tier 3. Subsectors of LDVs and PCs were reported together until the 2019 submission. Thanks to new methodology, it was possible to gain AD for these two vehicle categories separately. This results in proper reporting of the emissions for LDVs and PCs on the basis of these two subsectors.

The emission calculations in COPERT 5 are based on the numbers of vehicles, average annual mileage and average total mileage for the COPERT categories. Other important variables are:

- CS meteorological information
- EU average information about driver behavior (trip length, trip duration, average speed on different roads, etc.)
- The technical parameters of vehicles (technologies for reduction of emissions, A/C in vehicles, tank size, number of axles…)
- Fuel quality and composition of fuel
- Calorific value of fuels (from CzSO)
- H:C and O:C ratios

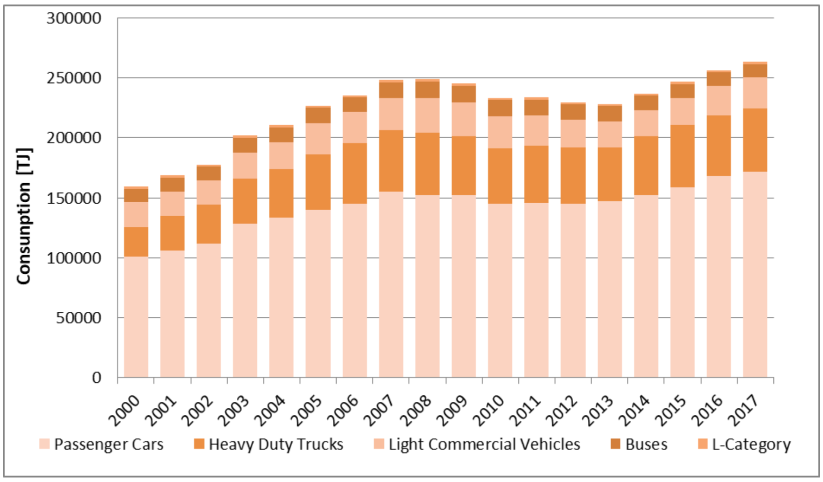


Fig. 3-24 Trend of fuel consumption according fossil fuels by PCs

This is an only brief summary. Full description of the COPERT 5 program can be found at: https://www.emisia.com/utilities/copert/documentation/. The full methodology of application of COPERT 5 in CZ is described in Pelikán, Brich 2017 and Pelikán, Brich 2018.

Activity data

AD for the COPERT program are obtained from two large databases - Czech Car Registry (CCR) and the database of Technical Control Stations (TCS). CCR contains information about numbers and technical details of vehicles registered in individual categories in CZ. TCS annually define traffic performance for a particular car. By combining these two databases, it is possible to obtain numbers of vehicles, average annual mileage and average total mileage for all the relevant 372 COPERT categories in CZ. The results are completely accurate for up to four years before the actual reported year. This is because new cars in CZ have to undergo technical control four years after registration in CCR. To obtain precise emission estimates, it is necessary to recalculate these values for 4 years back. This calculation procedure was developed by Brich in 2014 and this methodology was certified by the Czech MoT. COPERT uses these AD to calculate fuel consumption in all the categories. Fuel consumption in these categories is normalized by CzSO on the basis of total fuel consumption provided.

Fig. 3-24 shows trends in fuel consumption after 2000. The general increasing trend in fuel consumption by PCs and LDVs is in accordance with the general trend in all of Europe. There is an obvious influence of economic crisis between 2008 and 2013 to fossil fuels consumption (Tab. 3-40). Since 2014, there has been a significant increase in the consumption of the main fossil fuels. In 2016, almost 10 % lower prices of diesel and gasoline led to increased consumption of fossil fuels. The consumption of gasoline fluctuated around 90,000 TJ between 2002 and 2009, but has begun to decline significantly since 2010. It even reached a value of 64,000 TJ in 2014. This decline is caused especially by the downward trend in the average fuel consumption of modern passenger cars. In 2016, the gasoline consumption reached a value of 67,172 TJ. In 2017, this value for gasoline was still over 66,000 TJ. Consumption of diesel fuel increased steadily after 2000. Diesel fuel consumption in 2017 equaled 177 069 TJ.

Until 2008, almost no bioethanol and only a small amount of biodiesel were used in the Czech Republic. 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 fraction of biofuels in fossil fuels is also increasing (6.8 % in 2010 and 8.5 % in 2015). These facts (the reduction in the consumption and an increasing share of bio-components) have a favorable impact on CO_2 emissions. We can see an increase in the consumption of biodiesel in 2016 and 2017 compared to 2015. A decrease in taxes for blends with a high percentage of biodiesel was introduced in 2015 and customers slowly accepted this change. Bioethanol does not exhibit any specific long-term trend. Between 2014 and 2017, some fluctuations were caused by the variable ratio between the prices of gasoline and bioethanol.

Tab. 3-40 Fuel consumption in road transport in the Czech Republic

Year	Gasoline TJ	Diesel oil TJ	LPG TJ	CNG TJ	Biodiesel TJ	Bioethanol TJ
2000	79848	74321	2 849	97	2 590	0
2001	79848	74321	2 895	97	1 924	0
2002	79848	74321	2 941	243	2 701	0
2003	79848	74321	2 986	243	2 590	0
2004	79848	74321	3 124	146	1 332	0
2005	79848	74321	3 216	146	111	0
2006	79848	74321	3 308	146	703	54
2007	79848	74321	3 538	195	1 258	0
2008	79848	74321	3 676	244	3 145	1 458
2009	79848	74321	3 400	293	5 698	2 457
2010	79848	74321	3 538	343	7 252	2 430
2011	79848	74321	3 584	392	10 027	2 538

Year	Gasoline TJ	Diesel oil TJ	LPG TJ	CNG TJ	Biodiesel TJ	Bioethanol TJ
2012	79848	74321	3 951	489	9 176	2 349
2013	79848	74321	4 089	736	9 361	2 241
2014	79848	74321	4 503	1 033	10 508	2 754
2015	79848	74321	4 503	1 528	9 768	2 646
2016	79848	74321	4 549	2 081	10 582	1 998
2017	79848	74321	4 411	2 328	10 656	2 484

CNG buses have been used in the Czech Republic since 1994 and CNG PCs began to be used after 2000. The steep increase in CNG consumption from 2012 is a result of subsidies from public resources especially designed to encourage the use of CNG buses. Other subsidies were introduced for CNG LDVs and PCs used by local authorities. Consumption of LPG increased continuously until 2016. In 2017 there was slight decrease, most likely caused by the low prices of diesel fuel and gasoline.

Emission factors

The emission factors are COPERT-based. The COPERT methodology is in accordance with the IPCC 2006 Gl. and 2016 EMEP/EEA Guidebook. EFs for CO_2 are at the Tier 2 level and N_2O, CH_4 at the Tier 3 level. Generally, EFs for all GHG are compiled from Hot EFs, Cold EFs and are additionally dependent on the vehicle category and driving mode (share of urban, rural, highway driving).

Tab. 3-41 Implied EFs for CO2 in road transport

CO_2	Gasoline	Diesel Oil	LPG	CNG	Biomass
	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
2010	70.39	73.11	65.76	56.19	74.64
2011	70.23	73.20	65.76	56.25	74.90
2012	70.22	73.24	65.76	56.37	74.88
2013	70.21	73.24	65.76	56.16	74.95
2014	70.01	73.19	65.76	56.06	74.86
2015	69.94	73.27	65.76	55.92	74.83
2016	70.45	73.25	65.76	55.65	75.13
2017	70.42	73.25	65.76	55.65	74.97

EFs CO_2 include the use of A/C, SCR and lubricant consumption. Implied EFs are additionally dependent on the calorific value of fuel (kg/TJ) – updated every year from the Czech Oil Questionnaire for EEA, and country-specific H:C and O:C ratios (Černý, 2018). In the Tab. 3-43 lists the implied EFs of CO_2 after 2010.

Tab. 3-42 and Tab. 3-43 list the implied EFs of CH_4 and N_2O for road transport after 2010.

Tab. 3-42 Implied EFs for CH_4 in road transport

CH_4	Gasoline	Diesel Oil	LPG	CNG	Biomass
	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
2010	16.77	2.04	10.45	54.28	8.68
2011	16.18	1.77	10.32	53.38	7.01
2012	15.27	1.47	10.17	50.87	6.47
2013	14.19	1.19	10.07	48.86	5.61
2014	12.80	1.01	9.74	45.59	5.30
2015	11.66	0.77	9.66	46.19	4.80
2016	11.15	0.59	11.13	42.38	3.79
2017	10.78	0.52	11.05	36.39	3.58

Tab. 3-43 Implied EFs for N_2O in road transport

N_2O	Gasoline	Diesel Oil	LPG	CNG	Biomass
	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
2010	1.61	2.53	2.00	1.70	2.87

N_2O	Gasoline	Diesel Oil	LPG	CNG	Biomass
2011	1.53	2.63	1.86	1.66	2.95
2012	1.43	2.73	1.68	1.54	3.01
2013	1.32	2.83	1.51	1.45	3.07
2014	1.23	2.87	1.40	1.34	3.06
2015	1.08	2.88	1.27	1.35	3.01
2016	0.99	2.87	1.16	1.19	3.06
2017	0.94	2.85	1.12	0.94	2.98

CO_2 emissions

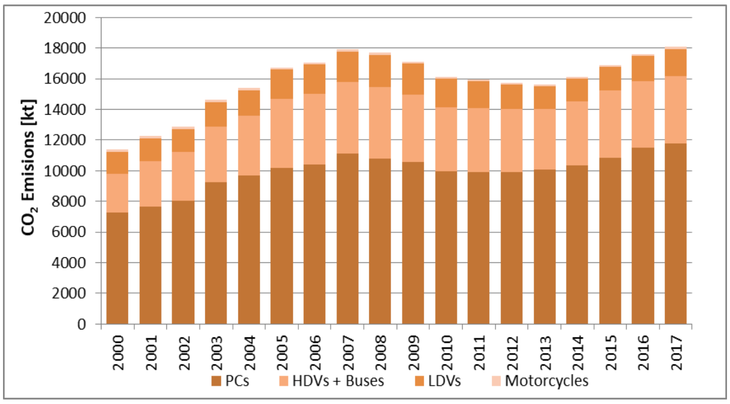


Fig. 3-25 Emissions of CO_2 from road transport according subsectors

Carbon dioxide emissions were calculated on the basis of the total consumption in the 372 COPERT vehicle categories which are relevant in CZ. COPERT separately calculates emissions from hot engines, cold engines, emissions originating from A/C and SCR usage (diesel cars) and emissions caused by lubricant consumption during combustion processes.

A gradually increasing share of transport in total CO_2 emissions in the Czech Republic became evident during the 1990s and this trend continued until 2007. Individual road and freight transport make the greatest contribution to energy consumption in road transport (see Fig 3-25). According to the methodology of calculating CO_2 emissions described above, it is obvious that the trend in CO_2 emissions copies the trend in fuel consumption (see Fig. 3-26).

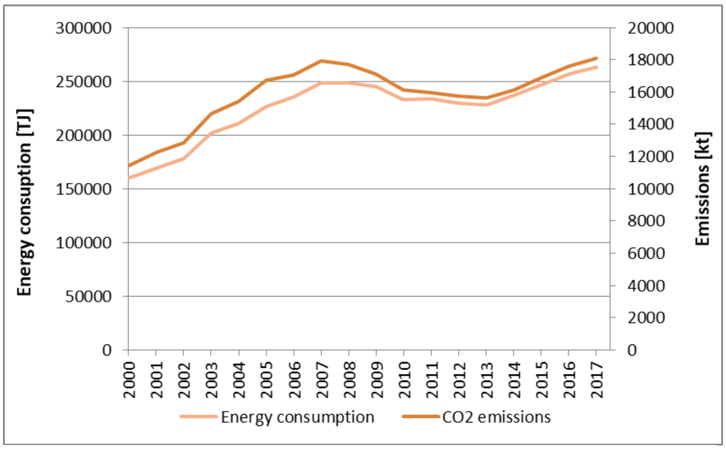


Fig. 3-26 Comparison of energy consumption and CO_2 emissions from road transport

In 2008, for the first time, emissions of carbon dioxide from road transport recorded a decrease, which has started a downward trend continuing until 2014 (Jedlicka et al, 2014). From 2014 until 2017, emissions from road transport increased to over 18,000 kt of CO_2. The trend in carbon dioxide emissions is primarily a result of the changes in traffic performance by gasoline and diesel cars. According to Fig. 3-26 the emissions of CO2 from road transportation follow the trend in energy consumption. There are no disproportions. A small fluctuation can be caused by fact that the EFs are calculated on the basis of the slightly variable calorific value of a particular fuel. These values are provided by CzSO every year. Other factor is the fact that CO2 emissions are dependent on the ratio for energy consumption of a particular type of fuel.

CH_4 emissions

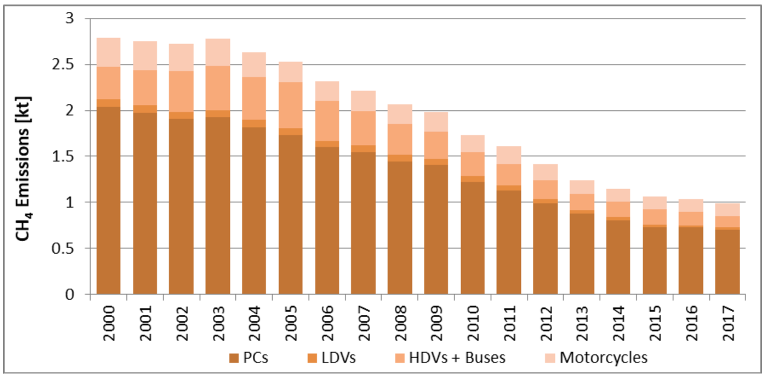


Fig. 3-27 Emissions of CH_4 from road transport according subsectors

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 Fig. 3-27. The annual trends in these emissions are constantly decreasing and are very similar to other hydrocarbons emissions, which are limited in accordance with EURO regulations. New vehicles must fulfill substantially higher EURO standards for hydrocarbons than older vehicles (currently the EURO 6 standard for passenger cars and EURO VI for heavy duty vehicles and buses). The greatest problems are associated with the slow renewal of the freight transport fleet. There has been a slight decrease in the number of older trucks in this country, where these older vehicles are frequently used in the construction and food industries. A potential problem in CH_4 emissions could be the increasing share of CNG vehicles (especially buses from 2012). CNG is composed of approx. 98 % CH_4. On the other hand, use of CNG is beneficial for other GHG and pollutants.

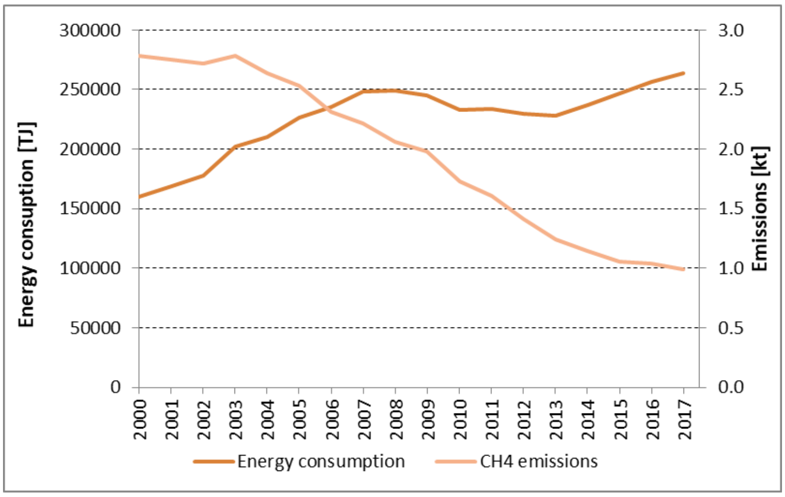


Fig. 3-28 Comparison of energy consumption and CH_4 emissions from road transport

Fig. 3-28 shows the opposite trend in emission production of CH_4 and energy consumption in road transportation. The continuous decrease started in 1996 when the EURO 2 (II) standard was implemented. The decrease in the following years was intensified by toughening of the THC limits in 2005 by the EURO 4 standard. Another cause of the downward trend is the increasing fraction of diesel passenger cars, which produce less CH_4, in the car fleet over the past few years. The increase in energy consumption continued in 2017 as a result of lower fuel prices compared to previous years, but renewal of the car fleet meant that CH_4 emissions continued to decrease to less than 1 kt of emissions in 2017.

N_2O emissions

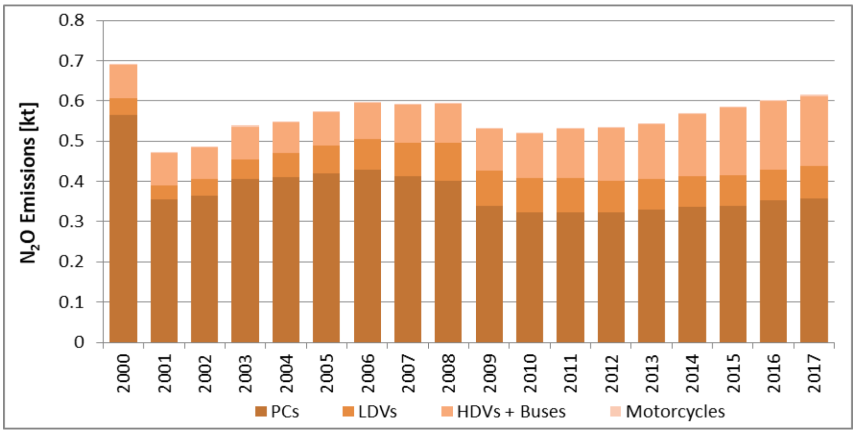


Fig. 3-30 Emissions of N2O from road transport according subsectors

Trends in production of N_2O emissions according to subsectors are shown in Fig. 3-30. Nitrous oxide emissions decreased from 2008, similar to carbon dioxide emissions, as a consequence of reduced consumption of gasoline and diesel oil. New vehicles produce higher emissions compared to older models because they are equipped with 3-way catalytic converters, which reduce only NO_X emissions but not N_2O emissions. However, this effect is suppressed in new vehicles as a consequence of the lower fuel consumption. Between 2008 and 2013, the N_2O emissions decreased similarly to carbon dioxide emissions. These emissions have been increasing since 2014. This fact is caused by the higher consumption of diesel fuel, influenced by changes in the national economy and by the increase in the transportation of goods and material. The increase in fuel consumption continued in 2017 as a result of lower fuel prices compared to the previous years. N_2O emissions reached 0.7 kt in 2017. This increase is mitigated by modernization of car fleet in the Czech Republic.

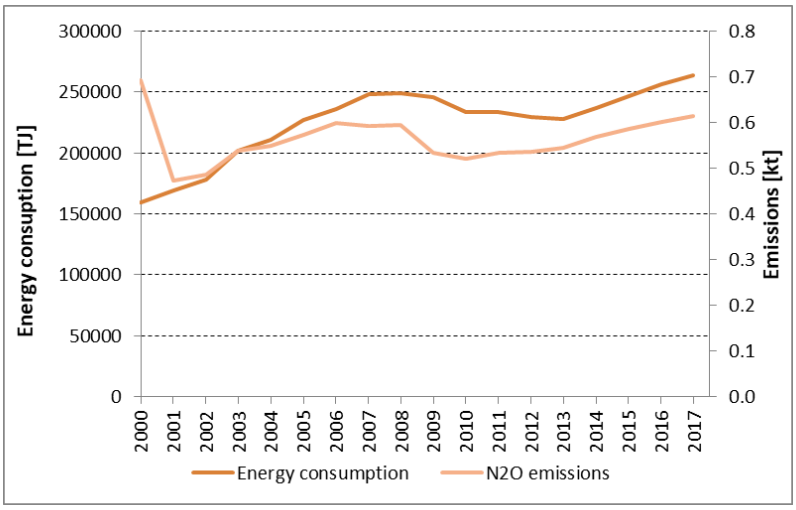


Fig. 3-29 Comparison of energy consumption and N2O emissions from road transport

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 larger contribution than CH_4 emissions. Among N_2O emissions from mobile sources, the most important source seems to be passenger automobile transport, especially gasoline-fueled passenger cars with catalytic converters. Fig. 3-29 shows a similar trend in N_2O emissions from road transport compared to the trend in energy consumption. Between 2006 and 2010, there was a more significant decrease in the trend on N_2O emissions compared to fuel consumption. This effect could be connected to the introduction of more advanced emission control technologies.

3.2.17.3.2 Uncertainties and time-series consistency

Uncertainties in road transport were calculated according to the 2016 EMEP/EEA air pollutant emission inventory guidebook. The uncertainty given here has been evaluated for all the time series (2000 – 2017) and reported categories. Combined uncertainties of national emissions within road transport for the individual pollutants are given in Tab. 3-44.

Tab. 3-44 Uncertainty data for road transport from uncertainty analysis

IPCC Source Category	Gas	Base year emissions (1990)	2017 year emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
		kt	kt	%	%	%
1A3bi PC-Gasoline	CO_2	3352.4	4391.7	3.0	4.0	5.0
1A3bi PC-Diesel Oil	CO_2	938.0	6983.4	3.0	1.5	3.3
1A3bi PC-LPG	CO_2	0.0	290.0	3.0	3.2	4.4
1A3bi PC-Gaseous Fuels	CO_2	0.0	90.0	3.0	3.2	4.4
1A3bi PC-Biomass	CO_2	0.0	600.1	3.0	2.5	3.9
1A3bi LDV-Gasoline	CO_2	83.9	115.7	3.0	4.0	5.0
1A3bi LDV-Diesel Oil	CO_2	896.8	1667.2	3.0	1.5	3.3
1A3bi LDV-Biomass	CO_2	0.0	108.2	3.0	1.8	3.5
1A3biii HDV-Diesel Oil	CO_2	4819.8	4353.8	3.0	1.5	3.3
1A3biii HDV-Gaseous Fuels	CO_2	0.0	39.6	3.0	3.2	4.4
1A3biii HDV-Biomass	CO_2	0.0	271.3	3.0	1.5	3.3
1A3biv Motorcycles-Gasoline	CO_2	153.3	149.2	3.0	4.0	5.0
1A3biv Motorcycles-Biomass	CO_2	0.0	5.6	3.0	4.0	5.0
1A3bi PC-Gasoline	CH_4	1.9	1.9	3.0	157.0	157.0
1A3bi PC-Diesel Oil	CH_4	0.1	25.2	3.0	101.3	101.3
1A3bi PC-LPG	CH_4	0.00	0.05	3.0	809.8	809.8
1A3bi PC-Gaseous Fuels	CH_4	0.00	0.04	3.0	809.8	809.8
1A3bi PC-Biomass	CH_4	0.0	1.8	3.0	123.0	123.0
1A3bi LDV-Gasoline	CH_4	0.03	0.04	3.0	157.0	157.0
1A3bi LDV-Diesel Oil	CH_4	0.1	4.1	3.0	101.3	101.3
1A3bi LDV-Biomass	CH_4	0.0	0.3	3.0	107.4	107.5
1A3biii HDV-Diesel Oil	CH_4	0.6	0.1	3.0	101.3	101.3
1A3biii HDV-Gaseous Fuels	CH_4	0.00	0.05	3.0	809.8	809.8
1A3biii HDV-Biomass	CH_4	0.000	0.005	3.0	101.3	101.3
1A3biv Motorcycles-Gasoline	CH_4	0.3	0.1	3.0	152.1	152.2
1A3biv Motorcycles-Biomass	CH_4	0.00	0.01	3.0	152.1	152.2
1A3bi PC-Gasoline	N_2O	0.1	0.1	3.0	133.8	133.8
1A3bi PC-Diesel Oil	N_2O	0.0	0.3	3.0	137.2	137.2
1A3bi PC-LPG	N_2O	0.000	0.005	3.0	1266.7	1266.7
1A3bi PC-Gaseous Fuels	N_2O	0.000	0.001	3.0	1266.7	1266.7
1A3bi PC-Biomass	N_2O	0.000	0.022	3.0	135.8	135.9
1A3bi LDV-Gasoline	N_2O	0.002	0.003	3.0	133.8	133.8
1A3bi LDV-Diesel Oil	N_2O	0.0	0.1	3.0	137.2	137.2
1A3bi LDV-Biomass	N_2O	0.00	0.01	3.0	136.8	136.8
1A3biii HDV-DieselOil	N_2O	0.2	0.2	3.0	137.2	137.2
1A3biii HDV-Gaseous Fuels	N_2O	0.000	0.001	3.0	1266.7	1266.7
1A3biii HDV-Biomass	N_2O	0.00	0.01	3.0	97.9	97.9
1A3biv Motorcycles-Gasoline	N_2O	0.003	0.003	3.0	156.9	156.9
1A3biv Motorcycles-Biomass	N_2O	0.0000	0.0002	3.0	156.9	156.9

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

3.2.17.4.1 Methodological issues

The Czech railway sector is undergoing a long-term modernization process. It is planned to make electricity the main energy source for rail transport. The use of electricity, instead of diesel fuel, to power locomotives has been increasing continually and electricity now provides 86 % of all energy for railway traffic. The share in energy consumption by 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 further text. In energy inputs used by trains, diesel fuel is the only energy source that plays a significant role apart from electrical power.

Activity data

Regular railway operation uses only diesel oil. Coal is used solely for historical trips and the percentage of its consumption is very small. In general, fuel consumption by railways has had a slightly decreasing trend since 2000. The only exception is the 2006 – 2008 period. After this, the increase stopped at approx. 85 kt per year because of the economic crisis and replacement of diesel-powered locomotives by electric ones. Diesel consumption in 2017 was 87 kt. Coal began to be used on Czech railways again in 2005 (bituminous coal) for historical trips. Since 2014 lignite has also been used . Total coal consumption equaled 2 kt in 2017.

Tab. 3-45 Fuel consumption by railways

Diesel Oil consumption [kt]				Coal consumption [kt]			
2000	104.0	**2009**	95.0	**2000**	0.0	**2009**	1.0
2001	97.0	**2010**	92.0	**2001**	0.0	**2010**	1.0
2002	94.0	**2011**	90.0	**2002**	0.0	**2011**	1.0
2003	92.0	**2012**	87.0	**2003**	0.0	**2012**	1.0
2004	91.0	**2013**	85.0	**2004**	0.0	**2013**	1.0
2005	92.0	**2014**	86.0	**2005**	1.0	**2014**	2.0
2006	96.0	**2015**	84.0	**2006**	1.0	**2015**	2.0
2007	95.0	**2016**	85.0	**2007**	1.0	**2016**	2.0
2008	105.0	**2017**	87.0	**2008**	1.0	**2017**	2.0

Emission factors

The emission factors for diesel oil and coal 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^{-1}] given in the IPCC 2006 Gl. for railways.

Tab. 3-46 Emission factors of CO_2, N_2O and CH_4 from railways in current year in [g.kg-1] of fuel

Transport type	Fuel type	EF CO_2	EF N_2O	EF CH_4
		[g.kg^{-1}]	[g.kg^{-1}]	[g.kg^{-1}]
Railways	Diesel Oil	3 183	1.2	0.2
Railways	Coal	1 973	0.03	0.04

Emissions

Emissions from railways are greatly dependent on fuel consumption. Emissions of GHG are given in Fig. 3-31. The sharpest decrease in emissions took place before 1994. This was connected with a decrease in freight transport because of significantly lower intensity of coal mining compared to the period before 1989. Another factor was electrification of core networks and modernization of the rolling stock during these years. In the following years, GHG emissions were almost constant and increased slightly between 2004 and 2008 in relation to economic growth. After 2008, a decrease in emissions was recorded in connection with the economic crisis.

After 2013, emissions of GHG from railways have oscillated around 270 kt, depending on the transport performance on railways in the current year. From 2005 there have been some minor emissions from combustion of coal, which has started to be used for historical trips. Emissions of GHG in 2017 were 277 kt from diesel oil and 4 kt from coal.

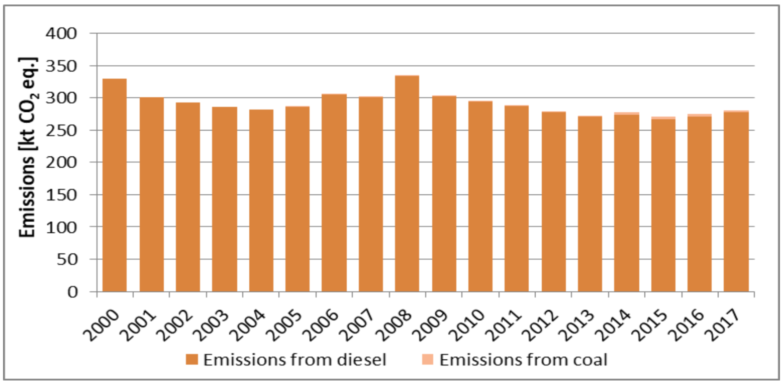


Fig. 3-31 Trend in emissions of CO_2, CH_4 and N_2O from railways

3.2.17.4.2 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 – 2017) and for all the reported categories. The combined uncertainties of national emissions within railways for individual pollutants are given in Tab. 3-47.

Tab. 3-47 Uncertainty data for railways from uncertainty analysis

IPCC Source Category	Gas	Base year emissions (1990)	2017 year emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
		kt	kt	%	%	%
1A3c Railways-Diesel Oil	CO_2	768.1	276.9	5.0	1.5	5.2
1A3c Railways-Coal	CO_2	0.0	3.9	5.0	14.2	15.0
1A3c Railways-Diesel Oil	CH_4	0.0	0.0	5.0	157.0	157.1
1A3c Railways-Coal	CH_4	0.0	0.0	5.0	135.0	135.1
1A3c Railways-Diesel Oil	N_2O	0.3	0.1	5.0	137.2	137.3
1A3c Railways-Coal	N_2O	0.0	0.0	5.0	150.0	150.1

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

3.2.17.5.1 Methodological issues

Primary data on fuels available via CzSO or other statistics do not allow proper 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. 3-48). CzSO provides only data for diesel oil consumption by the recreational fleet, which basically represents the majority of fuel consumption by national navigation in the Czech Republic. The Czech Republic does not have a merchant fleet.

Tab. 3-48 Fuel consumption by national navigation

Diesel Oil consumption (kt)			
2000	5	**2009**	5
2001	8	**2010**	4

Diesel Oil consumption (kt)			
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	**2017**	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 2006 Gl. for navigation.

Tab. 3-49 Emission factors of CO_2, N_2O and CH_4 from national navigation in current year in [g.kg^{-1}] of fuel

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

Emissions

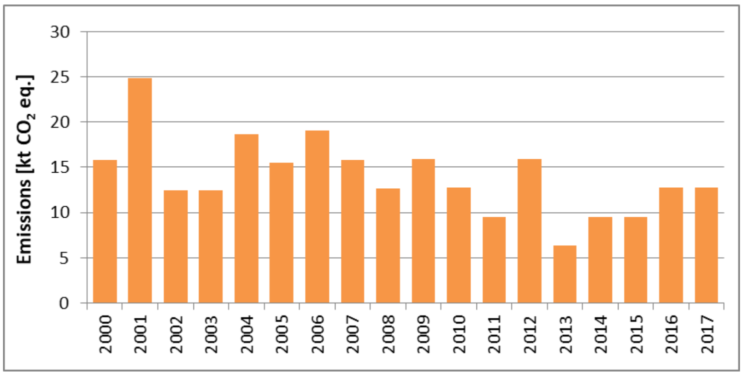


Fig. 3-32 Trend in emissions of CO_2, CH_4 and N_2O from domestic navigation

Emissions from national inland navigation are strongly dependent on fuel consumption. The values fluctuate substantially because of irregularities in traffic performance on Czech inland waterways. Overall emissions of GHG are given in Fig. 3-32.

3.2.17.6 Uncertainties and time-series consistency

Uncertainties for domestic navigation 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 – 2017) and for all the reported categories. The combined uncertainties of national emissions for national navigation for the individual pollutants are given in Tab. 3-50.

Tab. 3-50 Uncertainty data for national navigation from uncertainty analysis

IPCC Source Category	Gas	Base year emissions (1990)	2017 year emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
		kt	kt	%	%	%
1A3dii National navigation-Diesel Oil	CO_2	53.5	12.7	5.0	1.5	5.2
1A3dii National navigation-Diesel Oil	CH_4	0.0	0.0	5.0	157.0	157.1
1A3dii National navigation-Diesel Oil	N_2O	0.0	0.0	5.0	137.2	137.3

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

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

- Pipeline Transport

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

3.2.17.8 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 and completeness and to identify and address errors. All QC activities are documented and the results are archived. QC activities include methods such as accuracy checks on data acquisition and calculations, and the use of approved standardized 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 is guaranteed in the 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 details of inventory activities. These 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 the documentation and archiving of data. The inventory compiler designates responsibilities for implementation of QA/QC procedures among persons not directly involved in the compilation of the inventory and among organizations.

A QA/QC plan is a fundamental element of a 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, there has been close cooperation between CDV and CHMI in the field of energy and fuel consumption data, as well as specific energy data used in calculations in units [$MJ.kg^{-1}$] of fuel. CHMI in close cooperation with CzSO ensures that the Transport Research Centre works with the most updated data about total energy and specific energy consumed.

a. QA/QC activities

QC Activities:

- Checking criteria for the selection of activity data; emission factors and other estimated parameters are documented.
- Checking that emissions and removals are calculated correctly.
- Checking that parameters and units are correctly recorded and that appropriate conversion factors are used.
- Checking the integrity of database files.
- Checking for consistency in data between categories.
- Checking that the movement of inventory data among processing steps is correct.
- Checking that uncertainties in emissions and removals are estimated and calculated correctly.
- Checking time series consistency.

QA Activities:

- Checking completeness (confirming that estimates are reported for all the categories, all the years and all the subcategories and confirming that the entire category of mobile sources is included).
- Trend checks (checking the 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 inventory compiler of the inventory for mobile sources:

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

The third person check (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 carries out the first calculations, which are compared with previous years to reveal a trend in data from previous years. If there are some discrepancies, activity data are consulted with CzSO and inaccuracies are corrected. During the autumn, CzSO provides the final activity data. Then the final calculations are carried out. QC is also performed by the inventory compiler, and then by a person responsible for compilation of the Transport Yearbook in 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 of QC consists of European reviews. QA is carried out on activity data by comparing it with databases like Eurostat and IEA. The main discrepancies are consulted with CzSO and explained during reviews. Emission estimates are prepared for submission by 5 February and sent to an inventory coordinator. Stage 1 review questions are processed during the second half of March. Stage 2 review questions are processed during May and June.

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

There were some changes in all the reported subsectors. The most extensive changes were made in road transport due to transition of the modelling methodology to COPERT 5. In the other sectors, the changes were mainly caused by changes in the activity data from CzSO. Emissions from railways were newly calculated for solid fuels on Tier 1 level. The transport chapter was restructured in greater detail (as requested during ARR 2017, finding E.18) in separate chapters for aviation, road transportation, railways, navigation and pipeline transport.

3.2.17.8.2 Domestic aviation (CRF 1.A.3.a)

There were some minor changes in jet kerosene consumption in domestic aviation between 2002 and 2016. These changes were a result to recalculations by CzSO between subsectors 1.A.3.a and other subsectors using jet kerosene, especially 1.A.5.b.i – Mobile (aviation component). These changes are given in the table below.

Tab. 3-51 Differences in jet kerosene consumption

Year			2002	2003	2004	2005	2006	2007	2008	2009
2018 submission	FC	TJ	19.28	23.56	34.99	37.01	45.89	45.73	30.51	44.88
	CO_2	kt	1.38	1.68	2.5	2.65	3.28	3.27	2.18	3.21
	CH_4	kt	0.00001	0.00001	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	N_2O	kt	0.00004	0.00005	0.00007	0.00008	0.00009	0.00009	0.00006	0.00009
2019 submission	FC	TJ	19.28	23.56	34.99	37.01	45.89	45.73	30.51	44.88
	CO_2	kt	1.38	1.68	2.5	2.65	3.28	3.27	2.18	3.21
	CH_4	kt	0.00001	0.00001	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	N_2O	kt	0.00004	0.00005	0.00007	0.00008	0.00009	0.00009	0.00006	0.00009
Difference 2019 x 2018	AD	TJ	0.001	0.001	-0.001	-0.001	0	-0.001	-0.001	0
		%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Emissions	CO_2 [kt]	7.00E-05	7.00E-05	-4.00E-05	-8.00E-05	-2.00E-05	-4.00E-05	-7.00E-05	2.00E-05
		CH_4 [kt]	5.00E-10	5.00E-10	-3.00E-10	-5.00E-10	-2.00E-10	-3.00E-10	-5.00E-10	2.00E-10
		N_2O [kt]	2.00E-09	2.00E-09	-1.00E-09	-2.00E-09	-7.00E-10	-1.00E-09	-2.00E-09	6.00E-10
		%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Year			**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
2018 submission	FC	TJ	35.9	21.54	17.14	19.55	12.48	14.43	11.38	
	CO_2	kt	2.57	1.54	1.23	1.4	0.89	1.03	0.81	
	CH_4	kt	0.00002	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	
	N_2O	kt	0.00007	0.00004	0.00003	0.00004	0.00003	0.00003	0.00002	
2019 submission	FC	TJ	35.9	21.54	17.14	19.55	12.4	14.53	11.28	
	CO_2	kt	2.57	1.54	1.23	1.4	0.89	1.04	0.81	
	CH_4	kt	0.00002	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	
	N_2O	kt	0.00007	0.00004	0.00003	0.00004	0.00003	0.00003	0.00002	
Difference 2019 x 2018	AD	TJ	0	-0.001	0	0.003	-0.084	0.101	-0.101	
		%	0.00%	0.00%	0.00%	0.01%	-0.67%	0.70%	-0.89%	
	Emissions	CO_2 [kt]	0.00E+00	-6.00E-05	1.00E-05	-6.00E-05	-6.00E-03	7.00E-03	-7.00E-03	
		CH_4 [kt]	0.00E+00	-4.00E-10	7.00E-11	3.00E-08	-4.00E-08	5.00E-08	-5.00E-08	
		N_2O [kt]	0.00E+00	-2.00E-09	3.00E-10	1.00E-07	-2.00E-07	2.00E-07	-2.00E-07	
		%	0.00%	0.00%	0.00%	0.00%	-0.65%	0.70%	-0.89%	

The next recalculation was made for aviation gasoline in domestic aviation between 1998 and 2000. CzSO recalculated AD on the basis of better knowledge and newly acquired information for these years. The changes are given in the table below.

Tab. 3-52 Differences in aviation gasoline consumption

Year			1998	1999	2000
2018 submission	FC	TJ	87.60	131.40	131.40
	CO_2	kt	6.13	9.20	9.20
	CH_4	kt	0.00004	0.00007	0.00007
	N_2O	kt	0.00018	0.00026	0.00026
2019 submission	FC	TJ	43.80	87.60	43.80
	CO_2	kt	3.07	6.13	3.07
	CH_4	kt	0.00002	0.00004	0.00002
	N_2O	kt	0.00009	0.00018	0.00009
Difference 2019 x 2018	AD	TJ	-43.800	-43.800	-87.600
		%	-50.000%	-33.333%	-66.667%
	Emissions	CO_2 [kt]	-3E+00	-3E+00	-6E+00
		CH_4 [kt]	-2E-05	-2E-05	-4E-05
		N_2O[kt]	-9E-05	-9E-05	-2E-04
		%	-50%	-33%	-67%

It was also requested during ESD initial checks (number CZ-1A3a-2018-0001) that an explanation be given of why emissions provided in 2016 for aviation gasoline are identical to the ones reported in 2015. The same situation was repeated for 2017. This is because FC (provided by CzSO), calorific value (according to Czech Oil questionnaire) and EFs (Tier 1) were similar in 2015 – 2017. See the table below.

Tab. 3-53 Comparison of calculation parameters for aviation gasoline

Parameter	Unit	2015	2016	2017
FC	kt	3.00	3.00	3.00
Calorific value	MJ.kg-1	43.79	43.79	43.79
FC	TJ	131.37	131.37	131.37
CO_2 IEF	$g.kg^{-1}$ fuel	3065.00	3065.00	3065.00
CH_4 IEF	$g.kg^{-1}$ fuel	0.0219	0.0219	0.0219
N_2O IEF	$g.kg^{-1}$ fuel	0.0876	0.0876	0.0876
CO_2 emissions	kt	9195.90	9195.90	9195.90
CH_4 emissions	kt	0.0657	0.0657	0.0657
N_2O emissions	kt	0.2627	0.2627	0.2627

3.2.17.8.3 Road transport (CRF 1.A.3.b)

In this subsector extensive changes were made in calculation of road transport GHG emissions. First, in response to request in the review process (ARR review 2017 – finding number E.9), country specific values were calculated for H:C and O:C. This step led to an improvement in the emission calculation method for CO_2 to Tier 2. These values will be updated every 5 years. A brief summary of .calculation process for CS values is provided in chapter 3.2.17.8.3.1.

COPERT 5 methodology has been introduced for emission calculations for road transport. Because of this change, the method for N_2O and CH_4 was improved to Tier 3. Old and recalculated values of ADs and emissions are given in chapter 3.2.17.8.3.2. Introducing COPERT 5 resolves findings from Initial checks number CZ-1A3b-2017-0001. Subsectors of LDVs and PCs had been reported together until the 2019 submission. The new methodology made it possible to obtain AD separately for these two subsectors and emissions are reported properly divided into these two subsectors.

3.2.17.8.3.1 Calculation of country specific H:C and O:C ratios

These ratios are essential for the calculation of CO2 emissions and have been repeatedly requested by the EC in the course of the national greenhouse gas inventory audits. The national specific ratios were elaborated as part of an MoT project by the TriboChem company (Černý, 2018), one of the top Czech companies in this field. The following text includes only the most important analytical results. The most frequently used fuels in the Czech Republic were identified for these calculations. These are diesel, automotive gasoline, LPG (liquefied petroleum gases, typically propane-butane) and CNG (compressed natural gas) used both in transport and in equipment.

These fuels and also all bio-components of fuels used in transport were subjected to chemical analysis to determine the mass content of the predominant elements in the fuel – carbon, hydrogen and oxygen. Where pure hydrocarbon fuels could not be analysed, fuels including their bio-components were analyzed using the usual algorithms (listed below) and mass balances, the proportion of an individual bio-component in the fuel composition was subtracted. In this way, the elemental composition of pure hydrocarbon fuels and non-hydrocarbon components of fossil origin was obtained without including the bio-component.

Each fuel requires a different approach to analyze and determine its elemental composition (H, C, O) depending on the properties of the fuel, in particular its volatility and the boiling points of the components. The method and procedure for analyzing each fuel is described below.

To understand the properties of individual fuels and possible differences in their compositions, it is necessary to first briefly state some principles and procedures for fuel production in a refinery.

3.2.17.8.3.1.1 Selection of fuel samples and sampling of fuels

Sampling was performed to take into account differences in winter and summer fuel quality. In the winter, LPG contains a small predominance of C3 hydrocarbons (hydrocarbons with three carbon atoms per molecule), i.e. propane and possibly also propene and, to ensure sufficient vapour pressure in the summer, C4 hydrocarbons, i.e. with a slight predominance of butanes and butenes. The content of C3 and C4 hydrocarbons fluctuates by between cca. 30 and 70%. Summer LPG is distributed from 1 April to 1 November, while the winter mixture is distributed for the rest of the year.

Automobile gasoline is supplied to the distribution network in varying quality depending on the climatic conditions:

a) the summer quality is available from May 1 to September 30

b) the winter quality is available from November 1 to March 31

c) the transitional quality is delivered in the remaining period, i.e. in April and October

Differences in the quality of gasoline, depending on the season, are mainly due to varying content of light and volatile hydrocarbons, which ensures that the gasoline has sufficiently high vapour pressure to facilitate starting of engines under colder climatic conditions. These hydrocarbons are primarily C4 to C6 hydrocarbons, i.e. isomers of butane, pentane and hexane.

Diesel oil has a distillation range of about 170 °C to 360 °C; more precisely, in the distillation test, at least 95% of the volume of diesel must be distilled at 360 °C. The composition of diesel fuel changes, similar to gasoline and LPG, according to the season:

a) from 15 April to 30 September, summer diesel fuel is distributed, i.e. Class B diesel for a mild climate with a filterability of at most 0 °C

b) from 1 March to 14 April and from 1 October to 15 November, transitional diesel is distributed, i.e. Class D diesel for a mild climate with a filterability of a maximum of -10 °C

c) from 16 November to 28 February, winter diesel is distributed, i.e. Class F diesel for mild climate with a filterability of maximum of -20 °C

d) throughout the year, arctic diesel is distributed, with a filterability of a maximum of -32 °C; it is primarily intended for backup power sources in companies and for emergency forces (army, fire brigade, police, especially in winter)

Differences in the composition of individual diesel fuels, for the above-mentioned periods, are mainly a result of the content of the lighter kerosene fraction. Its higher proportion will ensure better low-temperature properties in the winter and the diesel fuel will remain liquid even at temperatures substantially below zero. Arctic oil has the highest proportion of the kerosene fraction. As the kerosene fractions increase in the diesel fuel, it should theoretically contain more hydrogen and less carbon. However, the differences may not be very great or may even be the opposite if another, less paraffinic raw material is used in the production of the diesel fuel. Oxygen components are not used to a significant degree in the production of diesel fuel. The addition of a phenolic (oxygenated) antioxidant to improve the storage life of the diesel fuel could be an exception. However, the oxygen content of the added amount of antioxidant is negligible.

Bio-diesel is used as a biofuel component in diesel fuels and is currently blended in an amount of up to 7% by volume. Biodiesel can also be distributed as a clean fuel for diesel engines (called B100); this option is unprofitable because of the high taxes.

Bio-ethanol is a biofuel component that is added automobile gasoline up to a maximum content of 5% of the fuel volume. However, it is anticipated that the concentration limit will increase to a maximum of 10% vol. from 2020. In addition to adding bio-ethanol to conventional automobile gasoline BA-95 Super, bio-ethanol is also distributed as bio-ethanol E85. This is a fuel with a high content of bio-ethanol which, however, must contain a certain amount of standard gasoline. In the winter, bio-ethanol E85 contains approximately 30% and, in the summer, this corresponds to about 15% vol. of standard gasoline. The gasoline is added to increase the vapour pressure and to make it easier to start engines. However, the engine must be specially adapted to use this fuel.

Selection of fuel samples:

CNG	2 samples
LPG	1 summer and 1 winter sample
BA-95 Super	3 summer and 3 winter samples
BA-98 Super Plus	1 summer and 1 winter sample
Diesel oil	3 summer and 3 winter samples
Bio-ethanol	3 samples
Bio-diesel	3 samples

Bioethanol need not be analyzed, its composition can be calculated from the chemical formula. Other types of fuels were not analyzed in the gasoline distribution network.

This applies in particular to bio-ethanol and blended diesel fuels because their production and consumption is minimal. If necessary, their elemental composition can be determined by computing the composition of the fossil part and the bio-component with an approximately known ratio of the two components (Chapters 3.5 and 3.6). The fossil part of bio-ethanol E85 is standard gasoline BA-95 Super and the fossil part of blended diesel is common diesel. Their elemental composition is given below in this report.

Individual fuels were taken from the distribution network of gas stations throughout the Czech Republic. Some of the fuel samples were also obtained from suppliers of fuel to the distribution network. Primagas LLC provided LPG samples that it supplies to a regular network of gas stations. LPG samples were contained in small pressure vessels. Čepro Inc. and Preol Inc. provided samples of the biodiesel (MEŘO) that is added to diesel as a bio-component.

Other fuel samples were taken from the network of gas stations. CNG was sampled in a small pressure vessel using special equipment and liquid fuel was sampled into a glass bottle from a dispensing gun. The fuels were collected throughout the Czech Republic in order to encompass possible regional differences in fuel quality and especially in the gasoline quality.

Samples of both BA-95 Super and BA-98 Super Plus gasoline contained the added bio-component, which was subtracted in the calculation of the composition to obtain only the fossil fuel composition.

Samples of diesel oil have been taken exclusively at Euro Oil gas stations owned by Čepro Inc. which, as one of the few, perhaps the only one, distributing diesel fuel without the addition of bio-components. The results obtained by the elemental analysis are then final and the influence of the bio-component (biodiesel) need not be calculated. Čepro Inc. delivers diesel fuel of the same quality to its Euro Oil network and to other distribution companies, except for the content of biofuel. The diesel fuel composition that is distributed by the Euro Oil network is thus representative for the whole Czech Republic.

3.2.17.8.3.1.2 Fuel analysis

The analysis is not necessary for precisely defined compounds, such as bio-ethanol and the elemental composition can be calculated from the chemical formula. The calculated elemental composition of the bio-ethanol is then used further in the calculation of the petroleum fraction of gasoline, where the proportion of bio-ethanol is deducted, if necessary, by mass balance.

LPG and CNG are relatively simple mixtures of hydrocarbons. Their elemental composition cannot be determined directly because gaseous fuels cannot be dispensed into the current conventional analyzers. Determination of their elemental composition requires gas chromatographic analysis and determination of the contents of individual hydrocarbons and then, based on knowledge of the contents of these hydrocarbons, the content of the individual elements can be calculated from their formula.

Also, automobile gasoline is a substance that cannot be simply sampled into elemental analyzers because gasoline is very volatile. This causes problems in weighing the samples for analysis, which involves loss of part of the material by evaporation, thus distorting the results of the analysis. Gasoline, similar to gaseous fuels, must be analyzed by gas chromatography in order to determine the detailed composition, i.e. the contents of the individual hydrocarbons in the gasoline. Although gasoline is a very complex mixture of hydrocarbons from C4 to C12 (hydrocarbons having four to twelve carbon atoms), procedures and associated tools (e.g., a suitable chromatographic column) have been developed for these analyses. Again, similar to gaseous fuels, the elemental composition of the individual hydrocarbons is first calculated and, then the elemental composition of the gasoline as a whole is determined by mass balance. In this calculation, the proportion of bio-components can also be deducted directly.

The distillation properties (low volatility) of diesel oil already allow an elemental analyzer to be used directly to determine the elemental composition of diesel fuel. The elemental analyzer yields the mass contents of carbon, hydrogen, sulfur and nitrogen. However, the sulfur and nitrogen contents must be at least a tenth of a percent, which is not the case for motor fuels. The carbon and hydrogen contents can be obtained from the diesel analysis, but the oxygen content is determined only retrospectively, based on calculation to 100%. It must be assumed that the error in the elemental determination equals a maximum of 0.2% of the weight of the sample, where the error in the oxygen content is cumulative as a result of the calculation method. Each analysis is performed 3 times and the arithmetic mean of the three determinations is given as the result. Bio-diesel can also be analyzed similarly to diesel fuel.

3.2.17.8.3.1.3 Calculation of fuel composition

Analysis of the elemental composition of fuels (bio-ethanol, CNG, LPG, gasoline) is based on the calculation of the content of individual chemical components. This is based on the chemical formulae of the individual pure compounds. Fuel molecules are composed of hydrogen, carbon, and sometimes oxygen.

The weights of the individual atoms in atomic mass units (Dalton, amu – atomic mass unit) are used to calculate the mass content. Units of molecular weight - g/mol are used for compounds. The masses of the atoms of the individual elements are tabulated as follows (rounded off to 3 decimal places):

Hydrogen 1.008 amu

Carbon 12.011 amu

Oxygen 15.999 amu

3.2.17.8.3.1.4 Summary results of fuel analysis

All the required results of the elemental composition of the monitored fuels are listed in the following tables. The results are expressed in percent and related to the fossil component of fuel. In the case of gasoline, the composition including the biofuel is also mentioned as a matter of interest; for CNG, the composition is also shown after subtracting inert gases, which are part of the extracted (fossil) natural gas. The H:C and O:C ratios are given as both atomic (as required by the client) and mass for information.

The monitored parameters are always highlighted in bold, where other accompanying results are given in tables below.

Tab. 3-54 CNG, winter and summer sample

		Natural gas - CNG	Natural gas - CNG
		ČS Euro Oil, Českomoravská, Praha 09 February 2018	ČS Euro Oil, Českomoravská, Praha 09 May 2018
Carbon, C	**% w/w**	**74.18**	**74.13**
Hydrogen, H	**% w/w**	**24.44**	**24.36**
Oxygen, O	**% w/w**	**0.53**	**0.68**
Nitrogen, N	**% w/w**	**0.86**	**0.83**
H/C ratio (by weight)		0.329	0.329
O/C ratio (by weight)		0.007	0.009
H/C atomic ratio		**3.925**	**3.916**
O/C atomic ratio		**0.005**	**0.007**
only a hydrocarbon "flammable" part without inert gases N2 a CO2			
Carbon, C	**% w/w**	75.22	75.26
Hydrogen, H	**% w/w**	24.78	24.74
H/C ratio (by weight)		0.329	0.329
O/C ratio (by weight)		0.000	0.000

	Natural gas - CNG ČS Euro Oil, Českomoravská, Praha 09 February 2018	Natural gas - CNG ČS Euro Oil, Českomoravská, Praha 09 May 2018
H/C atomic ratio	3.925	3.916
O/C atomic ratio	0.000	0.000

Tab. 3-55 LPG, winter and summer sample

	LPG Primagas, Inc., February 2018	LPG Primagas, Inc., May 2018
Carbon, C % w/w	**82.54**	**82.36**
Hydrogen, H % w/w	**17.46**	**17.64**
H/C ratio (by weight)	0.212	0.214
O/C ratio (by weight)	0.000	0.000
H/C atomic ratio	**2.52**	**2.551**
O/C atomic ratio	**0.000**	**0.000**

Tab. 3-56 Petrol BA – 95 Super, winter samples

	BA – 95 Super ČS Globus, Praha – Černý Most, February 2018	BA – 95 Super ČS Euro Oil, Prostějov, Feb-18	BA – 95 Super ČS MOL, Plzeň, Feb-18
whole petrol including bio-component			
Carbon, C % w/w	84.62	85.44	84.60
Hydrogen, H % w/w	12.97	12.98	13.00
Oxygen, O % w/w	2.41	1.58	2.40
fossil part of petrol without bio-component			
Carbon, C % w/w	86.16	87.02	86.12
Hydrogen, H % w/w	12.96	12.98	13.00
Oxygen, O % w/w	0.87	0.00	0.88
H/C ratio (by weight)	0.150	0.149	0.151
O/C ratio (by weight)	0.010	0.000	0.010
H/C atomic ratio	1.793	1.777	1.798
O/C atomic ratio	0.008	0.000	0.008

Tab. 3-57 Petrol BA – 95 Super, summer samples

	BA – 95 Super Benzina, Praha 9 – Horní Počernice, May 2018	BA – 95 Super Shell, Tábor May-18	BA – 95 Super OMV, Opava May-18
whole petrol including bio-component			
Carbon, C % w/w	84.94	84.57	84.45
Hydrogen, H % w/w	13.09	13.00	13.14
Oxygen, O % w/w	1.96	2.43	2.41
fossil part of petrol without bio-component			
Carbon, C % w/w	**86.23**	**85.90**	**86.18**
Hydrogen, H % w/w	**13.09**	**13.00**	**13.14**
Oxygen, O % w/w	**0.68**	**1.10**	**0.69**
H/C ratio (by weight)	0.152	0.151	0.152
O/C ratio (by weight)	0.008	0.013	0.008
H/C atomic ratio	**1.809**	**1.803**	**1.816**
O/C atomic ratio	**0.006**	**0.010**	**0.006**

Tab. 3-58 Petrol BA – 98 Super Plus

	BA – 98 Super Plus	BA – 98 Super Plus
	OMV, Maxx Motion BA-100 motorway D1 Jihlava Feb-18	Benzina, Verva BA-100 Karlovy Vary May-18
whole petrol including bio-component		
Carbon, C % w/w	84.35	85.02
Hydrogen, H % w/w	13.05	12.87
Oxygen, O % w/w	2.60	2.11
fossil part of petrol without bio-component		
Carbon, C % w/w	**86.01**	**86.76**
Hydrogen, H % w/w	**13.05**	**12.86**
Oxygen, O % w/w	**0.95**	**0.38**
H/C ratio (by weight)	0.152	0.148
O/C ratio (by weight)	0.011	0.004
H/C atomic ratio	**1.807**	**1.766**
O/C atomic ratio	**0.008**	**0.003**

Tab. 3-59 Bio-diesel, B-100, winter and summer samples

	Bio-diesel B-100, MEŘO	Bio-diesel B-100, MEŘO	Bio-diesel B-100, MEŘO
	Čepro Inc., February 2018	Preol Inc., February 2018	Čepro Inc., May 2018
Carbon, C % w/w	**77.14**	**77.22**	**77.11**
Hydrogen, H % w/w	**12.03**	**12.05**	**12.06**
Oxygen, O % w/w	**10.83**	**10.73**	**10.83**
H/C ratio (by weight)	0.156	0.156	0.156
O/C ratio (by weight)	0.140	0.139	0.140
H/C atomic ratio	**1.859**	**1.859**	**1.863**
O/C atomic ratio	**0.105**	**0.104**	**0.105**

Tab. 3-60 Diesel oil, winter (without bio-component)

	Diesel oil	Diesel oil	Diesel oil
	Euro Oil, Prostějov Feb-18	Euro Oil, Nehvizdy Feb-18	Euro Oil, Litomyšl Feb-18
Carbon, C % w/w	**86.46**	**86.12**	**86.14**
Hydrogen, H % w/w	**13.54**	**13.88**	**13.86**
H/C ratio (by weight)	0.157	0.161	0.161
O/C ratio (by weight)	0.000	0.000	0.000
H/C atomic ratio	**1.866**	**1.920**	**1.918**
O/C atomic ratio	**0.000**	**0.000**	**0.000**

Tab. 3-61 Diesel oil, summer (without bio-component)

	Diesel oil	Diesel oil	Diesel oil
	May-18	May-18	May-18

	Diesel oil	Diesel oil	Diesel oil
	May-18	May-18	May-18
Carbon, C % w/w	**86.44**	**86.48**	**86.54**
Hydrogen, H % w/w	**13.56**	**13.52**	**13.46**
H/C ratio (by weight)	0.157	0.156	0.156
O/C ratio (by weight)	0.000	0.000	0.000
H/C atomic ratio	**1.869**	**1.862**	**1.854**
O/C atomic ratio	**0.000**	**0.000**	**0.000**

Tab. 3-62 Bio-ethanol, calculation

	Bio-ethanol
Carbon, C % w/w	**52.14**
Hydrogen, H % w/w	**13.13**
Oxygen, O % w/w	**34.73**
H/C ratio (by weight)	0.252
O/C ratio (by weight)	0.666
H/C atomic ratio	**3.000**
O/C atomic ratio	**0.500**

3.2.17.8.3.2 Recalculation due to introducing COPERT 5

Major changes were made in the emission estimates for road transport in whole 1990 – 2016 time series, for two main reasons. The first one is the different EFs and their methodology (original methodology – EFs in [g.kg^{-1}] versus COPERT – [g.km^{-1}]). The second one is the different type of AD. In the old methodology, AD was calculated from fuel consumption in tons of fuel. COPERT 5 requires AD in vehicle kilometers per category and the values for fuel consumption [TJ] are calculated from this input using EF [TJ.km^{-1}] implemented in COPERT 5. Vehicle kilometers are obtained by combining the database of the Central Car Registry and the Technical Control database (see chapter 3.2.17.3). Old and recalculated values are given in the tables below.

Tab. 3-63 Changes in FC and emissions for passenger cars

Year	2018 submission								2019 submission							
	FC					Emissions			FC					Emissions		
	Gasoline	Diesel	LPG	Gaseous fuels	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	LPG	Gaseous fuels	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	TJ	TJ	kt	kt	kt	TJ	TJ	TJ	TJ	TJ	kt	kt	kt
1990	50053	6321	0	0	0	3937	1.1	0.4	46865.1	12665.5	0.0	0	0	4290.4	2.0	0.1
1991	46767	5263	0	0	0	3631	1.0	0.3	43743.0	12016.6	0.0	0	0	4021.0	1.9	0.1
1992	60876	6910	0	0	13	4731	1.3	0.5	56482.8	11549.3	0.0	0	18	4896.7	2.4	0.2
1993	58113	8003	200	0	26	4633	1.2	0.5	53514.0	12921.5	200.0	0	40	4801.4	2.2	0.2
1994	67547	8270	376	0	48	5319	1.3	0.6	62107.7	15399.2	375.7	0	85	5615.5	2.4	0.3
1995	70537	9234	551	0	78	5609	1.3	0.7	64809.4	13656.3	551.3	0	150	5695.3	2.3	0.3
1996	79410	10475	551	0	109	6316	1.4	0.9	73335.7	12844.3	551.3	0	217	6252.4	2.5	0.4
1997	79284	11249	1149	0	165	6404	1.4	0.9	72800.2	13825.4	1148.6	0	361	6326.3	2.3	0.4

Year	2018 submission								2019 submission							
	FC					Emissions			FC					Emissions		
	Gasoline	Diesel	LPG	Gaseous fuels	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	LPG	Gaseous fuels	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	TJ	TJ	kt	kt	kt	TJ	TJ	TJ	TJ	TJ	kt	kt	kt
1998	77557	12626	2527	0	178	6477	1.2	1.0	71877.1	19184.2	2527.0	0	416	6747.8	2.2	0.5
1999	82243	16506	2941	0	222	7116	1.2	1.1	76676.8	20522.7	2940.5	0	557	7216.9	2.2	0.5
2000	79437	18738	2849	0	305	7081	1.1	0.5	74221.1	23432.2	2848.6	0	817	7247.7	2.0	0.6
2001	81277	21650	2895	2	226	7428	1.1	0.5	76349.7	26504.2	2894.6	0	618	7670.3	2.0	0.4
2002	82122	24821	2941	10	318	7725	1.0	0.5	77453.6	30549.9	2940.5	0	922	8054.7	1.9	0.4
2003	89678	30814	2986	34	305	8697	1.0	0.6	84960.0	39344.6	2986.5	0	963	9258.8	1.9	0.4
2004	89358	34973	3124	32	157	8992	0.9	0.6	84768.2	44870.3	3124.3	0	515	9676.9	1.8	0.4
2005	87712	42535	3216	35	13	9444	0.8	0.6	83403.4	53116.1	3216.2	7	44	10208.8	1.7	0.4
2006	86786	47662	3308	43	136	9766	0.8	0.6	82617.0	58805.8	3308.1	20	338	10415.7	1.6	0.4
2007	90522	52617	3538	76	148	10410	0.8	0.7	85801.5	64898.4	3537.8	45	537	11115.4	1.5	0.4
2008	87103	55180	3676	109	2584	10373	0.7	0.7	82140.5	63739.1	3675.6	77	2678	10760.8	1.4	0.4
2009	84885	55563	3400	145	4578	10232	0.7	0.7	79975.8	63901.3	3400.0	75	4757	10545.8	1.4	0.3
2010	77056	55085	3538	189	5224	9665	0.6	0.7	72651.7	63270.3	3537.8	86	5504	9978.2	1.2	0.3
2011	74047	56943	3584	233	6522	9600	0.6	0.7	69910.7	65212.6	3583.7	105	6963	9926.4	1.1	0.3
2012	68965	59404	3951	316	6112	9459	0.5	0.7	65363.2	69180.7	3951.3	163	6612	9927.5	1.0	0.3
2013	64798	61484	4089	524	6156	9345	0.5	0.7	61668.3	74428.5	4089.1	285	6877	10067.2	0.9	0.3
2014	64121	65874	4503	728	7242	9662	0.5	0.7	61139.6	78244.0	4502.7	469	7962	10330.7	0.8	0.3
2015	64627	71527	4503	1058	6906	10133	0.6	0.7	61684.9	84483.2	4502.7	675	7563	10840.2	0.7	0.3
2016	66551	75951	4549	1463	6706	10619	0.6	0.8	63629.8	91193.9	4548.6	1135	7588	11526.1	0.7	0.4

Tab. 3-64 Differences in numbers and percentages between submissions for passenger cars

Year	Difference 2019 x 2018 submission								Difference 2019 x 2018 submission							
	FC					Emissions			FC					Emissions		
	Gasoline	Diesel	LPG	Gaseous fuels	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	LPG	Gaseous fuels	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	TJ	TJ	kt	kt	kt	%	%	%	%	%	%	%	%
1990	-3188	6344	0	0	0	353	0.94	-0.25	-6.4	100.4	0	0.0	0.0	9.0	89.6	-65.9
1991	-3024	6754	0	0	0	390	0.88	-0.23	-6.5	128.3	0	0.0	0.0	10.7	90.1	-65.8
1992	-4393	4640	0	0	5	166	1.12	-0.29	-7.2	67.1	0	0.0	34.6	3.5	87.4	-65.1
1993	-4599	4918	0	0	14	168	1.00	-0.30	-7.9	61.4	0	0.0	54.6	3.6	85.2	-61.6
1994	-5439	7129	0	0	37	297	1.11	-0.35	-8.1	86.2	0	0.0	77.5	5.6	85.6	-57.6
1995	-5728	4422	0	0	72	86	1.06	-0.37	-8.1	47.9	0	0.0	92.0	1.5	82.8	-53.3
1996	-6075	2370	0	0	109	-63	1.16	-0.46	-7.6	22.6	0	0.0	99.8	-1.0	84.8	-54.4
1997	-6484	2577	0	0	195	-77	0.97	-0.50	-8.2	22.9	0	0.0	118.0	-1.2	71.5	-54.0
1998	-5680	6558	0	0	238	271	0.97	-0.50	-7.3	51.9	0	0.0	133.2	4.2	79.1	-51.8
1999	-5566	4017	0	0	335	101	0.96	-0.56	-6.8	24.3	0	0.0	150.9	1.4	77.7	-50.6
2000	-5216	4694	0	0	512	166	0.93	0.11	-6.6	25.1	0	0.0	168.0	2.4	84.5	24.2

Year	Difference 2019 x 2018 submission								Difference 2019 x 2018 submission							
	FC					Emissions			FC					Emissions		
	Gasoline	Diesel	LPG	Gaseous fuels	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	LPG	Gaseous fuels	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	TJ	TJ	kt	kt	kt	%	%	%	%	%	%	%	%
2001	-4927	4854	0	-2	392	243	0.92	-0.13	-6.1	22.4	0	-100.0	173.1	3.3	87.4	-26.2
2002	-4668	5729	0	-10	605	330	0.92	-0.14	-5.7	23.1	0	-100.0	190.3	4.3	93.1	-27.6
2003	-4718	8530	0	-34	658	562	0.93	-0.17	-5.3	27.7	0	-100.0	215.9	6.5	94.2	-29.1
2004	-4589	9897	0	-32	358	685	0.91	-0.18	-5.1	28.3	0	-100.0	228.6	7.6	99.8	-31.0
2005	-4308	10581	0	-28	31	765	0.90	-0.21	-4.9	24.9	0	-79.4	234.4	8.1	109.4	-33.5
2006	-4169	11144	0	-23	201	649	0.82	-0.22	-4.8	23.4	0	-53.3	147.8	6.6	105.8	-33.9
2007	-4721	12281	0	-32	389	706	0.77	-0.28	-5.2	23.3	0	-41.6	262.7	6.8	99.4	-40.6
2008	-4963	8559	0	-32	94	387	0.72	-0.30	-5.7	15.5	0	-29.0	3.6	3.7	99.7	-42.8
2009	-4909	8338	0	-70	180	314	0.74	-0.36	-5.8	15.0	0	-48.4	3.9	3.1	110.5	-51.4
2010	-4405	8185	0	-103	280	313	0.63	-0.34	-5.7	14.9	0	-54.4	5.4	3.2	106.2	-51.4
2011	-4136	8270	0	-128	441	326	0.57	-0.34	-5.6	14.5	0	-54.8	6.8	3.4	102.2	-51.4
2012	-3602	9776	0	-154	501	469	0.46	-0.34	-5.2	16.5	0	-48.5	8.2	5.0	86.5	-50.9
2013	-3130	12945	0	-239	721	722	0.35	-0.32	-4.8	21.1	0	-45.6	11.7	7.7	67.7	-49.6
2014	-2981	12370	0	-259	720	669	0.26	-0.34	-4.6	18.8	0	-35.6	9.9	6.9	48.2	-50.4
2015	-2942	12956	0	-383	656	707	0.16	-0.38	-4.6	18.1	0	-36.2	9.5	7.0	27.8	-52.5
2016	-2922	15243	0	-327	882	907	0.11	-0.40	-4.4	20.1	0	-22.4	13.2	8.5	17.9	-53.4

Subsectors of LDVs and PCs were reported together until the 2019 submission. The new methodology made it possible to obtain AD for these two subsectors separately and the emissions are reported properly divided into these two subsectors. Therefore, there is no reason for a comparison table for LDVs in numbers and percentages. This is obvious from Tab. 3-65.

Tab. 3-65 Changes in FC and emissions for LDVs

Year	2018 submission						2019 submission					
	FC			Emissions			FC			Emissions		
	Gasoline	Diesel	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	kt	kt	kt	TJ	TJ	TJ	kt	kt	kt
1990	0	0	0	0	0	0	1171.21	12109.68	0.00	980.73	0.08	0.00
1991	0	0	0	0	0	0	1194.27	10862.60	0.00	890.32	0.08	0.00
1992	0	0	0	0	0	0	2094.93	10519.30	16.00	929.19	0.10	0.00
1993	0	0	0	0	0	0	2448.91	11063.09	34.58	994.81	0.10	0.01
1994	0	0	0	0	0	0	3059.51	12421.20	68.57	1139.10	0.11	0.01
1995	0	0	0	0	0	0	3357.82	10914.29	120.26	1049.34	0.11	0.02
1996	0	0	0	0	0	0	3638.85	11000.61	186.20	1075.69	0.11	0.02
1997	0	0	0	0	0	0	3416.67	11643.03	303.64	1106.83	0.09	0.03
1998	0	0	0	0	0	0	3416.96	15799.31	342.80	1414.15	0.10	0.03
1999	0	0	0	0	0	0	3561.66	16148.14	438.22	1446.78	0.10	0.04
2000	0	0	0	0	0	0	3387.80	16584.44	577.92	1466.27	0.09	0.04
2001	0	0	0	0	0	0	3120.92	17117.36	399.20	1509.61	0.08	0.04
2002	0	0	0	0	0	0	2976.74	16588.65	500.86	1458.92	0.08	0.04

Year	2018 submission						2019 submission					
	FC			Emissions			FC			Emissions		
	Gasoline	Diesel	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	kt	kt	kt	TJ	TJ	TJ	kt	kt	kt
2003	0	0	0	0	0	0	3036.38	18329.58	448.41	1594.17	0.08	0.05
2004	0	0	0	0	0	0	3079.66	19579.43	224.69	1693.12	0.08	0.06
2005	0	0	0	0	0	0	3100.63	22587.45	18.57	1922.45	0.08	0.07
2006	0	0	0	0	0	0	3041.66	22590.33	112.04	1878.04	0.07	0.08
2007	0	0	0	0	0	0	3433.48	23546.96	194.75	1977.67	0.07	0.08
2008	0	0	0	0	0	0	3684.39	25333.13	583.13	2121.53	0.07	0.10
2009	0	0	0	0	0	0	3629.66	23983.00	1027.32	2012.26	0.07	0.09
2010	0	0	0	0	0	0	3310.34	22114.90	1232.52	1850.28	0.06	0.09
2011	0	0	0	0	0	0	3047.02	20719.19	1560.28	1731.09	0.06	0.08
2012	0	0	0	0	0	0	2569.05	19317.94	1316.37	1595.74	0.05	0.08
2013	0	0	0	0	0	0	2142.56	18389.26	1249.91	1497.54	0.04	0.08
2014	0	0	0	0	0	0	2042.43	18087.68	1325.39	1467.10	0.03	0.08
2015	0	0	0	0	0	0	1917.24	19311.54	1234.11	1549.30	0.03	0.08
2016	0	0	0	0	0	0	1831.31	20893.33	1354.25	1659.56	0.03	0.08

Tab. 3-66 Changes in FC and emissions for HDVs and buses

Year	2018 submission							2019 submission						
	FC				Emissions			FC				Emissions		
	Gasoline	Diesel	Gaseous fuels	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	Gaseous fuels	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	TJ	kt	kt	kt	TJ	TJ	TJ	TJ	kt	kt	kt
1990	0	29974	0	0	2221	0.42	0.09	110	65079	0	0	4828	0.58	0.20
1991	0	24689	0	0	1829	0.35	0.07	100	57861	0	0	4293	0.52	0.18
1992	0	31782	0	98	2355	0.45	0.09	123	50886	0	77	3777	0.46	0.16
1993	0	35684	0	196	2644	0.49	0.11	123	47035	0	147	3491	0.43	0.15
1994	0	36874	54	359	2735	0.49	0.12	127	45902	54	253	3409	0.44	0.14
1995	0	39731	88	588	2949	0.51	0.13	120	35872	88	395	2669	0.36	0.11
1996	0	42556	90	816	3158	0.52	0.14	124	30802	90	521	2293	0.32	0.09
1997	0	43048	95	1241	3195	0.50	0.15	106	28443	95	742	2116	0.29	0.08
1998	0	45206	97	1339	3355	0.50	0.17	99	34931	97	758	2595	0.35	0.10
1999	0	53030	97	1665	3935	0.56	0.20	89	32861	97	892	2434	0.33	0.08
2000	0	55587	97	2285	4124	0.56	0.22	82	34304	97	1195	2540	0.35	0.08
2001	0	60848	95	1698	4514	0.60	0.25	71	38870	97	907	2928	0.38	0.08
2002	0	64637	233	2383	4802	0.61	0.27	66	42312	243	1278	3193	0.44	0.08
2003	0	75057	209	2285	5573	0.66	0.32	65	48185	243	1179	3634	0.48	0.08
2004	0	81099	113	1175	6016	0.65	0.36	58	51603	146	592	3890	0.47	0.08
2005	0	92489	111	98	6860	0.68	0.42	60	59291	138	49	4472	0.50	0.08
2006	0	96503	103	620	7157	0.64	0.43	42	62729	126	306	4624	0.43	0.09
2007	0	99484	119	1110	7378	0.61	0.45	39	63616	151	526	4693	0.38	0.09
2008	0	97480	135	2008	7231	0.56	0.45	32	63560	167	1310	4677	0.33	0.10

Year	2018 submission							2019 submission						
	FC				Emissions			FC				Emissions		
	Gasoline	Diesel	Gaseous fuels	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	Gaseous fuels	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	TJ	kt	kt	kt	TJ	TJ	TJ	TJ	kt	kt	kt
2009	0	92489	148	3560	6862	0.48	0.43	29	60152	218	2316	4418	0.30	0.10
2010	0	86980	154	4440	6454	0.42	0.42	26	56674	257	2894	4160	0.26	0.11
2011	0	85682	159	6024	6358	0.38	0.41	25	56702	287	3987	4168	0.24	0.12
2012	0	84763	173	5395	6290	0.36	0.41	22	55673	326	3544	4098	0.20	0.13
2013	0	84845	213	5428	6299	0.35	0.41	21	53516	451	3424	3946	0.18	0.14
2014	0	87604	305	5998	6508	0.37	0.43	20	57158	564	3914	4216	0.17	0.15
2015	0	91613	470	5485	6814	0.39	0.45	21	59348	853	3554	4397	0.16	0.17
2016	0	94159	618	5857	7011	0.41	0.46	20	58113	945	3614	4310	0.14	0.17

Tab. 3-67 Differences in numbers and percentages between submissions for HDVs and buses

Year	Difference 2019 x 2018 submission							Difference 2019 x 2018 submission						
	FC				Emissions			FC				Emissions		
	Gasoline	Diesel	Gaseous fuels	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	Gaseous fuels	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	TJ	kt	kt	kt	%	%	%	%	%	%	%
1990	110	35105	0	0	2606	0.16	0.12	N/A	117.1	0.0	0.0	117.3	38.0	137.2
1991	100	33172	0	0	2464	0.17	0.11	N/A	134.4	0.0	0.0	134.7	48.4	159.5
1992	123	19104	0	-21	1422	0.01	0.07	N/A	60.1	0.0	-21.0	60.4	2.5	79.1
1993	123	11351	0	-49	847	-0.05	0.04	N/A	31.8	0.0	-24.9	32.0	-11.3	38.1
1994	127	9029	0	-106	674	-0.05	0.03	N/A	24.5	0.0	-29.4	24.6	-10.2	25.3
1995	120	-3860	0	-192	-280	-0.15	-0.02	N/A	-9.7	0.0	-32.7	-9.5	-29.4	-14.5
1996	124	-11753	0	-295	-865	-0.20	-0.05	N/A	-27.6	0.0	-36.1	-27.4	-39.3	-35.9
1997	106	-14605	0	-499	-1079	-0.21	-0.07	N/A	-33.9	0.0	-40.2	-33.8	-41.5	-45.0
1998	99	-10275	0	-581	-760	-0.15	-0.07	N/A	-22.7	0.0	-43.4	-22.6	-30.2	-42.5
1999	89	-20169	0	-773	-1501	-0.23	-0.12	N/A	-38.0	0.0	-46.4	-38.1	-40.5	-58.1
2000	82	-21282	0	-1090	-1585	-0.21	-0.14	N/A	-38.3	0.0	-47.7	-38.4	-37.5	-62.2
2001	71	-21979	2	-791	-1586	-0.23	-0.17	N/A	-36.1	2.3	-46.6	-35.1	-37.3	-67.3
2002	66	-22325	10	-1106	-1610	-0.17	-0.19	N/A	-34.5	4.3	-46.4	-33.5	-28.1	-70.9
2003	65	-26871	34	-1107	-1939	-0.18	-0.24	N/A	-35.8	16.2	-48.4	-34.8	-26.9	-74.9
2004	58	-29496	32	-583	-2126	-0.18	-0.28	N/A	-36.4	28.6	-49.6	-35.3	-27.9	-78.5
2005	60	-33198	28	-49	-2388	-0.17	-0.34	N/A	-35.9	25.1	-50.2	-34.8	-25.7	-80.4
2006	42	-33775	23	-314	-2533	-0.21	-0.34	N/A	-35.0	22.1	-50.7	-35.4	-32.6	-79.2
2007	39	-35867	32	-584	-2685	-0.24	-0.36	N/A	-36.1	26.7	-52.6	-36.4	-38.8	-79.5
2008	32	-33920	32	-698	-2554	-0.22	-0.36	N/A	-34.8	23.4	-34.8	-35.3	-39.9	-78.8
2009	29	-32337	70	-1244	-2443	-0.19	-0.33	N/A	-35.0	47.6	-34.9	-35.6	-38.6	-76.2
2010	26	-30306	103	-1546	-2294	-0.15	-0.30	N/A	-34.8	66.8	-34.8	-35.5	-36.8	-73.4
2011	25	-28980	128	-2037	-2190	-0.15	-0.29	N/A	-33.8	80.4	-33.8	-34.4	-38.1	-70.0

Year	Difference 2019 x 2018 submission							Difference 2019 x 2018 submission						
	FC				Emissions			FC				Emissions		
	Gasoline	Diesel	Gaseous fuels	Biomass	CO_2	CH_4	N_2O	Gasoline	Diesel	Gaseous fuels	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	TJ	TJ	kt	kt	kt	%	%	%	%	%	%	%
2012	22	-29089	154	-1851	-2193	-0.16	-0.28	N/A	-34.3	89.0	-34.3	-34.9	-44.1	-68.1
2013	21	-31329	239	-2003	-2353	-0.18	-0.28	N/A	-36.9	112.1	-36.9	-37.4	-50.4	-67.4
2014	20	-30446	259	-2084	-2292	-0.20	-0.28	N/A	-34.8	84.8	-34.7	-35.2	-54.3	-64.4
2015	21	-32266	383	-1931	-2417	-0.23	-0.28	N/A	-35.2	81.5	-35.2	-35.5	-58.7	-63.0
2016	20	-36046	327	-2244	-2700	-0.26	-0.29	N/A	-38.3	53.0	-38.3	-38.5	-64.6	-63.5

Tab. 3-68 Changes in FC and emissions for motorcycles

Year	2018 submission					2019 submission				
	FC		Emissions			FC		Emissions		
	Gasoline	Biomass	CO_2	CH_4	N_2O	Gasoline	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	kt	kt	kt	TJ	TJ	kt	kt	kt
1990	264.92	0.00	18.36	0.03	0.0004	2155.03	0.00	153.28	0.32	0.0032
1991	247.83	0.00	17.17	0.02	0.0003	1961.77	0.00	139.50	0.29	0.0029
1992	323.34	0.00	22.41	0.03	0.0004	2481.42	0.00	176.70	0.37	0.0037
1993	309.82	0.00	21.47	0.03	0.0004	2318.89	0.00	165.13	0.35	0.0035
1994	360.12	0.00	24.96	0.03	0.0005	2592.05	0.00	184.82	0.39	0.0039
1995	377.73	0.00	26.18	0.04	0.0005	2607.17	0.00	186.02	0.39	0.0039
1996	428.46	0.00	29.69	0.04	0.0006	2716.35	0.00	194.08	0.40	0.0040
1997	431.38	0.00	29.89	0.04	0.0006	2715.99	0.00	193.99	0.40	0.0040
1998	426.25	0.00	29.54	0.04	0.0006	2558.56	0.00	182.65	0.38	0.0038
1999	460.25	0.00	31.90	0.04	0.0006	2339.99	0.00	167.08	0.34	0.0034
2000	451.22	0.00	31.27	0.04	0.0006	2157.52	0.00	153.91	0.31	0.0032
2001	473.89	0.00	32.84	0.04	0.0006	2165.32	0.00	154.66	0.31	0.0032
2002	494.80	0.00	34.29	0.05	0.0007	2072.45	0.00	147.86	0.30	0.0030
2003	559.67	0.00	38.79	0.05	0.0008	2121.13	0.00	151.19	0.30	0.0031
2004	576.42	0.00	39.95	0.05	0.0008	1969.08	0.00	140.44	0.27	0.0028
2005	577.04	0.00	39.99	0.05	0.0008	1663.07	0.00	118.32	0.22	0.0024
2006	584.73	0.36	40.52	0.05	0.0008	1624.78	1.00	114.01	0.21	0.0023
2007	625.44	0.00	43.34	0.06	0.0008	1793.39	0.00	125.99	0.22	0.0026
2008	618.55	10.28	42.87	0.06	0.0008	1845.05	30.67	129.60	0.21	0.0027
2009	618.85	17.78	42.89	0.06	0.0008	1865.83	53.62	130.04	0.21	0.0027
2010	576.18	18.04	39.93	0.05	0.0008	1645.87	51.52	114.42	0.19	0.0024
2011	567.66	19.31	39.34	0.05	0.0008	1637.18	55.69	113.39	0.19	0.0024
2012	544.65	18.41	37.74	0.05	0.0007	1560.74	52.74	107.97	0.17	0.0023
2013	522.09	17.91	36.18	0.05	0.0007	1493.86	51.25	103.35	0.16	0.0022
2014	528.88	22.53	36.65	0.05	0.0007	1468.40	62.55	101.10	0.14	0.0022

Year	2018 submission					2019 submission				
	FC		Emissions			FC		Emissions		
	Gasoline	Biomass	CO_2	CH_4	N_2O	Gasoline	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	kt	kt	kt	TJ	TJ	kt	kt	kt
2015	546.73	22.20	37.89	0.05	0.0007	1567.01	63.62	107.80	0.14	0.0023
2016	576.30	17.15	39.94	0.05	0.0008	1706.71	51.44	118.50	0.14	0.0025

Tab. 3-69 Differences in numbers and percentages between submissions for motorcycles

Year	Difference 2019 x 2018 submission					Difference 2019 x 2018 submission				
	FC		Emissions			FC		Emissions		
	Gasoline	Biomass	CO_2	CH_4	N_2O	Gasoline	Biomass	CO_2	CH_4	N_2O
	TJ	TJ	kt	kt	kt	%	%	%	%	%
1990	1890.12	0.00	134.92	0.30	0.00	713.47	0.00	734.91	1184.84	797.56
1991	1713.93	0.00	122.33	0.27	0.00	691.56	0.00	712.26	1148.04	771.86
1992	2158.08	0.00	154.29	0.34	0.00	667.43	0.00	688.56	1110.71	745.78
1993	2009.07	0.00	143.66	0.32	0.00	648.46	0.00	669.09	1079.07	723.68
1994	2231.93	0.00	159.87	0.35	0.00	619.78	0.00	640.59	1031.85	690.70
1995	2229.44	0.00	159.85	0.35	0.00	590.22	0.00	610.64	984.61	657.70
1996	2287.89	0.00	164.38	0.36	0.00	533.98	0.00	553.62	894.76	594.93
1997	2284.60	0.00	164.09	0.36	0.00	529.60	0.00	548.90	884.59	587.81
1998	2132.31	0.00	153.11	0.34	0.00	500.25	0.00	518.33	837.43	554.85
1999	1879.74	0.00	135.19	0.30	0.00	408.42	0.00	423.85	688.81	451.43
2000	1706.30	0.00	122.65	0.27	0.00	378.16	0.00	392.22	634.41	413.48
2001	1691.43	0.00	121.82	0.27	0.00	356.92	0.00	370.93	599.08	390.85
2002	1577.65	0.00	113.57	0.25	0.00	318.85	0.00	331.21	531.05	346.57
2003	1561.46	0.00	112.41	0.24	0.00	279.00	0.00	289.82	462.23	301.78
2004	1392.65	0.00	100.49	0.22	0.00	241.60	0.00	251.57	399.50	260.76
2005	1086.03	0.00	78.33	0.17	0.00	188.21	0.00	195.87	311.47	202.58
2006	1040.05	0.64	73.49	0.16	0.00	177.87	177.87	181.35	285.31	194.10
2007	1167.95	0.00	82.64	0.17	0.00	186.74	0.00	190.67	283.24	203.68
2008	1226.51	20.39	86.73	0.16	0.00	198.29	198.29	202.33	268.50	216.57
2009	1246.98	35.83	87.15	0.15	0.00	201.50	201.50	203.21	262.29	223.61
2010	1069.69	33.48	74.49	0.13	0.00	185.65	185.65	186.55	249.74	209.32
2011	1069.52	36.38	74.05	0.13	0.00	188.41	188.41	188.23	253.81	213.90
2012	1016.09	34.34	70.23	0.12	0.00	186.56	186.56	186.07	246.30	211.71
2013	971.77	33.34	67.17	0.11	0.00	186.13	186.13	185.65	221.24	210.82
2014	939.52	40.02	64.45	0.09	0.00	177.64	177.64	175.84	185.68	201.15
2015	1020.28	41.42	69.91	0.09	0.00	186.61	186.61	184.51	171.95	209.50
2016	1130.41	34.29	78.56	0.09	0.00	196.15	199.88	196.72	160.47	214.39

3.2.17.8.4 Railways (CRF1.A.3.c)

Recalculation for emissions from diesel oil was carried out for 1990 – 1997 on the basis of the data newly obtained from CzSO, which led to recalculation of AD based on better knowledge and information newly acquired for these years. The changes are given in the table below.

Tab. 3-70 Differences in diesel oil consumption

Year	2018 submission				2019 submission				Difference 2019 x 2018					
	FC	CO_2	CH_4	N_2O	FC	CO_2	CH_4	N_2O	AD		Emissions			
	TJ	kt	kt	kt	TJ	kt	kt	kt	TJ	%	CO_2 [kt]	CH_4 [kt]	N_2O[kt]	%
1990	8824.00	653.86	0.04	0.25	10366.34	768.15	0.04	0.30	1542.34	17.48	114.29	0.01	0.04	17.48
1991	7856.00	582.13	0.03	0.22	8452.13	626.30	0.04	0.24	596.13	7.59	44.17	0.00	0.02	7.59
1992	6670.00	494.25	0.03	0.19	7903.14	585.62	0.03	0.23	1233.14	18.49	91.38	0.01	0.04	18.49
1993	5604.00	415.26	0.02	0.16	6417.80	475.56	0.03	0.18	813.80	14.52	60.30	0.00	0.02	14.52
1994	4517.00	334.71	0.02	0.13	6207.48	459.97	0.03	0.18	1690.48	37.42	125.26	0.01	0.05	37.42
1995	4506.00	333.89	0.02	0.13	6715.95	497.65	0.03	0.19	2209.95	49.04	163.76	0.01	0.06	49.04
1996	4443.00	329.23	0.02	0.13	5528.64	409.67	0.02	0.16	1085.64	24.43	80.45	0.00	0.03	24.43
1997	3820.00	283.06	0.02	0.11	5148.79	381.53	0.02	0.15	1328.79	34.79	98.46	0.01	0.04	34.79

Emissions from combustion of coal are newly calculated for this year's submission. Coal has been used on Czech railways for historical trips since 2005. As can be seen in the table below, these emissions are negligible compared to emissions from diesel oil.

Tab. 3-71 Recalculated emissions from coal used in the Czech railways

Year	Coal - submisson 2019			
	FC	CO_2	CH_4	N_2O
	TJ	kt	kt	kt
2005	13.68	1.31	0.00003	0.00002
2006	15.50	1.49	0.00003	0.00002
2007	13.00	1.25	0.00003	0.00002
2008	13.50	1.30	0.00003	0.00002
2009	13.86	1.33	0.00003	0.00002
2010	15.45	1.49	0.00003	0.00002
2011	15.08	1.45	0.00003	0.00002
2012	15.18	1.46	0.00003	0.00002
2013	15.55	1.49	0.00003	0.00002
2014	43.43	4.17	0.00009	0.00007
2015	42.52	4.09	0.00009	0.00006
2016	41.08	3.95	0.00008	0.00006
2017	41.07	3.95	0.00008	0.00006

3.2.17.8.5 Navigation (CRF 1.A.3.d)

Recalculation for emissions from diesel oil was carried out for 1990 – 1997, on the basis of the data newly obtained from CzSO, which led to recalculation of AD based on better knowledge and information newly acquired for these years. The changes are given in the table below.

Tab. 3-72 Differences in diesel oil consumption

Year	2018 submission				2019 submission				Difference 2019 x 2018					
	FC	CO_2	CH_4	N_2O	FC	CO_2	CH_4	N_2O	AD		Emissions			
	TJ	kt	kt	kt	TJ	kt	kt	kt	TJ	%	CO_2 [kt]	CH_4 [kt]	N_2O[kt]	%
1990	764.00	56.61	0.0053	0.0015	722.25	53.52	0.0051	0.0014	-41.76	-5.47	-3.09	-0.0003	-0.0001	-5.47
1991	758.00	56.17	0.0053	0.0015	722.04	53.50	0.0051	0.0014	-35.96	-4.74	-2.66	-0.0003	-0.0001	-4.74
1992	740.00	54.83	0.0052	0.0015	722.33	53.52	0.0051	0.0014	-17.67	-2.39	-1.31	-0.0001	0.0000	-2.39
1993	733.00	54.32	0.0051	0.0015	680.03	50.39	0.0048	0.0014	-52.97	-7.23	-3.92	-0.0004	-0.0001	-7.23
1994	722.00	53.50	0.0051	0.0014	680.27	50.41	0.0048	0.0014	-41.73	-5.78	-3.09	-0.0003	-0.0001	-5.78
1995	745.00	55.20	0.0052	0.0015	680.10	50.40	0.0048	0.0014	-64.90	-8.71	-4.81	-0.0005	-0.0001	-8.71
1996	620.00	45.94	0.0043	0.0012	680.45	50.42	0.0048	0.0014	60.45	9.75	4.48	0.0004	0.0001	9.75
1997	520.00	38.53	0.0036	0.0010	595.73	44.14	0.0042	0.0012	75.73	14.56	5.61	0.0005	0.0002	14.56

3.2.17.8.6 International aviation (CRF 1.D.1.a)

Some minor changes were made to the values for jet kerosene consumption in international aviation for 2002 – 2016. These changes are based on recalculations by CzSO between subsectors 1.A.3.a and other subsectors for jet kerosene, especially 1.A.5.b.i – Mobile (aviation component). The changes are given in the table below.

Tab. 3-73 Differences in jet kerosene consumption

	2018 submission				2019 submission				Difference 2019 x 2018					
Year	FC	CO_2	CH_4	N_2O	FC	CO_2	CH_4	N_2O	AD		Emissions			
	TJ	kt	kt	kt	TJ	kt	kt	kt	TJ	%	CO_2 [kt]	CH_4 [kt]	N_2O[kt]	%
2002	7556.3	540.3	0.004	0.015	7556.7	540.3	0.004	0.015	0.4	0.005	0.03	0.0000002	0.0000008	0.005
2003	10162.8	726.6	0.005	0.021	10163.2	726.7	0.005	0.021	0.4	0.004	0.03	0.0000002	0.0000008	0.004
2004	13061.8	933.9	0.007	0.027	13061.6	933.9	0.007	0.027	-0.2	-0.002	-0.01	-0.0000001	-0.0000004	-0.002
2005	13573.4	970.5	0.007	0.028	13573.0	970.5	0.007	0.028	-0.4	-0.003	-0.03	-0.0000002	-0.0000008	-0.003
2006	14069.9	1006.0	0.007	0.028	14069.8	1006.0	0.007	0.028	-0.1	-0.001	-0.01	0	-0.0000002	-0.001
2007	14762.9	1055.5	0.007	0.03	14762.7	1055.5	0.007	0.03	-0.2	-0.001	-0.01	-0.0000001	-0.0000004	-0.001
2008	15644.1	1118.6	0.008	0.032	15643.6	1118.5	0.008	0.032	-0.5	-0.003	-0.04	-0.0000002	-0.000001	-0.003
2009	14287.4	1021.6	0.007	0.029	14287.5	1021.6	0.007	0.029	0.1	0.001	0.01	0	0.0000002	0.001
2010	13387.1	957.2	0.007	0.027	13387.1	957.2	0.007	0.027	0.0	0	0	0	0	0
2011	13271.6	948.9	0.007	0.027	13271.1	948.9	0.007	0.027	-0.5	-0.004	-0.04	-0.0000002	-0.000001	-0.004
2012	12366.7	884.2	0.006	0.025	12366.8	884.2	0.006	0.025	0.1	0.001	0.01	0	0.0000002	0.001
2013	11929.2	852.9	0.006	0.024	11930.8	853.1	0.006	0.024	1.6	0.013	0.11	0.0000008	0.0000032	0.013
2014	12328.0	881.5	0.006	0.025	12248.3	875.8	0.006	0.025	-79.7	-0.647	-5.7	-0.0000399	-0.0001612	-0.647
2015	12412.6	887.5	0.006	0.025	12412.2	887.5	0.006	0.025	-0.4	-0.003	-0.03	-0.0000002	-0.0000008	-0.003
2016	13368.3	955.8	0.007	0.027	13249.9	947.4	0.007	0.027	-118.4	-0.886	-8.47	-0.0000592	-0.0002395	-0.886

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

During recent years extensive improvements have been made in road transport, with some improvements in the railway subsectors. Improvements are now planned for the process of calculation of emissions from domestic and international aviation (enhanced methodology of obtaining more precise

AD and calculation method). The calculation should also be improved in similar way in the railways subsector. This should all be completed by 2024.

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

3.2.18.1 Category description (CRF 1.A.4.a)

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

1.A.4.a, 2017								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O/TJ]	[kt]
LPG	275.67	65.86*)	1	18.15	5	0.00138	0.1	0.00003
Other kerosene	85.60	71.90	1	6.15	10	0.00086	0.6	0.00005
Heating and Other Gasoil	85.20	74.10	1	6.31	10	0.00085	0.6	0.00005
Fuel Oil - Low Sulphur	276.50	77.40	1	21.40	10	0.00277	0.6	0.00017
Fuel Oil - High Sulphur	79.00	77.40	1	6.11	10	0.00079	0.6	0.00005
Other Bituminous Coal	29.20	94.09*)	0.9707*)	2.67	10	0.00029	1.5	0.00004
Brown Coal + Lignite	839.24	98.68*)	0.9846*)	81.53	10	0.00839	1.5	0.00126
Coke	76.92	107.00	1	8.23	10	0.00077	1.5	0.00012
Brown Coal Briquets	400.16	97.50	0.9846*)	38.41	10	0.00400	1.5	0.00060
Natural Gas	50 065.53	55.46*)	1	2 776.70	5	0.25033	0.1	0.00501
Wood/Wood Waste	471.40	112.00	1	52.80	300	0.14142	4	0.00189
Gaseous Biomass	871.85	54.60	1	47.60	5	0.00436	0.1	0.00009
Total year 2017	**53 556.27**			**2 965.68**		**0.27042**		**0.00737**
Total year 2016	52 373.03			2 892.14		0.26375		0.00728
Index 2017/2016	1.02			1.03		1.03		1.01
Total year 1990	119 864.09			9 907.15		1.00085		0.10113
Index 2017/1990	0.45			0.30		0.27		0.07

*) *Country specific data*

The origin of the data, the employed emission factors and the method of calculating the levels of emissions for the individual gases are shown in detail in the following outline.

2017							
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
Other kerosene	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Heating and Other Gasoil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - Low Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - High Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other Bituminous Coal	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Coke	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Brown Coal Briquets	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Waste - fossil fraction	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Gaseous Biomass	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

Category 1.A.4 includes emissions which are not included in categories 1.A.1 and 1.A.2. 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 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 implementation of energy-efficiency-oriented modernizations 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 decreases constantly over time. On the other hand, the consumption of Natural Gas increased during the period, as did Biomass consumption. Liquid Fuels play a minor role in this category.

CO_2 emissions produced in category 1.A.4.a in 2017 represent 23% of all of 1.A.4, which is 3% of CO_2 emissions from the Energy sector 1.A.

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

The CzSO Questionnaire (CzSO, 2018) reports the consumption of the individual kinds of fuels in Other sectors under the item:

- Commercial and Public Services
- Unspecified (Other)

The latter are included under 1.A.4.a Commercial/Institutional on the basis of an agreement with CzSO. This includes the fuels of the 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.

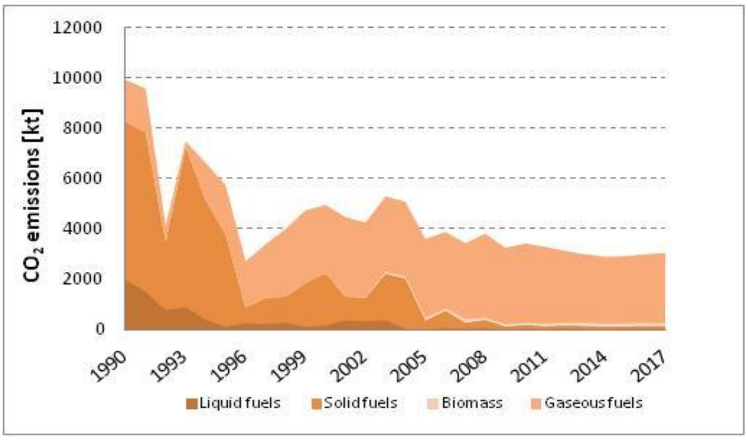


Fig. 3-33 Development of CO_2 emissions in source category 1.A.4.a

Fig. 3-33 shows that, at the beginning of the period in subsector 1.A.4.a, the consumption of fossil fuels predominated, which was coupled with liquid fuels and gradually replaced primarily by natural gas. The share of biofuels in this subsector is minor. The overall decrease in fuel consumption is about 50%, which resulted in a decrease in CO_2 emissions by about 65%. The higher decrease in emissions than the fuel consumption is determined by the changes in the structure of fuels in favor of natural gas.

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

3.2.18.2 Methodological issues (CRF 1.A.4.a)

During processing data for subsector 1.A.4.a, the employed fuels also included fuels that are listed in the "Transport sector" section in the questionnaires of CzSO. The amounts of these fossil fuels are given in Tab. 3-74 in TJ.

Tab. 3-74 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**	**2017**
TJ/year	12.5	37.3	37.3	12.7	35.2	33.7	36.5	38.1

According to the communication of CzSO, this fuel is used for heating the buildings of the Czech Railways state-owned company and thus its combustion was classified in subsector 1.A.4.a. This corresponds to the consumption of bituminous coal, lignite and coke-oven coke of 1-2 kt per year. The amounts of these fuels have virtually no effect on the total balance of 1.A.4.a.

No other sector-specific methodological aspects are addressed; the general aspects are described in chapter 3.2.4.

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

See chapter 3.2.5.

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

See chapter 3.2.6.

3.2.18.5 Category-specific recalculations (CRF 1.A.4.a)

Quite extensive recalculations were carried out in this submission based on uploads of activity data for Solid fuels (2014-2016) and Liquid fuels (1990-1998).

Tab. 3-75 Changes after recalculation in 1.A.4.a for Solid Fuels

Fuel consumption		2014	2015	2016
Submission 2018-2016	TJ	1220.19	1080.44	1036.46
Submission 2019-2017	TJ	1209.20	1072.74	1381.69
Difference	TJ	-10.99	-7.70	345.23
	%	-0.91	-0.72	24.99
CO_2 emission		**2014**	**2015**	**2016**
Submission 2018-2016	Kt	118.82	105.25	101.68
Submission 2019-2017	Kt	117.86	104.58	133.59
Difference	Kt	-0.96	-0.67	31.91
	%	-0.81	-0.64	23.89
CH_4 emission		**2014**	**2015**	**2016**
Submission 2018-2016	Kt	0.01220	0.01080	0.01036
Submission 2019-2017	Kt	0.01209	0.01073	0.01382
Difference	Kt	-0.00011	-0.00008	0.00345
	%	-0.91	-0.72	24.99
N_2O emission		**2014**	**2015**	**2016**
Submission 2018-2016	Kt	0.00183	0.00162	0.00155
Submission 2019-2017	Kt	0.00181	0.00161	0.00207
Difference	Kt	-0.00002	-0.00001	0.00052
	%	-0.91	-0.72	24.99

Tab. 3-76 Changes after recalculation in 1.A.4.a for Liquid Fuels

Fuel consumption		1990	1991	1992	1993	1994	1995	1996	1997	1998
Submission 2018-2016	TJ	27443.32	21578.45	11855.66	13176.14	7170.20	4063.87	5073.70	4052.39	4614.70
Submission 2019-2017	TJ	25871.72	20049.65	10530.10	12002.62	5673.90	1895.76	3824.54	3498.29	4106.96
Difference	TJ	-1571.60	-1528.80	-1325.56	-1173.53	-1496.30	-2168.12	-1249.16	-554.10	-507.74
	%	-6.07	-7.63	-12.59	-9.78	-26.37	-114.37	-32.66	-15.84	-12.36
CO_2 emission		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	2116.19	1656.60	907.12	1011.68	547.05	304.59	379.50	303.49	346.02
Submission 2019-2017	kt	1999.74	1543.32	808.89	924.72	436.18	143.93	286.94	262.43	308.39

Difference	kt	-116.46	-113.28	-98.22	-86.96	-110.88	-160.66	-92.56	-41.06	-37.62
	%	-5.82	-7.34	-12.14	-9.40	-25.42	-111.62	-32.26	-15.65	-12.20
CH_4 emission		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.27443	0.21578	0.11856	0.13176	0.07170	0.04064	0.05074	0.04052	0.04615
Submission 2019-2017	kt	0.25872	0.20050	0.10530	0.12003	0.05674	0.01896	0.03825	0.03498	0.04107
Difference	kt	-0.01572	-0.01529	-0.01326	-0.01174	-0.01496	-0.02168	-0.01249	-0.00554	-0.00508
	%	-6.07	-7.63	-12.59	-9.78	-26.37	-114.37	-32.66	-15.84	-12.36
N_2O emission		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Submission 2018-2016	kt	0.01647	0.01295	0.00711	0.00791	0.00430	0.00244	0.00304	0.00243	0.00277
Submission 2019-2017	kt	0.01552	0.01203	0.00632	0.00720	0.00340	0.00114	0.00229	0.00210	0.00246
Difference	kt	-0.00094	-0.00092	-0.00080	-0.00070	-0.00090	-0.00130	-0.00075	-0.00033	-0.00030
	%	-6.07	-7.63	-12.59	-9.78	-26.37	-114.37	-32.66	-15.84	-12.36

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

Currently no improvements are planned in this category.

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

3.2.19.1 Category description (CRF 1.A.4.b)

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

1.A.4.b, 2017								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
LPG	1 975.66	65.86*)	1	130.11	5	0.00988	0.1	0.00020
Other Bituminous Coal	9 322.40	93.98*)	0.9707*)	850.44	300	2.79672	1.5	0.01398
Brown Coal + Lignite	28 760.17	96.28*)	0.9846*)	2726.39	300	8.62805	1.5	0.04314
Coke	887.38	107.00	1	94.95	300	0.26621	1.5	0.00133
Brown Coal Briquets	3 067.81	99.26*)	0.9846*)	294.51	300	0.92034	1.5	0.00460
Natural Gas	84 117.32	55.46*)	1	4665.26	5	0.42059	0.1	0.00841
Wood/Wood Waste	75 817.91	112.00	1	8491.61	300	22.74537	4	0.30327
Charcoal	396.31	112.00	1	44.39	200	0.07926	1	0.00040
Total year 2017	204 344.95			8 761.65		13.04179		0.07167
Total year 2016	199 641.80			8 457.54		12.18162		0.06733
Index 2017/2016	1.02			1.03		1.07		1.06
Total year 1990	251 958.35			23 219.87		60.61958		0.41486
Index 2017/1990	0.81			0.38		0.22		0.17

*) *Country specific data*

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

2017							
Structure of Fuels	**Source for 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 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

		2017					
Structure of Fuels	**Source for Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Coke	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Brown Coal Briquets	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Wood/Wood Waste	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Charcoal	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

Fuel consumption in households is determined on the basis of the results of the statistical study "Energy consumption in households", published in 1997 and 2004 by the Czech Statistical Office according to the PHARE/EUROSTAT method.

In the CzSO Questionnaire (CzSO, 2018), the consumption of the individual kinds of fuels in this sector is reported in 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 2017. 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 Fig. 3-34.

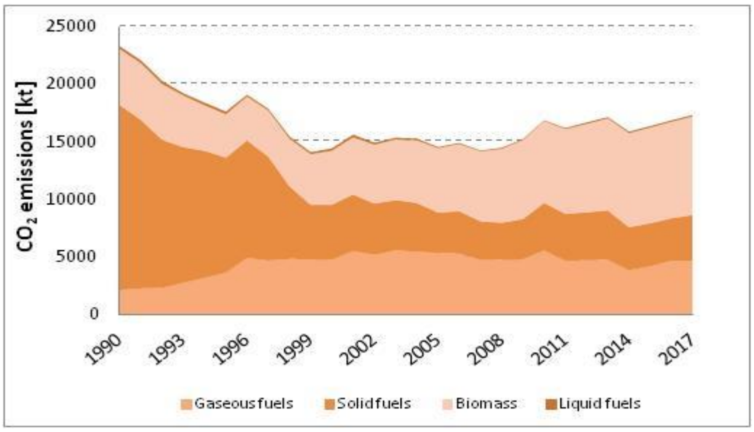


Fig. 3-34 Development of CO_2 emissions in source category 1.A.4.b

The graph shows that, at the beginning of the period in subsector 1.A.4.b, the consumption of fossil fuels predominated, but these have been gradually substituted primarily by natural gas and 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 can be attributed to fluctuations in the average annual temperatures. A slight decrease can be observed in fuel consumption throughout the Residential sector, which was affected by the replacement of old boilers by more modern ones with higher efficiency and, most importantly, insulation of buildings, which is subsidized under the "Green Savings" national programs. The increasing share of biomass has a favorable effect on reducing CO_2 emissions, which are included in total greenhouse gas emissions. While total fuel consumption has generally declined only slightly in this subsector (by about 20%), CO_2 emissions from the combustion of fossil fuels decreased by about 50%.

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

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

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

See chapter 3.2.5.

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

See chapter 3.2.6.

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

We did not carry out any recalculations in this submission.

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

Currently there no improvements are planned in this category.

3.2.20 Other Sectors – Agriculture/Forestry/Fishing (1.A.4.c)

The subsector is further divided into:

- Stationary sources – 1.A.4.c.i
- Off-road Vehicles and Other Machinery – 1.A.4.c.ii

The structure of the fuels throughout subsector 1.A.4.c, their consumption, the employed emission factors and emissions of individual greenhouse gases are shown in the following outline.

1.A.4.c, 2017								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O/TJ]**	**[kt]**
LPG	183.78	65.86*)	1	12.10	5	0.00092	0.1	0.00002
Gasoline	256.53	69.30	1	17.78	6.90	0.00177	0.6	0.00494
Diesel Oil	13 416.36	74.10	1	994.15	5.43	0.07290	0.6	0.06627
Fuel Oil - Low Sulphur	118.50	77.40	1	9.17	10	0.00119	0.6	0.00007
Other Bituminous Coal	26.49	94.09*)	0.9707*)	2.42	300	0.00795	1.5	0.00004
Brown Coal + Lignite	230.01	98.67*)	0.9846*)	22.35	300	0.06900	1.5	0.00035
Coke	7.45	107.00	1	0.80	300	0.00223	1.5	0.00001
Natural Gas	2 745.94	55.46*)	1	152.29	5	0.01373	0.1	0.00027
Wood/Wood Waste	395.25	112.00	1	44.27	300	0.11857	4	0.00158
Gaseous Biomass	5 461.39	54.60	1	298.19	5	0.02731	0.1	0.00055
Total year 2017	**22 841.70**			**1 210.98**		**0.16968**		**0.07195**
Total year 2016	23 150.19			1 217.29		0.19318		0.07314
Index 2017/2016	0.99			0.99		0.88		0.98
Total year 1990	46 022.87			3 671.66		5.40541		0.08166
Index 2017/1990	0.50			0.33		0.03		0.88

*) *Country specific data*

The large emissions of CH_4 in 1990 are mainly due to the large consumption of other bituminous coal and lignite, which have large emission factors (300 kg CH_4/TJ) compared to other fuels, at the start of this period. There was a significant decrease in the consumption of solid fossil fuels at the end of the period.

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

2017							
Structure of Fuels	**Source for**	**Emission factors**			**Method used**		
	Activity data	**CO_2**	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Gasoline	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Diesel Oil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - Low Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

Other Bituminous Coal	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Coke	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Wood/Wood Waste	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Gaseous Biomass	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

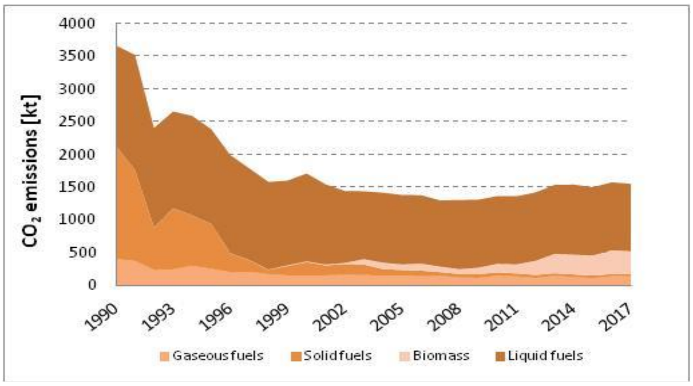


Fig. 3-35 Development of CO_2 emissions in source category 1.A.4.c

This subcategory includes both combustion by stationary sources for heating buildings and emissions from animal breeding and plant cultivation halls and other operational facilities. These are areas in the agriculture (crop and livestock production), forest and fishing sectors. In rural areas emissions are produced by very energy-intensive operations, such as heating greenhouses, drying grain and hops.

Unlike the previous submission, this section also includes off-road means of transport and machinery. In accordance with the IPCC 2006 Gl., data on fuel consumption and emission data are divided into two subcategories, as mentioned above. In rural areas this corresponds mainly to fuel consumption for land cultivation and harvesting mechanism and mainly mining mechanisms in forestry. Fishing is of minor importance in the Czech Republic and consists almost exclusively of fish farming.

In the CzSO Questionnaire (CzSO, 2018), the consumption of the individual kinds of fuels in this sector is reported in the capture Industry Sector under the item:

- Agriculture/Forestry
- Fishing

Fuels are distributed according to their nature – motor fuels are allocated to subcategory 1.A.4.c.ii and all other fuels -to subcategory 1.A.4.c.i. This division is subsequently agreed annually with the CzSO through mutual consultation.

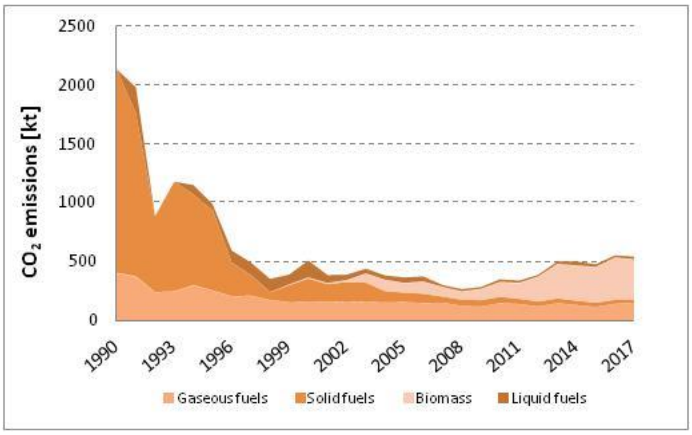


Fig. 3-36 Development of CO_2 emissions in source category 1.A.4.c.i

This includes the fuels of the 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 equaled 9% in 2017. This contributed 1% to CO_2 emissions in the whole Energy sector.

Development of fuel consumption and the corresponding CO_2 emissions throughout subcategory 1.A.4.c are depicted in Fig. 3-36.

It is evident from the graph Fig. 3-36 that the greatest consumption in the entire subsector and in the overall period is that of liquid fuel (as will be shown later, this mainly consists of propellant fuel). At the beginning of the period there was a significant share of fossil fuels, but their consumption during the entire period declined due to replacement of inefficient means of heating buildings and processing plants. Biofuels were used increasingly towards the end of the period.

Fig. 3-37 show CO_2 emissions from only stationary sources.

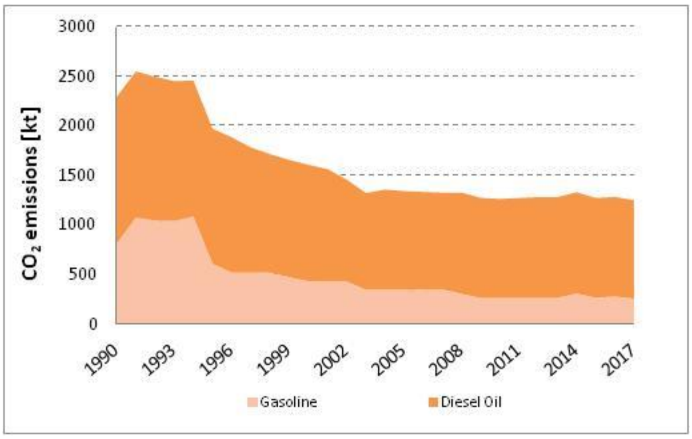


Fig. 3-37 Development of CO_2 emissions in source category 1.A.4.c.ii

Amongst stationary sources, the consumption of fossil solid and liquid fuels decreased decisively. Natural gas consumption was virtually stable throughout the period and, towards the end of the period, the use of biofuels increased, especially that of biogas, produced in biogas stations, on individual agricultural farms.

Mobile sources and other mechanisms are largely responsible for the consumption of diesel fuels, while automobile gasoline is of minor importance and other fuels are virtually absent. Roughly in the first half of the period, a noticeable decrease in fuel consumption roughly in the first half of the period occurred, caused by the higher technical level of engines and especially by a decline in demand for agricultural products in all the subsectors.

3.2.20.1 Methodological issues (CRF 1.A.4.c)

The basic requirement for processing fuel consumption from mobile sources is their division among subsectors 1.A.3 Transport, 1.A.4.c.ii Off-road vehicles and other machinery and 1.A.5 Other. This distribution is performed in coordination with CDV so that no fuel is included twice in the balance, and no fuel is omitted. Therefore, the following distribution is performed:

Motor fuels, which are consumed in subsector 1.A.4.c.ii are used only for off-road vehicles and other mechanisms.

Motor fuels, which are consumed in subsector 1.A.5 are allocated to 1.A.3. This is the fuel consumption by military (transport on and off road, kerosene jet fuel consumption for air transport), and consumption in the areas of construction, extraction of fuels and minerals, industry (only aerial transport) and also includes the consumption of motor fuels for mobile sources in the public sector (ambulance, fire brigade, etc.), both on and off road, as well as the consumption of aviation fuels.

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

See chapter 3.2.5.

3.2.20.3 Category-specific QA/QC and verification (CRF 1.A.4.c)

QA/QC procedures in this subsector must be coordinated with CDV. Before each submission, KONEKO, as the company responsible for processing all of sector 1.A, calculates the distribution of motor fuels among 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 are made as to whether the predetermined distribution of fuel was properly employed and, if necessary, corrections are proposed to avoid double counting of fuels, or their omission.

Other QA/QC and verification - see section 3.2.6

3.2.20.4 *Category-specific recalculations (CRF 1.A.4.c)*

Quite extensive recalculations were carried out in this submission because of uploads of activity data in 1.A.4.c.i Solid fuels (2011-2016) and 1.A.4.c.ii for Liquid fuels (1990-1997).

Tab. 3-77 Changes after recalculation in 1.A.4.c.i for Solid Fuels

Fuel consumption		2011	2012	2013	2014	2015	2016
Submission 2018-2016	TJ	464.56	453.64	417.47	393.40	381.66	305.92
Submission 2019-2017	TJ	461.93	448.96	412.55	388.62	377.59	343.60
Difference	TJ	-2.63	-4.68	-4.91	-4.78	-4.07	37.67
	%	-0.57	-1.04	-1.19	-1.23	-1.08	10.96
CO_2 emission		2011	2012	2013	2014	2015	2016
Submission 2018-2016	kt	44.89	43.80	40.21	37.97	36.81	29.65
Submission 2019-2017	kt	44.66	43.39	39.78	37.55	36.45	33.23
Difference	kt	-0.23	-0.41	-0.43	-0.42	-0.35	3.58
	%	-0.51	-0.94	-1.08	-1.11	-0.97	10.76
CH_4 emission		2011	2012	2013	2014	2015	2016
Submission 2018-2016	kt	0.13937	0.13609	0.12524	0.11802	0.11450	0.09178
Submission 2019-2017	kt	0.13858	0.13469	0.12377	0.11659	0.11328	0.10308
Difference	kt	-0.00079	-0.00140	-0.00147	-0.00143	-0.00122	0.01130
	%	-0.57	-1.04	-1.19	-1.23	-1.08	10.96
N_2O emission		2011	2012	2013	2014	2015	2016
Submission 2018-2016	kt	0.00070	0.00068	0.00063	0.00059	0.00057	0.00046
Submission 2019-2017	kt	0.00069	0.00067	0.00062	0.00058	0.00057	0.00052
Difference	kt	0.00000	-0.00001	-0.00001	-0.00001	-0.00001	0.00006
	%	-0.57	-1.04	-1.19	-1.23	-1.08	10.96

Tab. 3-78 Changes after recalculation in 1.A.4.c.ii for Liquid Fuels – Diesel Oil

Fuel consumption		1990	1991	1992	1993	1994	1995	1996	1997
Submission 2018-2016	TJ	21568.00	18411.00	17043.00	16438.00	16510.00	15500.00	14890.00	15545.00
Submission 2019-2017	TJ	19967.95	19834.89	19545.40	18998.39	18452.38	18362.59	18414.62	17020.80
Difference	TJ	-1600.05	1423.89	2502.40	2560.39	1942.38	2862.59	3524.62	1475.80
	%	-8.01	7.18	12.80	13.48	10.53	15.59	19.14	8.67
CO_2 emission		1990	1991	1992	1993	1994	1995	1996	1997
Submission 2018-2016	kt	1598.19	1364.26	1262.89	1218.06	1223.39	1148.55	1103.35	1151.88
Submission 2019-2017	kt	1479.63	1469.77	1448.31	1407.78	1367.32	1360.67	1364.52	1261.24
Difference	kt	-118.56	105.51	185.43	189.73	143.93	212.12	261.17	109.36
	%	-8.01	7.18	12.80	13.48	10.53	15.59	19.14	8.67
CH_4 emission		1990	1991	1992	1993	1994	1995	1996	1997
Submission 2018-2016	kt	0.11229	0.09211	0.08527	0.08369	0.08255	0.07752	0.07445	0.07773
Submission 2019-2017	kt	0.10396	0.09923	0.09779	0.09672	0.09226	0.09183	0.09207	0.08510
Difference	kt	-0.00833	0.00712	0.01252	0.01303	0.00971	0.01432	0.01762	0.00738
	%	-8.01	7.18	12.80	13.48	10.53	15.59	19.14	8.67
N_2O emission		1990	1991	1992	1993	1994	1995	1996	1997
Submission 2018-2016	kt	0.05277	0.04502	0.04215	0.04193	0.04395	0.04215	0.04208	0.04581
Submission 2019-2017	kt	0.04885	0.04850	0.04833	0.04846	0.04912	0.04994	0.05204	0.05016
Difference	kt	-0.00391	0.00348	0.00619	0.00653	0.00517	0.00778	0.00996	0.00435
	%	-8.01	7.18	12.80	13.48	10.53	15.59	19.14	8.67

3.2.20.5 *Improvements (CRF 1.A.4.c)*

Currently there no improvements are planned in this category.

3.2.21 Other (1.A.5)

This subsector is further divided into:

- Stationary sources – 1.A.5.a (Unspecified stationary; Emissions from fuel combustion in stationary sources that are not specified elsewhere)
- Mobile sources – 1.A.5.b (Unspecified mobile; Mobile Emissions from vehicles and other machinery, marine and aviation (not included in 1.A.4.c.ii or elsewhere). This includes emissions from fuel delivered for aviation and water-borne navigation to the country's military as well as fuel delivered within this country but used by the military forces of other countries that are not engaged in.

The structure of fuels throughout subsector 1.A.5., their consumption, the employed emission factors and emissions of the individual greenhouse gases are shown in the following outline.

1.A.5.b, 2017								
Structure of Fuels	**Activity**	**CO_2**			**CH_4**		**N_2O**	
	data	**EF**	**OxF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
	[TJ]	**[t CO_2/TJ]**		**[kt]**	**[kg CH_4/TJ]**	**[kt]**	**[kg N_2O TJ]**	**[kt]**
Gasoline	300.93	69.30	1	20.85	6.90*)	0.00208	19.27*)	0.00580
Kerosene Jet Fuel	2 286.56	71.50	1	163.49	14.38*)	0.03289	10.26*)	0.02346
Diesel Oil	3 578.33	74.10	1	265.15	5.43*)	0.01944	4.94*)	0.01768
Total year 2017	**6 165.82**			**449.50**		**0.05441**		**0.04693**
Total year 2016	5 394.73			393.95		0.04441		0.03999
Index 2017/2016	1.14			1.14		1.23		1.17
Total year 1990	n.a			n.a		n.a		n.a
Index 2017/1990	-			-		-		-

*) *Country specific data*

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

2017							
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 the stationary sources were reported in subsectors 1.A.1., 1.A.2. and 1.A.4., only mobile sources that were not discussed in subsectors 1.A.3. and 1.A.4.c will be reported in this subsector (starting with this submission).

In accordance with the IPCC 2006 Gl., subsector 1.A.5.b. is subdivided into:

- 1.A.5.b.i – Mobile (aviation component)
- 1.A.5.b.iii – Mobile (other)

Subsector 1.A.5.b.i reports fuel consumption and the corresponding emissions of greenhouse gases from aviation, except for public air transport. This correponds primarily to the consumption of aviation fuels by the military, state institutions (aerial vehicles of the Integrated Rescue System) or private air transport.

Subsector 1.A.5.b.ii is not relevant for the submission of the Czech Republic, especially as it relates to maritime transport which is not operated in the Czech Republic.

Subsector 1.A.5.b.iii encompassed reporting for all the remaining fuels (and greenhouse gases) that were not reported elsewhere; this corresponds mainly to the consumption of automotive fuels for ground vehicles in the military and in governmental institutions (Integrated Rescue System). It also includes consumption in the areas of construction, mining of fuels and minerals, industry (only aerial transport).

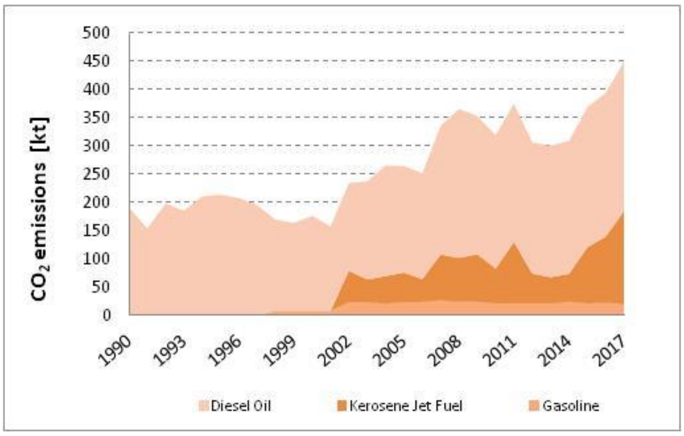


Fig. 3-38 Development of CO_2 emissions in source category 1.A.5.b.

The CO_2 emissions from subsector 1.A.5 in 2017 contributed 0.5% to total CO_2 emissions in all of Energy sector 1.A.Development of fuel consumption and the corresponding CO_2 emissions throughout subcategory 1.A.5.b. are depicted in Fig. 3-38. Data for Kerosene Jet Fuel and Gasoline consumption before 1998 are not available in sufficient detail. The shares of fuels and the corresponding emissions before 1998 are reported in sector 1.A.3. Transport.

The graph in Fig. 3-38 shows that a decisive proportion corresponds to diesel oil, while another significant share corresponds to kerosene jet fuel (mainly military), where of gasoline makes a minor contribution.

3.2.21.1 Methodological issues (CRF 1.A.5.b)

The basic requirement for processing fuel consumption by mobile sources is their division between subsectors 1.A.3 Transport and 1.A.4.c.ii and 1.A.5. This distribution is carried out in coordination with CDV to ensure that no fuel is included twice in the balance 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 1990. This corresponds to the consumption of motor fuels for mobile sources by the military and the public sector (ambulance, fire brigade, etc.), both on and off road.

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

See chapter 3.2.5.

3.2.21.3 Category-specific QA/QC and verification (CRF 1.A.5.b)

The QA/QC procedures in this subsector must be coordinated with CDV. KONEKO, as the company responsible for processing all of 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 part of the submission, it checks whether the predetermined distribution of fuels was properly employed and, if necessary, proposes corrections to avoid double counting of fuels or their omission.

Other QA/QC and verification - see section 3.2.6.

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

Improvement

Thanks to extensive updates of consumption of motor fuels, we obtained the activity data for Diesel Oil for 1990-1997, which missing in previous submissions.

Tab. 3-79 Changes after recalculation in 1.A.5.b

Fuel consumption		1990	1991	1992	1993	1994	1995	1996	1997
Submission 2018-2016	TJ	NO	NO	NO	NO	NO	NO	NO	NO
Submission 2019-2017	TJ	2591.59	2081.18	2676.87	2507.62	2848.64	2890.41	2806.85	2638.22
Difference	TJ	2591.59	2081.18	2676.87	2507.62	2848.64	2890.41	2806.85	2638.22
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CO_2 emission		1990	1991	1992	1993	1994	1995	1996	1997
Submission 2018-2016	kt	NO	NO	NO	NO	NO	NO	NO	NO
Submission 2019-2017	kt	192.04	154.22	198.36	185.81	211.08	214.18	207.99	195.49
Difference	kt	192.04	154.22	198.36	185.81	211.08	214.18	207.99	195.49
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CH_4 emission		1990	1991	1992	1993	1994	1995	1996	1997
Submission 2018-2016	kt	NO	NO	NO	NO	NO	NO	NO	NO
Submission 2019-2017	kt	0.01349	0.01041	0.01339	0.01277	0.01424	0.01445	0.01403	0.01319
Difference	kt	0.01349	0.01041	0.01339	0.01277	0.01424	0.01445	0.01403	0.01319
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
N_2O emission		1990	1991	1992	1993	1994	1995	1996	1997
Submission 2018-2016	kt	NO	NO	NO	NO	NO	NO	NO	NO
Submission 2019-2017	kt	0.00634	0.00509	0.00662	0.00640	0.00758	0.00786	0.00793	0.00777
Difference	kt	0.00634	0.00509	0.00662	0.00640	0.00758	0.00786	0.00793	0.00777
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3.2.21.5 Category-specific planned improvements (CRF 1.A.5.b)

Currently no improvements are planned in this category.

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

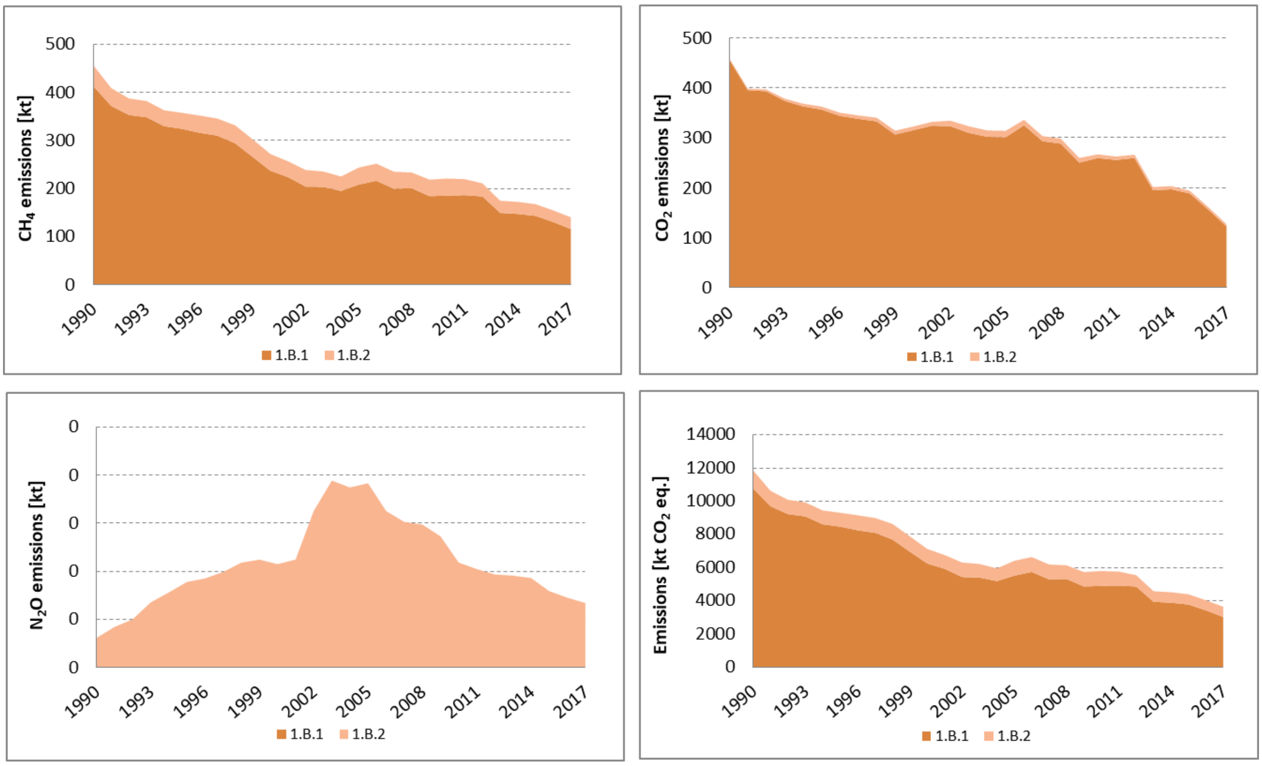


Fig. 3-39 GHG emissions trends from Fugitive emissions from fuels [kt/year]

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

Especially 1.B.1.a Coal Mining and Handling was evaluated as a key category in 1.B Fugitive Emissions from the Fuels category (Tab. 3-1). Category 1.B.2 was also identified as a key category in 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.

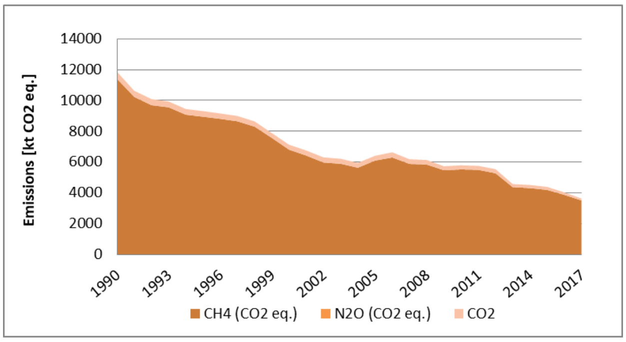


Fig. 3-40 The share of individual GHG emissions from the total emissions, expressed as CO_2 eq. (1.B.)

Development of individual emissions of greenhouse gases in sector 1.B is shown on the graphs in Fig. 3-39.

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 represent an average of 15% of the total emissions. CO_2 emissions are formed primarily in subcategory 1.B.1 - Solid fuels (the share in subcategory 1.B.2 is of low importance – about 2% of total CO_2 emissions). N_2O emissions originate only from subsector 1.B.2.a - Oil and are insignificant The importance of individual greenhouse gases from the total emissions, expressed as CO_2 equivalent, is visible from Fig. 3-40.

It is also clear from the graphs in Fig. 3-39 and Fig. 3-40 that a significant decrease in GHG emissions occurred across category 1.B during this period 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 2017, the decrease of total GHG emissions is 72% compared to the 1990 level.

3.3.1 Solid Fuels (CRF 1.B.1)

The category is further divided into the following subcategories according to IPCC 2006 Gl.:

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

3.3.1.1 Category description (CRF 1.B.1)

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

1.B.1, 2017								
Structure of sector		Activity data [kt]	CH_4 EF [kg CH_4/t]	CH_4 Emission [kt]	CO_2 EF [t CO_2/t]	CO_2 Emission [kt]	N_2O EF [kg N_2O/t]	N_2O Emission [kt]
1.B.1.a	Coal mining/handl.	44 712		60.54	22.7	122.45		NO
1.B.1.a.1	Underground mines	5 400		60.54	22.7	122.45		NA
1.B.1.a.1.i	Mining		8.750	47.25	22.7	122.45	NA	NA
1.B.1.a.1.ii	Post-mining activ.		1.675	9.05	NA	NA	NA	NA
1.B.1.a.1.iii	Abandoned mines		+)	4.24		NA	NA	NA
1.B.1.a.2	Surface mines	39 306		55.30		NA		NA
1.B.1.a.2.i	Mining		1.340	52.67	NA	NA	NA	NA
1.B.1.a.2.ii	Post-mining activ.		0.067	2.63	NA	NA	NA	NA
1.B.1.b	Solid fuel transformation	6	30	0.18	NO	NE	NA	NA
Total year 2017				116.02		122.45		NA
Total year 2016				130.57		156.46		NA
Index 2017/2016				0.89		0.78		NA
Total year 1990				412.93		456.24		NA
Index 2017/1990				0.28		0.27		NA

+) Methodology and emission factors are explained in 3.3.1.2.

The origin of the data, the employed emission factors used and the method of calculating the level of emissions for each gas are shown in detail in the following outline.

2017			
Structure of sector	Source of	Emission factors	Method used

		Activity data	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.

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 category 1.B.1 Solid Fuels 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 the emission 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.

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

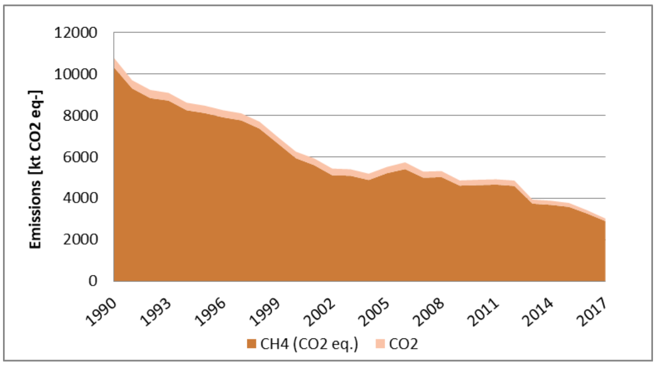


Fig. 3-41 The trend of GHG emissions and the relationship between emissions of CO_2 and CH_4 (1.B.1)

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

The graph in Fig. 3-41 shows the time trend of total emissions of greenhouse gases in all of subsector 1.B.1. The chart also demonstrates the share of CO_2 emissions in the total GHG emissions, which corresponds on an average of about 5%.

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. 3-42.

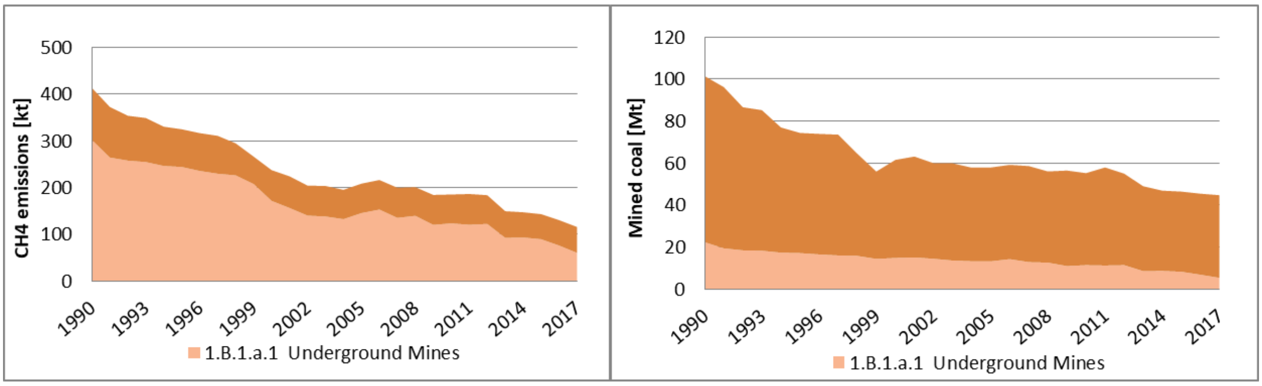


Fig. 3-42 The ratio of methane emissions from Underground mines and Surface mines and the corresponding development of mining of Hard Coal and Lignite (1.B.1)

The 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 12% of the total volume, is accompanied by considerably more significant CH_4 emissions than the 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 coal mining area. At the end of 2016, part of the Ostrava-Karvinná coal mining area was closed, leading to a decreased of amount of mined Hard Coal and emissions. 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 Northern Bohemia. Emissions from this mine are reported together with the 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 IEA/EUROSTAT (the CZECH_COAL.xls report). Data from the miners yearbooks issued by the State Mining Administration and the Employers' Association of Mining and Oil Industries are used for control purposes.

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 the 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. Mine ventilation must be regulated according to the amounts of gas released to keep its concentration at a safe level. At the end of the 1950s mine-gas removal systems were introduced when opening new mines and mining levels in the Ostrava – Karviná coal-mining area, which permitted separate exhausting of some of the methane released into the mixture of the mine air in the mining activity. 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 processes 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). Of methane emissions, only abandoned mines in OKR are relevant. Coal mining in the Kladno Basin was terminated in 2002. Methane was absent in these mines, so the methane emissions estimate is based only on OKR mines.

Coal has been extracted for more than two hundred years in the Ostrava-Karvina coalfield. Crucial decline of mining in this area started in 1991, but mines were also closed in the 1920s.

Ostrava mines have always been significant sources of coal seam gas and, in terms of mine safety regulations, they were categorized in terms of mines with the greatest threat of the occurrence of methane. Methane has been observed for more than 100 years and reached a peak in the 1960s, when in mining in Ostrava reached maximum levels. At that time, the amount of gas released daily exceeded 500 thousand. m^3 CH_4. The gas was discharged from the mines using ventilation with 17 air pits and mine degassing. The amount on gas released from abandoned mines today, after the destruction of almost all pits, has stabilized at around 40 thousand m^3 CH_4 per day. Based on the amount of methane that escaped in recent years and using international experience, it can be forecast that this gas will continue to be released from the underground spaces in Ostrava for a great many more years.

Some of the abandoned mines have CH_4 recovery systems. A company has been established in mining areas for mining of fire-damp in the Ostrava-Karviná area. The abandoned mines contain automatic suction devices and firedamp stations. Firedamp rises from abandoned mining pits and surface boreholes into abandoned areas. The mined firedamp is used at the mining site 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, primarily in the Northern Bohemia area. Small parts of very young Lignite mines are located in Southern Moravia.

Lignite was extracted from underground mines before surface mining began in Northern Bohemia, where a decisive amount of lignite is still mined in the Czech Republic. The abundance of methane in these mines has never been a problem. Any explosion in the mines in the past was caused by coal dust. Surface mining began in the 1950s and the underground mines were no longer in use after 1990.

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 production of briquettes are included in subcategory 1.A.2.g.

Production of charcoal

CH_4 emissions from charcoal production were estimated 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 obtained by extrapolation. The default net calorific value 30 MJ/kg (Table 1-13 in the Revised 1996 Guidelines) was used to the convert activity data to energy units. The resulting CH_4 emissions are shown in Tab. 3-46. Unfortunately, the IPCC 2006 Gl. (IPCC 2006) do not provide default emissions factors for fugitive emissions from charcoal production. Thus, the emission factor given in the Revised 1996 Guidelines (IPCC 1997) is still used. Since these emissions are very low, the national inventory team considers this approach to be justified here.

Tab. 3-80 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

1.B.1.b Solid Fuel Transformation			
	Production kt/year	Production TJ/year	CH_4 emissions kt/year
2016	6.00	180.00	0.18
2017	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 the IPCC 2006 Gl. (IPCC 2006) do not give a default emission factor for this activity.

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 1990s: the ratio between mining and the volume of methane emissions is given in Tab. 3-81, see (Takla and Nováček, 1997).

Tab. 3-81 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**	**3 375.3**	**20.2**
1990 till 1996	50.76	927.8	18.3

Only the values for 1990, 1995 and 1996 from this table were used 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 coal mining area for 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, new, revised emission factors CH_4/t mined coal were determined.

The management of OKD, a.s. (Ostrava-Karviná mines, joint share company) was contacted, since this company monitors aspects of methane production in great detail. 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. 3-82.

Tab. 3-82 Methane production from gas absorption of mines and its use

mil.m^3 CH_4 * year^{-1}					
Year	Total amount of gas	Pumped out by gas absorption	Industrial use	Venting from gas absorption into the atmosphere	Released into the atmosphere - total
2000	236.7	84.1	77.9	6.2	158.8
2001	210.7	73.9	71.1	4.0	140.8
2002	210.0	81.0	70.3	1.3	130.3
2003	200.6	74.8	72.8	2.0	127.8
2004	194.6	77.1	73.4	3.2	120.7
2005	207.7	73.9	70.3	3.6	137.4
2006	221.1	76.9	75.9	0.8	145.0
2007	194.7	71.5	71.0	0.5	123.7
2008	199.5	68.8	68.5	0.3	131.0

This data was used to calculate the emission factors and to determine the average emission factor, which is used for the period after 2000 – 2008.

The emission factors given in Tab. 3-83 are used for 2000 – 2008. After 2008, the emission factor calculated as the average value from the values for 2000 – 2008 is used, i.e. 8.12 t/kt. A study to determine this emission factor was carried out in 2011.

Tab. 3-83 Calculation of emission factors from OKD mines for period 2000 onwards

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

The emission factors given inTab. 3-83 for calculation of the emission factors for OKD mines were used for 2000 – 2008. The average emission factors for the 2000 – 2008 period is used for the years after 2008: 8.12 t/kt of mined hard coal; the value for the period before 1999 is same as in the previous submission 12.3 t/kt of mined coal (Takla and Nováček, 1997).

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

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

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 specifically 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 Tab. 3-84.

Tab. 3-84 Emission factors and emissions from underground mining of hard coal

year	production OKD	emission factor	emission of CO_2
	[kt/year]	[t CO_2/kt]	[kt CO_2/year]
1990	20 059	22.75	456.24
1991	17 371	22.75	395.10
1992	17 271	22.75	392.83
1993	16 419	22.75	373.45
1994	15 942	22.75	362.60
1995	15 661	22.75	356.21
1996	15 109	22.75	343.65
1997	14 851	22.75	337.79
1998	14 620	22.75	332.53
1999	13 468	22.75	306.33
2000	13 855	22.75	315.13
2001	14 246	22.75	324.03
2002	14 200	22.75	322.98
2003	13 614	22.75	309.65
2004	13 272	22.75	301.87
2005	13 227	22.75	300.85
2006	14 280	22.75	324.80
2007	12 886	22.75	293.09
2008	12 622	22.75	288.00
2009	11 001	22.75	250.22
2010	11 435	22.68	259.30
2011	11 265	22.68	255.45
2012	11 440	22.68	259.41
2013	8 594	22.68	194.88
2014	8 680	22.68	196.83
2015	8 314	22.68	188.53
2016	6 900	22.68	156.46
2017	5 400	22.68	122.45

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. 3-85 Employed emissions factors and calculation of CH_4 emissions from underground coal mining – post mining operations in 1990 - 2017

year	production OKD [kt/year]	emission factor [t CH_4/kt]	emission of CH_4 [kt CH_4/year]
1990	22 371	1.675	37.47
1991	19 461	1.675	32.60
1992	18 481	1.675	30.96
1993	18 297	1.675	30.65
1994	17 376	1.675	29.10
1995	17 169	1.675	28.76
1996	16 532	1.675	27.69

year	production OKD [kt/year]	emission factor [t CH_4/kt]	emission of CH_4 [kt CH_4/year]
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
2017	5 400	1.675	9.05

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 IPCC 2006 Gl. methodology 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 only mines with a large amount of gas occur in the Ostrava-Karvina coalfield, the values from the High column were used for the percentage of coal mines that are gassy (2006 IPCC Guidelines for National Greenhouse Gas Inventories: Tab. 4.1.5: TIER 1 – ABANDONED UNDERGROUND MINES, DEFAULT VALUES - PERCENTAGE OF COAL MINES THAT ARE GASSY, page 4.24.), the following:

1901 – 1925: 0%
1926 – 1950: 50%
1951 – 1975: 75%
1976 – 2017: 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. 3-86.

Tab. 3-86 Emission of CH_4 on abandoned mines

year	CH_4 emission in period [kt/year]				Calculated	Use of CH_4	Total
	1926 - 1950	1951 - 1975	1976 - 2000	2001 - 2017	emission	[%]	emissions
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 emission in period [kt/year] 1926 - 1950	1951 - 1975	1976 - 2000	2001 - 2017	Calculated emission	Use of CH_4 [%]	Total emissions
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	11.63		11.63
2002	0.41	1.99	8.86	0	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	5.00	10.66
2006	0.40	1.90	7.84	0.76	10.90	7.50	10.08
2007	0.40	1.87	7.62	0.69	10.59	20.00	8.47
2008	0.40	1.85	7.44	0.64	10.33	25.00	7.75
2009	0.39	1.83	7.26	1.80	11.29	50.00	5.65
2010	0.39	1.81	7.09	1.70	10.99	60.00	4.40
2011	0.39	1.79	6.94	1.61	10.73	70.00	3.22
2012	0.38	1.77	6.79	1.53	10.48	70.00	3.15
2013	0.38	1.76	6.65	1.47	10.25	70.00	3.08
2014	0.38	1.74	6.53	1.41	10.05	70.00	3.02
2015	0.38	1.73	6.41	1.36	9.86	70.00	2.96
2016	0.37	1.71	10.31	1.75	14.13	70.00	4.24
2017	0.37	1.71	10.31	1.75	14.13	70.00	4.24

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

The total emissions, employed activity data and emission factors for proper extraction of lignite (Brown Coal) from surface mines and post-mining related adjustments are presented in Tab. 3-87.

Tab. 3-87 Employed activity data, emission factors and calculation of CH_4 emissions from surface coal mining and post-mining operations in 1990 - 2017

year	Brown Coal production [kt/year]	Emission factors for activities: mines [t CH_4/kt]	post-mines [t CH_4/kt]	Emission of CH_4 [kt CH_4/year]
1990	78 983	1.34	0.067	111.13
1991	76 680	1.34	0.067	107.89
1992	68 084	1.34	0.067	95.79
1993	66 884	1.34	0.067	94.11
1994	59 568	1.34	0.067	83.81
1995	57 163	1.34	0.067	80.43
1996	57 356	1.34	0.067	80.70
1997	57 446	1.34	0.067	80.83
1998	48 619	1.34	0.067	68.41
1999	41 524	1.34	0.067	58.42
2000	46 655	1.34	0.067	65.64
2001	47 960	1.34	0.067	67.48
2002	45 480	1.34	0.067	63.99
2003	46 240	1.34	0.067	65.06
2004	44 498	1.34	0.067	62.61
2005	44 619	1.34	0.067	62.78
2006	44 849	1.34	0.067	63.10
2007	45 664	1.34	0.067	64.25
2008	43 362	1.34	0.067	61.01
2009	45 416	1.34	0.067	63.90
2010	43 774	1.34	0.067	61.59
2011	46 639	1.34	0.067	65.62
2012	43 533	1.34	0.067	61.25
2013	40 385	1.34	0.067	56.82
2014	38 177	1.34	0.067	53.72

year	Brown Coal production [kt/year]	Emission factors for activities mines [t CH_4/kt]	post-mines [t CH_4/kt]	Emission of CH_4 [kt CH_4/year]
2015	38 105	1.34	0.067	53.61
2016	38 528	1.34	0.067	54.21
2017	39 306	1.34	0.067	55.30

Determination of the activity data and emission factors for mining and post-mining treatment are given in the description of the individual activities at 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, 2018) were employed to determine the activity data for the 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 the level of 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 the activity data to energy units. Unfortunately the IPCC 2006 Gl. (IPCC 2006) do not provide default emission factors for fugitive emissions from charcoal production. Thus, the emission factor provided in the Revised 1996 Guidelines (IPCC 1997) is still used. Since these emissions are very low, the team considers this approach to be acceptable here.

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 2017. 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. 3-88.

Tab. 3-88 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

In conformance with the requirements of the QSE handbook and its associated applicable documents, general quality control and source-specific quality control (Tier 1 and Tier 2) were performed to the full extent.

QC activities at the level of Tier 1 were performed by the sector compiler according to the QA/QC plan. 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 the Tier I level for the calculation of CH_4 emissions from abandoned mines and the performance of our own calculations were checked. The calculation procedure was consulted with an independent expert from VSB-Technical University of Ostrava. It was concluded that the input data and the method of calculation are in accordance with the methodology.

It was checked 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 is archived at the coordination workplace. The protocols on the performed QA/QC procedures are also stored.

3.3.1.5 Category-specific recalculations

No recalculations were performed in this submission.

3.3.1.6 Category-specific planned improvements

Given that the aspect of emissions from abandoned mines was included in the same time as the transition to the new IPCC 2006 Gl. methodology, the Tier 1 approach was used. Planned improvements assume a change to a higher level, at least Tier II. In terms of the planned improvements, cooperation was established with a specialist on the aspect of leakage of methane from abandoned mines in the Ostrava-Karvina coalfield.

No improvements in the other sub-sectors are planned at the present.

3.3.2 Oil and Natural Gas (CRF 1.B.2)

The category is divided according to IPCC 2006 Gl. and CRF Reporter into subcategories:

- 1.B.2.a Oil
    - 1.B.2.a.1 Exploration
    - 1.B.2.a.2 Production
    - 1.B.2.a.3 Transport
    - 1.B.2.a.4 Refining/Storage
    - 1.B.2.a.5 Distribution of Oil Products
    - 1.B.2.a.6 Other
- 1.B.2.b Natural Gas
    - 1.B.2.b.1 Exploration
    - 1.B.2.b.2 Production
    - 1.B.2.b.3 Processing
    - 1.B.2.b.4 Transmission and Storage
    - 1.B.2.b.5 Distribution
    - 1.B.2.b.6 Other
- 1.B.2.c Venting and Flaring
    - 1.B.2.c.1 Venting
    - 1.B.2.c.2 Flaring

3.3.2.1 Category description (CRF 1.B.2)

The structure of the sector, the corresponding activity data, the employed emission factors and emissions of the individual greenhouse gases can be seen in the following outline.

1.B.2, 2017								
Structure of sector		**Activity**	**CH_4**		**CO_2**		**N_2O**	
		Data	**EF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
		[PJ]	**[t CH_4/PJ]**	**[kt]**	**[t CO_2/PJ]**	**[kt]**	**[kg N_2O/PJ]**	**[kt]**
1.B.2.a.1	Exploration	NE						
1.B.2.a.2	Production and Upgr.	4.58	4.746	0.022	7.576	0.0347	NA	-
1.B.2.a.3	Transport	333.43	0.146	0.049	0.013	0.0044	NA	-
1.B.2.a.4	Refining	333.43	0.134	0.195	NA	-	NA	-
1.B.2.a.5	Distrib. of Oil Prod.	333.43	NA	-	NA	-	NA	-
1.B.2.a.6	Other	NO						
1.B.2.b.1	Exploration	NE						
1.B.2.b.2	Production	7.80	38.65	0.301	+)	0.0001	NA	-
1.B.2.b.3	Processing	NO						
1.B.2.b.4	Transmission and Storage	1 192.06	4.74	6.402	+)	0.0255	NA	-
1.B.2.b.5	Distribution	136.61	119.89	16.263	+)	0.0648	NA	-
1.B.2.b.6	Other	I.E.						
1.B.2.c.1	Venting - Oil	4.58	235.3	1.078	48.7	0.2230	NA	-
1.B.2.c.2	Flaring - Oil	4.58	0.568	0.003	919.9	4.2125	0.015	0.0001
Total year 2017				**24.312**		**4.565**		**0.0001**
Total year 2016				24.212		4.936		0.0001
Index 2017/2016				1.00		0.92		0.92
Total year 1990				43.196		2.202		0.00003
Index 2017/1990				0.58		2.07		2.23

+) As emission factor is used the average annual CO_2 content in natural gas

The origin of the data, the employed emission factors and the method of calculating the level of emissions for each gas are shown in detail in the following outline.

2017								
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.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

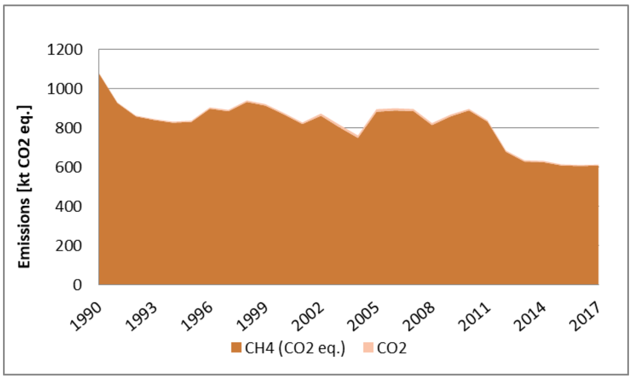


Fig. 3-43 The trend of GHG emissions and the relationship between CO_2 and CH_4 emissions (1.B.2)

Approximately 93% of the emissions in the Czech Republic are formed in the gas industry in extraction, storage, transport and distribution of Natural Gas and in its final use. Crude Oil extraction and refining processes are much lessi important.

Determination of methane emissions from the processes of refining of Crude Oil is based on the recommended (default) emission factors according to the IPCC 2006 Gl. (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. 3-43 gives an overview of the trend in emissions in this category in the time series since 1990.

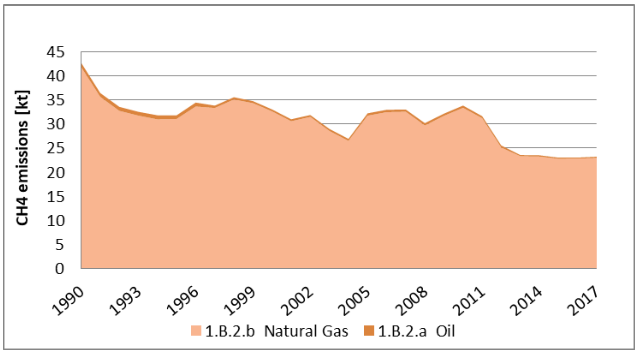


Fig. 3-44 The ratio of methane emissions from subsector Oil (1.B.2.a) and Natural Gas (1.B.2.b)

The graph in Fig. 3-43 shows that the fraction of total CO_2 emissions in 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 in Fig. 3-44.

As shown on Fig. 3-44 the emissions, produced in the gas industry are therefore crucial for the amount of CH_4 emissions in sector 1.B.2. Oil and Natural Gas.

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

In the Oil subcategory 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% of the total (from 0.7 to 4.8%). The time profile of domestic production and imports of crude oil in the Czech Republic is shown in Fig. 3-45.

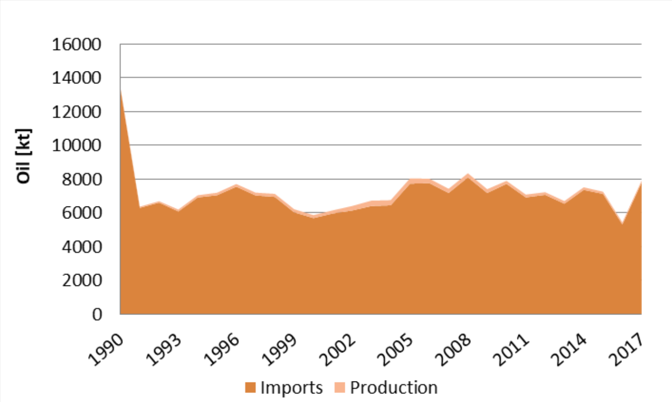


Fig. 3-45 Crude Oil production and import in the CR in 1990 – 2017

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, since the activity data are not available. Exploration is not regularly carried out in the Czech Republic. The statement of MND a.s. (the only company with a license for exploration in the Czech Republic) is that they did not perform any exploration in the last few years and this activity is not performed in the Czech Republic, or only completely at random.

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

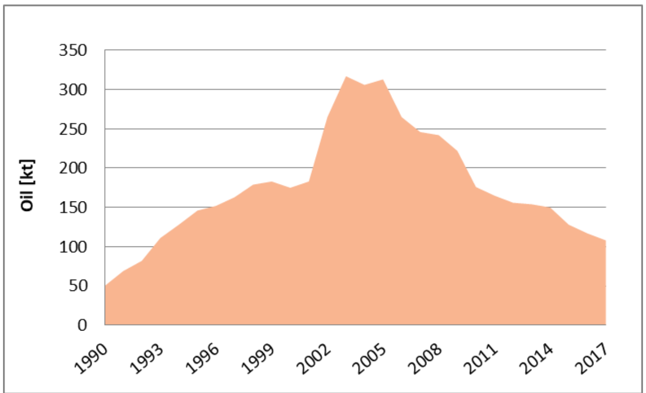


Fig. 3-46 Crude Oil production in the CR in 1990 – 2017

Crude Oil is mined in the Czech Republic in Southern Moravia. The following Fig. 3-47 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. It can be seen in Fig. 3-46 that maximum extraction was carried out in the period from 2003 to 2006. It was assumed that the decline in production continued in 2017.

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 – the Družba Oil pipeline from Russia and Ingolstat pipeline 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. 3-45.

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)

Fig. 3-47 Natural Gas production end import in the CR in 1990 – 2017

In the Natural Gas subcategory 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 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 natural gas in the Czech Republic is shown in Fig. 3-47.

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

Emissions from exploratory boreholes are not reported in this subcategory. This activity is not carried out in the Czech Republic, or only completely at 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. 3-48 gives the amount of Natural Gas production in the territory of the Czech Republic.

The development of domestic extraction is relatively stable over time. Fluctuations in the individual years are due to the technical and geological conditions of mining and market demand.

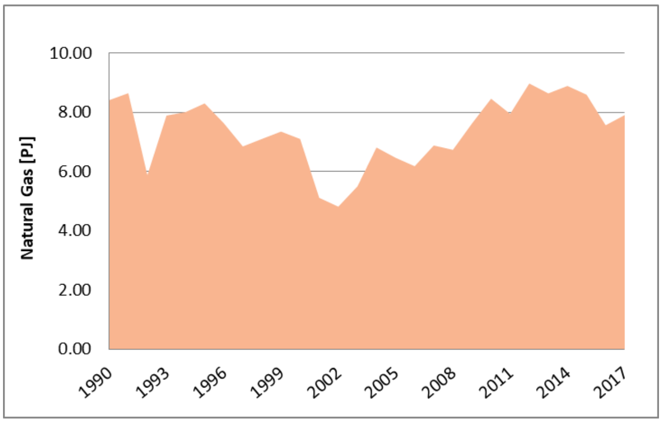


Fig. 3-48 Natural Gas production in the area of CR in 1990 – 2017

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, an estimation is made of the emissions from the transit system and high-pressure gas pipelines and, in the second step, emissions from underground gas storage facilities are estimated. A different methodological approach is used for each part of the gas system.

A transit gas pipeline with a length of 3,821 km runs through the territory of the Czech Republic, transporting Natural Gas from Russia to the countries of Western Europe. 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 centers of consumption. In 2017, the high-pressure gas pipelines had an overall length of 12,871 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 5,192 mil. m^3 in 2017.

Distribution (1.B.2.b.iii.5)

Emissions from distribution gas pipelines, with an overall length in 2017 of 65,119 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. 3-89 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. 3-89 further contains values of emissions of CH_4, CO_2 and N_2O from Flaring in domestic production of Crude Oil. It is clear from the table that this is a minor fraction of the total emissions in whole subcategory Oil and Gas (1.B.2.a).).

Tab. 3-89 Emissions of CH_4, CO_2 and N_2O from Venting and Flaring in 1990 – 2017

	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

	Venting - emissions [t/year]		Flaring - emissions [t/year]		
	CH_4	CO_2	CH_4	CO_2	N_2O
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
2017	1.08	0.22	0.003	4.21	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 2006 Gl. (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 could not 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 under 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 determining emissions in this subsector.

Activity data: number of mined boreholes – notation key NE, default emission factors have not been published for CO_2 and CH_4 – notation key NE. 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 data published in (Zanat et al., 1997). The emission factor was determined as the sum of the individual emission factors for pumping of raw Crude Oil and for storage of raw Crude Oil. These data were obtained by direct measurement. The resultant emission factor was increased by estimate of the fugitive emissions from mining boreholes (probes).

CO_2 emissions are estimated based on the default emission factor (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operations 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

No emission factor was available for estimating N_2O emissions.

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 the IPCC 2006 Gl., Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operations 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.

No emission factor was available for estimating N_2O emissions,.

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 Gl.). Emissions are calculated by multiplying the amount of Crude Oil input to refinery by the emission factor. The emission factor value employed was 585 kg/PJ.

This emission factor is based on the data from the IPCC 2006 Gl., Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operations 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 is no known process in which fugitive CO_2 or CH_4 emissions could arise 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 1990s, the distribution network was newly constructed almost entirely from welded plastics and the old pipeline was reconstructed in the same manner to a major degree. 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 remedied as soon as possible. On the whole, gas distribution in the CR meets high technical standards 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, IPCC 2006 Gl., page 4.71)

The given total emission value corresponds to about 0.3% of the total consumption of Natural Gas in the Czech Republic. The detailed calculation 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 regularly performed in the Czech Republic and thus the notation key NE 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 Natural Gas units.

Tab. 3-90 Model calculation of CH_4 emissions in the Natural Gas sector (2017)

	EF		Activity data		Losses of NG
	value	units	value	units	mil.m^3/year
production	0.2	% vol.	229	mil. m^3	0.45
high pressure pipelines	600	m^3/km.year	12 871	km	7.58
transmission pipelines *)					0.37
compressors **)					0.23
storage ***)					1.37
regulation stations	1 000	m^3/station	4 500	pcs	4.42
distribution network	300	m^3/km.year	48 428	km	14.27
final comsumption	2	m^3/consumer	2 835 714	pcs	5.59
Total					**34.28**
	Emissions in Gg (0.67 kg/m^3)				**22.97**

**) 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 during oil production were obtained by using the default EFs provided by the IPCC 2006 Gl. (see Tab. 4.2.4, pages 4.48 – 4.54). In this case, the following EFs were used:

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 the 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

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 at 75%.

Summary of uncertainty values provides Tab. 3-91.

Tab. 3-91 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) have been performed to the full extent in conformance with the requirements of the QSE handbook and its associated applicable documents.

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, 2018) 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 Tier 2 level.

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

We are planning obtain activity data for subcategory Exploration 1.B.2.a.iii.1.

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 2017, the total aggregate GHG emissions from industrial processes were 15 656.35 kt of CO_2 equivalents, which represent increase of 1% compared to the previous year. Emissions decreased by 9% 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, F-gases Use in Refrigeration and Air Conditioning, Cement Production, Petrochemical and Carbon Blak Production, Ammonia Production and Lime Production can be considered to be key categories (KC) according to IPCC 2006 Gl. (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 2017 and lists type of key category analysis for key categories.

Tab. 4-1 Overview of key categories in sector Industrial Processes (2017)

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	yes	yes	yes	yes	5.07	4.99
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	LA	LA, TA	yes	yes	yes	yes	2.83	2.78
2.A.1 Cement Production	CO_2	LA, TA	LA	yes	yes	yes	yes	1.36	1.34
2.B.8 Petrochemical and Carbon Black Production	CO_2	LA, TA	LA, TA	yes	yes	yes	yes	0.79	0.78
2.B.1 Ammonia Production	CO_2	LA, TA		yes	yes			0.58	0.57
2.A.2 Lime Production	CO_2	LA, TA		yes	yes			0.53	0.52

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.

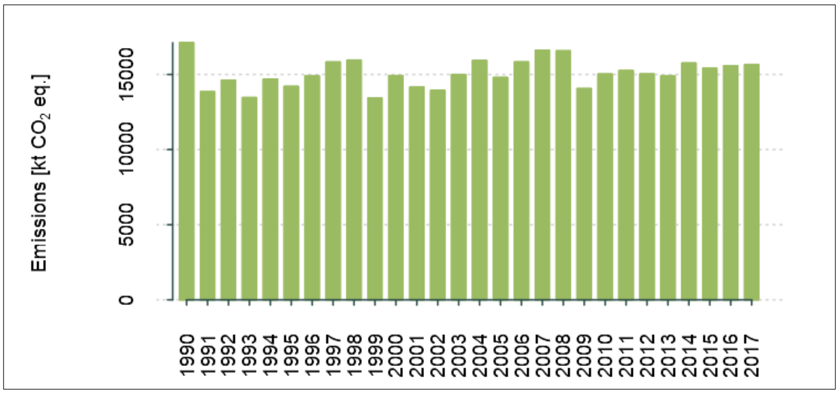


Fig. 4-1 Trend of emissions from IPPU [kt CO_2 eq.]

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. substitutes to ozone depleting substances). GHG emission trend from Industrial Processes and Product Use from base year 1990 to 2017 is depicted in Fig. 4-1. CO_2 eq. emissions have shown stable trend since 2010 with minor fluctuation.

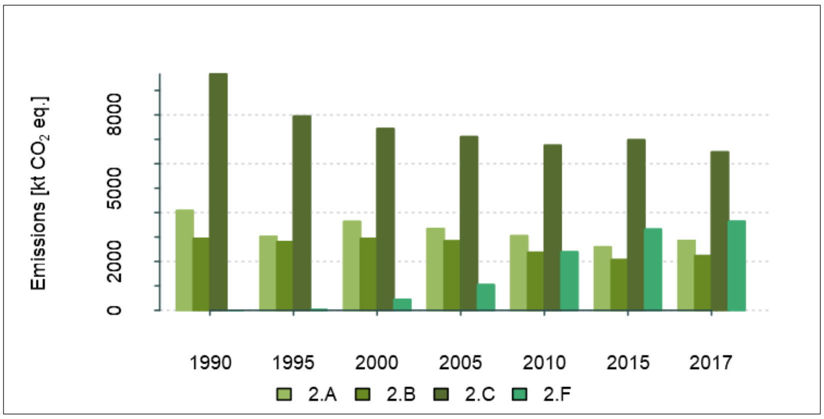


Fig. 4-2 Emissions from principal subcategories of IPPU [kt CO_2 eq.]

GHG emission trends for the principal categories of IPPU are depicted on Fig. 4-2 for years 1990, 1995, 2000, 2005, 2010, 2015 and 2017. Emissions in 2009 and 2010 were rather influenced by the economic crisis. Emissions from category 2.A are decreasing since 2010. Emissions decreased by 30% compared to 1990. Similar decreasing trend of emissions is observed for categories 2.B and 2.C. Emissions decreased by 24% for 2.B and 33% for 2.C compared to 1990. It can be seen that the emissions of fluorinated greenhouse gases from category 2.F are constantly increasing. A brief description of the relevant category trends is provided for all the categories in the following chapters. Tab. 4-2 lists all categories under IPPU sector with indicated type of emissions.

Tab. 4-2 Overview of categories in sector Industrial Processes and Product Use (2017)

IPCC Category	Emissions							
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	HFO 1234yf
2.A Mineral Industry	x							
2.B Chemical Industry	x	x	x					
2.C Metal Industry	x	x						
2.D Non Energy Products from Fuels and Solvent Use	x							
2.E Electronics Industry					x	x	x	
2.F Product Uses as Substitutes for ODS				x	x			
2.G Other Product Manufacture and Use			x			x		
2.H Other								x

4.2 Mineral Industry (CRF 2.A)

This category describes GHG emissions from the non-combustion processes from the following categories: 2.A.1 Cement Production, 2.A.2 Lime Production, 2.A.3 Glass Production, 2.A.4 Other Process Uses of Carbonates.

Emission trend for category 2.A Mineral Industry is depicted on Fig. 4-3. The major share 61% belongs to 2.A.1 Cement Production, 24% belongs to 2.A.2 Lime Production, 5% belongs to 2.A.3 Glass Production and 10% to 2.A.4 Other Process Uses of Carbonates.

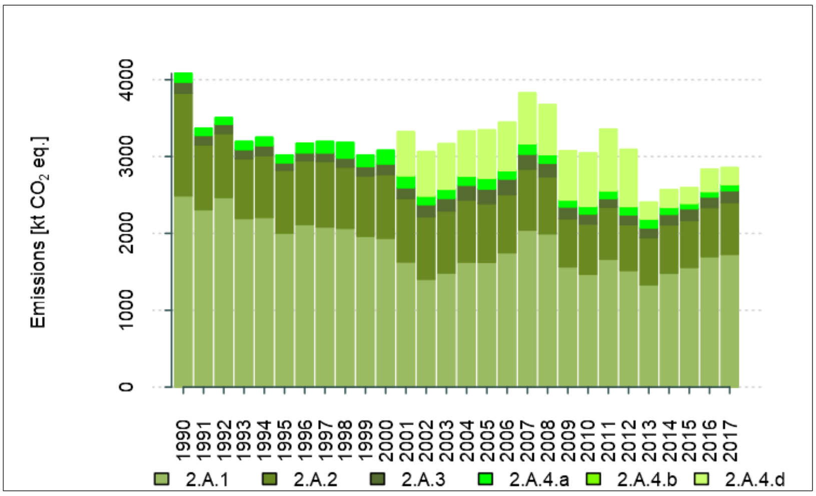


Fig. 4-3 Trend of emissions from 2.A Mineral Industry and share of specific subcategories [kt CO_2]

Tab. 4-3 lists the CO_2 emissions in the individual subcategories in 2.A Mineral Products in 2017.

Tab. 4-3 CO_2 emissions in individual subcategories in 2.A Mineral Products category in 1990 – 2017

	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	203.58
2016	1697.60	639.82	138.06	70.26	1.01	287.50
2017	1728.27	673.53	155.01	78.97	1.15	218.61

Tab. 4-4 gives an overview of the emission factors and methodology used for computations of emissions in category 2.A Mineral Products in 2017.

Tab. 4-4 CO_2 emission factors and methodology used for computations of 2017 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	0.76	t CO_2/t CaO	CS	Tier 3
2.A.3 Glass Production	0.13	t CO_2/t Glass	EU ETS	Tier 3
2.A.4.a Ceramics	0.16	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	0.44	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
Denitrification	0.74	t CO_2/t urea	CS (EU ETS)	Tier 3

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%. Total CO_2 emissions equal to 1728.27 kt in 2017. 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 Gl. (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 - 2017. 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 emission estimates in the EU ETS system.

Data on cement clinker production is published yearly by the Czech Cement Association (CCA), which associates all Czech cement producers. Clinker production data together with interpolated EFs were 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. 4-5 introduces the activity data for clinker production, emission factor and CO_2 emissions for the whole time series.

Tab. 4-5 Activity data, CO_2 emission factor and CO_2 emissions in 2.A.1 Cement Production category in 1990 - 2017

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Clinker production	[kt]	4726.00	4368.00	4653.00	4122.00	4134.00	3740.00	3934.00	3829.00	3758.00	3547.00
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]	2489.18	2308.92	2468.42	2194.55	2208.38	2005.01	2116.49	2083.36	2067.65	1962.91
	Unit	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Clinker production	[kt]	3537.00	2954.00	2549.00	2725.00	3017.00	3045.06	3287.74	3837.02	3758.65	2923.20
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]	1936.86	1628.84	1403.48	1484.85	1626.76	1624.53	1748.45	2043.08	1996.15	1566.08
	Unit	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**		
Clinker production	[kt]	2748.47	3132.27	2837.60	2472.20	2792.10	2919.19	3188.09	3236.05		
EF CO_2	[t CO_2/ t clinker]	0.535	0.531	0.535	0.539	0.529	0.531	0.532	0.534		
CO_2 emissions	[kt]	1469.00	1664.53	1517.15	1331.79	1482.73	1558.16	1697.60	1728.27		

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 IPCC 2006 Gl. (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 2017.

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 2017 obtained from CCA and other sources are as follows:

- Difference between the data from CCA and CzSO: 0.00%
- Difference between the data from CCA and ISPOP: -12.37%
- Difference between the data from CCA and EU ETS: 0.00%

The difference between the data from CCA and ISPOP for 2017 is caused by one facility which reported in ISPOP amount of produced clinker higher than it was reported for CzSO and for EU ETS. The difference is approximately by 455 kt of clinker. 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

In this year, no recalculations were performed in this sector.

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 50%. 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 758.07 kt. In 2017, production of lime increased to 888.04 kt which represent increase by 52.27 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 Gl. (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 - 2017 for each process. This data are at the Tier 3 level. Data in EU ETS take 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 time period 2005 - 2009, 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 reporting. 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 time period 1990 - 2009, 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 time period 1990 - 2009, 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 - 2017 time period, the activity data are based on the data from EU ETS, 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 - 2017

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Lime production	[kt]	1823.00	1152.00	1134.00	1062.00	1100.00	1115.00	1133.00	1163.00	1087.00	1074.00
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]	1336.65	844.66	831.46	778.67	806.53	817.53	830.73	852.73	797.00	787.47
	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Lime production	[kt]	1130.00	1128.00	1112.00	1102.00	1103.00	1040.38	1033.83	1083.00	1012.00	853.00
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]	828.53	827.06	815.33	808.00	808.73	762.82	758.02	794.07	742.01	625.43
	Unit	2010	2011	2012	2013	2014	2015	2016	2017		
Lime production	[kt]	831.75	858.11	758.07	777.97	816.17	800.22	835.77	888.04		
EF CO_2	[t CO_2/ t $CaCO_3$]	0.788	0.788	0.788	0.788	0.773	0.764	0.766	0.758		
CO_2 emissions	[kt]	655.77	676.44	597.44	612.99	630.90	611.54	639.82	673.53		

4.2.2.3 Uncertainties and time-series consistency

The uncertainties for this category are in line with the IPCC 2006 Gl. (IPCC 2006). Since activity data are based on the EU ETS for time period 2010 - 2017, 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 2017.

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 2017 obtained from EU ETS and other sources are as follows:

- Difference between the data from EU ETS and CLA: 5.29%
- Difference between the data from EU ETS and CzSO: 5.63%

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

In this year, no recalculations were performed in this sector.

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% since 1990. The production of glass reached a maximum value in 2006, equalling 1750.00 kt. CO_2 emissions from 2.A.3 Glass production equalled 155.01 kt CO_2 in 2017.

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 Gl. (IPCC 2006) since 2010.

Since 2010, CO_2 emissions have been based on data submitted by the glass producers in the EU ETS. The ETS data are available for the time period 2010 - 2017 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 - 2017. The country specific emission factor used for emission estimates in 1990 - 2009 equals 0.115 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. 4-7 lists activity data for glass production, emission factors and CO_2 emissions for the whole time series.

Tab. 4-7 Activity data, CO_2 emission factor and CO_2 emissions in 2.A.3 Glass Production category in 1990 – 2017

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Glass production	[kt]	1236.58	1060.24	1046.14	1014.73	1097.13	832.00	875.00	970.00	1012.00	1042.00
EF CO_2	[t CO_2/ t glass]	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115
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]	1197.00	1203.00	1349.00	1416.00	1662.00	1654.00	1750.00	1688.00	1519.20	1329.30
EF CO_2	[t CO_2/ t glass]	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115

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	2017
Glass production	[kt]	1022.50	1055.47	1088.44	1157.57	1119.28	1254.66	1295.26	1194.48
EF CO_2	[t CO_2/ t glass]	0.125	0.108	0.118	0.109	0.121	0.121	0.107	0.130
CO_2 emissions	[kt]	127.78	113.84	128.09	126.25	135.23	151.96	138.06	155.01

4.2.3.3 Uncertainties and time-series consistency

Since activity data are based on the EU ETS for time period 2010 - 2017, 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 2017.

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

In this year, no recalculations were performed in this sector.

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 2.A.4 Other Process Uses of Carbonates have increased since 1990 by 162%.

CO_2 emissions from 2.A.4.a Ceramics equalled to 78.97 kt in 2017. 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 1.15 kt CO_2 in 2017. CO_2 emissions from 2.A.4.d Other amounted to 218.61 kt CO_2 in 2017.

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 0.10 and 1.15 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, flue-gas desulphurisation and denitrification. The CRF reporter does not allow separation of these three categories by adding new nodes under 2.A.4.d Other category. Consequently, these three 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 Gl. (IPCC 2006) since 2010.

The activity data and emissions are taken directly from EU ETS forms for 2010 - 2017. 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 used, 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, flue-gas desulphurisation and denitrification by using urea.

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 - 2017. 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 forms 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).

Denitrification using urea was introduced in EU ETS for the first time in 2017. Denitrification using urea is primarily used to reduce the NOx emissions that are produced during combustion processes. An aqueous urea solution (CO(NH2)2) is used as a reducing agent in the denitrification process. The denitrification process can by described by the following equation

$$CO(NH_2)_2 + 2NO + {}^{1}/_{2}\,O_2 \rightarrow 2N_2 + CO_2 + 2H_2O$$

It is obvious that CO2 emissions are emitted as a side effect of this process. In 2017, 21 facilities (power plants, heating plants and chemical plants) reported CO2 emissions from denitrification processes. Data (activity data, emission factors and CO2 emissions) are obtained directly from the users of this process and thus the Tier 3 methodology is used for emission estimates. CO2 emissions from denitrification equalled 2.72 kt in 2017; these emissions are below the threshold of significance.

These three categories (mineral wool production, flue-gas desulphurization and denitrification) are reported collectively in CRF Reporter. Activity data for this category are reported as C (NK). It is not possible to add up activity data for mineral wool production, flue-gas desulphurization and denitrification because activity data describe completely different type of inputs and thus activity data are reported as C (NK).

Tab. 4-8 lists the CO_2 emissions in the individual subcategories in 2.A.4 Other Process Uses of Carbonates for time period 1990 - 2017.

Tab. 4-8 CO_2 emissions in individual subcategories in 2.A.4 Other Process Uses of Carbonates category in 1990 - 2017

	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	2.A.4.d Denitrification
1990	113.86	NO	NE	NO	NO
1991	89.98	NO	NE	NO	NO
1992	85.36	NO	NE	NO	NO
1993	105.49	NO	NE	NO	NO
1994	108.31	NO	NE	NO	NO
1995	100.49	NO	NE	NO	NO
1996	123.10	NO	NE	76.00	NO
1997	146.87	NO	NE	240.63	NO
1998	200.61	NO	NE	417.31	NO
1999	145.88	NO	NE	536.94	NO
2000	177.02	NO	13.08	539.69	NO
2001	156.33	0.10	19.82	551.38	NO
2002	113.01	0.21	25.02	551.38	NO
2003	119.83	0.33	29.03	560.04	NO
2004	118.51	0.44	33.04	551.06	NO
2005	141.15	0.47	37.06	588.79	NO
2006	109.05	0.35	41.07	586.55	NO
2007	135.06	0.50	45.08	613.93	NO
2008	112.43	0.56	41.19	607.00	NO
2009	90.78	0.41	39.40	600.00	NO
2010	100.43	0.86	43.57	651.00	NO
2011	100.31	1.06	61.31	739.31	NO
2012	108.31	1.09	41.63	698.70	NO
2013	116.73	1.03	42.83	173.08	NO

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	2.A.4.d Denitrification
2014	89.94	1.11	46.89	183.00	NO
2015	68.64	1.01	47.62	155.96	NO
2016	70.26	1.01	46.00	241.50	NE
2017	78.97	1.15	48.89	167.00	2.72

4.2.4.3 Uncertainties and time-series consistency

The uncertainties for this category are in line with the IPCC 2006 Gl. (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 2017.

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 2017.

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 2017 and for flue-gas desulphurization from 1996 to 2017.

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

Subcategory 2.A.4.d Other was recalculated due to updated activity data for mineral wool production for 2016 and flue-gas desulphurization for 2015 and 2016.

The impact of the recalculation on the total emissions from 2.A.4.d is shown in Tab. 4-9.

Tab. 4-9 Impact of the recalculation in category 2.A.4.d

CO_2 emissions	Unit	2015	2016
Submission 2018	[kt]	184.48	269.32
Submission 2019	[kt]	203.58	287.50
Difference	[%]	-9.38	-6.32

Subcategory 2.A.4.d Other was extended by CO_2 emissions from denitrification. Emissions from denitrification are reported for year 2017 and thus this change doesn't have impact on total emissions from this subcategory for previous years.

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)

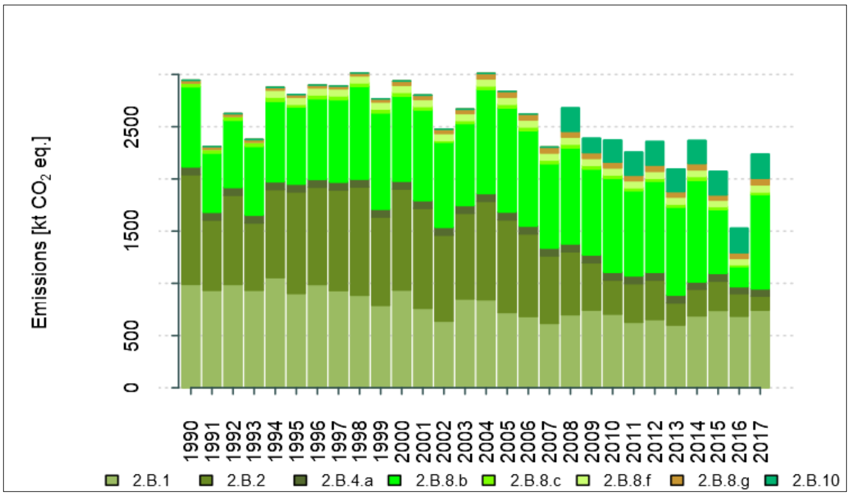


Fig. 4-4 Trend of emissions from 2.B Chemical Industry and share of specific subcategories [kt CO_2 eq.]

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 48% belongs to 2.B.8 Petrochemical and Carbon Black Production, 33% belongs to 2.B.1 Ammonia Production, 10% to 2.B.10 Other, 6% to 2.B.2 Nitric Acid Production and 3% belongs to 2.B.4.a Caprolactam Production.

The emission trend for the category 2.B Chemical Industry is depicted in Fig. 4-4.

Tab. 4-10 lists the exact amount of CO_2 eq. emissions from the individual subcategories in 2.B Chemical Industry for time period 1990 - 2017.

Tab. 4-10 CO_2 eq. emissions in individual subcategories in 2.B Chemical industry category in 1990 - 2017

	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

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
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
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
2017	743.75	134.32	69.76	1058.64	229.49

Tab. 4-11 gives an overview of the emission factors used for computations of emissions in category 2.B Chemical Industry for year 2017.

Tab. 4-11 Emission factors used for computations of 2017 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	0.83	kg N_2O /t HNO_3	IEF	Tier 3
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
	C	t CO_2/t carbon black	PS	Tier 3
	0.06	kg CH_4/t carbon black	Default (IPCC 2006)	Tier 1
	C	t CO_2/t styrene	PS	Tier 1
	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.

The following table (Tab. 4-12) contains information about chemical production in the Czech Republic and the number of manufactures. It can be seen that, except for production of nitric acid, only one manufacturer of specific chemicals have production in the Czech Republic and thus, for reasons of confidentiality, it is very difficult to obtain direct information about production and emissions related to production from manufacturers. Each manufacturer (in the Czech Republic – chemical plants) reports their emissions in EU ETS, but only as bulk emissions, which is not sufficient for emission estimates for chemical production because these emission values are related to the total emissions from all the processes carried out in a plant (other production, combustion processes, etc.). Consequently, Tier 1 methodology is used for emission estimates, except for N2O emissions from nitric acid production and CO2 emissions from carbon black production.

Tab. 4-12 Chemical production in the Czech Republic with number of manufacturers

IPCC Category	Number of manufactures
2.B.1 Ammonia Production	1
2.B.2 Nitric Acid Production	3 (4 installation units)
2.B.4 Caprolactam	1
2.B.8.b Ethylene	1
2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer	1
2.B.8.f Carbon Black	1
2.B.8.g Styrene	1

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 2017 equalled to 743.75 kt of CO_2, emissions decreased by 25% compared to 1990 and increased by 9% compared to previous year. Emissions in period 2005 - 2017 fluctuate slightly every year with minimum in 2013 and maximum in 2009. Increase of emissions from 2014 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, Table 3.1, corresponding to the total fuel requirement, which is 44.65 GJ (NCV)/t 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. 4-13. 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. 4-13 Activity data and CO_2 emissions from ammonia production in 1990 – 2017

	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]	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**	**2017**		
Residual fuel oil used for NH_3 product	[TJ]	11 484	10 278	10 659	8 212	9 400	10 118	9 355	10146		
Ammonia produced	[kt]	257.19	230.18	238.72	183.91	210.53	226.60	209.51	227.24		
CO_2 from 2.B.1	[kt]	705.45	628.05	653.79	601.13	689.05	741.66	685.72	743.75		
CO_2 consumed in urea production	[kt]	136.34	125.34	127.54	0.81	NO	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 IPCC 2006 Gl. (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 2017.

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. Research will be conducted by cooperation with experts from the University of Chemistry and Technology in Prague.

Only one manufacturer produces ammonia in the Czech Republic. Producer reports emissions related to Energy activities under EU ETS. Unfortunately, no data reported in EU ETS are related to emissions originating from ammonia production. It is not possible to obtain data related to emissions from ammonia production directly from producers for reasons of confidentiality and thus data about production obtained from CzSO are used for emission estimates.

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 2017 equalled to 0.45 kt N_2O, emissions have decreased by 87% 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 2017, the production of nitric acid (N_2O emissions) was identified as a key category by trend assessment..

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. 4-14. The emission factors for the basic process (without $DENO_X$ technology) are in accord with the principles given in IPPC 2006 Gl. (IPCC 2006). 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. 4-14 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. 4-15 Emission factors for N_2O recommended by Markvart and Bernauer, for 2004 and thereafter

Pressure in HNO_3 production	0.1 MPa	0.4 MPa	0.4 MPa	0.7 MPa
Technology $DENO_X$	SCR	SCR	NSCR	SCR
Emission factors N_2O [kg N_2O/t HNO_3]	9.05	4.9	1.09	7.8 [a)]

[a)] *EF without N_2O mitigation.*

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 - 2017, 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. 4-16.

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. 4-16).

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. 4-16 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	2017
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	1.35
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	82.71

a) EF without N_2O mitigation.

The emission factors used in the Czech Republic are compared with the EFs presented in the IPCC 2006 Gl. (IPCC 2006) in the Tab. 4-17.

Tab. 4-17 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	 9.05	(Markvart and Bernauer, 2009,

Production process	N_2O Emission factor (kg N_2O/t 100% HNO_3)	Reference
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)	4.90 1.09 7.80 4.82 – 1.29	2010)

Tab. 4-18 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. 4-18 Emission trends for HNO_3 production and N_2O emissions in 1990 - 2017

	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
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
2017	543.93	0.45	0.83

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. 4-14 and Tab. 4-15, 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. 4-16) 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 IPCC 2006 Gl. (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 2017.

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

In this year, no recalculations were performed in this sector.

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. For 2014 - 2016, the activity data have been obtained directly from the producer. Activity data for 2017 have not been obtained directly from manufacturer and thus activity data were calculated as average production for 2014 - 2016.

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 source 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

In this year, no recalculations were performed in this sector.

4.3.4.6 Category-specific planned improvements, including tracking of those identified in the review process

No improvement is planned for the next submission. Emissions are estimated according a series of studies (Markvart and Bernauer, 2004 – 2013) and (Bernauer and Markvart, 2014 - 2016). Data from EU ETS forms include only the aggregated amount of emissions, which cannot be linked with specific chemicals.

4.3.5 Carbide Production (CRF 2.B.5)

Carbides are not produced in the Czech Republic.

4.3.6 Titanium Dioxide Production (CRF 2.B.6)

In the Czech Republic titanium dioxide is produced using sulphate route process and as it is stated in the IPCC 2006 Gl. (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)

This category includes carbon dioxide and methane emissions from the production of ethylene, ethylene dichloride, carbon black and styrene. Total emissions from category 2.B.8 Petrochemical and Carbon Black Production equalled to 1058.64 kt CO_2 eq., emissions have increased by 27% compared to 1990 and by 226% compared to previous year. Decrease of emissions for 2015 and 2016 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 was reconstructed. The production capacity of the unit is now greater than that before the accident and thus emissions from ethylene production increased rapidly compared to previous year. Category 2.B.8 was identified as a key source.

4.3.8.1 Source category description

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 Gl. (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 2006 Gl. provides a value of 1.73 t CO_2/t ethylene produced (with correction factor 110% for countries of Eastern Europe) and 3 kg CH_4/t ethylene produced as default emission factors (IPCC 2006). In the period 1990 – 2017, CO_2 emissions varied between 184.41 (due to the accident) to 958.85 kt CO_2 and methane emissions varied between 0.29 and 1.51 kt CH_4, detailed values for each year are available in Tab. 4-19.

Tab. 4-19 Emission trends from CO_2 and CH_4 emissions from production of ethylene in 1990 - 2017

	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
2017	456.10	867.96	1.37

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 Gl. methodology provides a value of emissions of carbon dioxide 0.294 t CO_2/t VCM produced and for methane 0.0226 kg CH_4/t VMC produced as default emission factors (IPCC 2006). Carbon dioxide emissions varied in the period 1990 - 2017 between 16.68 kt CO_2 and 40.29 kt CO_2. Due to the low emission factors' value, the values of methane emissions varied in the period 1990 – 2017 between 0.001 and 0.003 kt CH_4, which is considered as insignificant value. In 2017, emissions of carbon dioxide equalled to 25.16 kt and methane emissions equalled to 0.0019 kt.

CO_2 and CH_4 emissions from the production of carbon black

Exact information on activity data related to carbon black production 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. equals to 0.06 kg CH_4/t carbon black produced and 2.62 t CO_2/t carbon black produced (IPCC 2006). In 2017, emissions of carbon dioxide equalled to 68.90 kt and methane emissions equalled to 0.0016 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 2006 Gl. equals to 0.004 kt CH_4/kt styrene (IPCC 2006). The emission factor for CO_2 emissions is 0.27 kt CO_2/kt styrene (Bernauer and Markvart, 2015) (IPCC 2006). 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 2017, emissions of carbon dioxide equalled to 45.48 kt and methane emissions equalled to 0.67 kt CH_4.

4.3.8.3 Uncertainties and time-series consistency

The uncertainties for this category are in line with the IPCC 2006 Gl. (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 subcategory.

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

In this year, no recalculations were performed in this sector.

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 229.49 kt CO_2 in 2017.

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. 4-20 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. 4-20 Emission trends for category 2.B.10 Other in 2008 - 2017

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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	212.09
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	17.40

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 in line with IPCC 2006 Gl. (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 2017.

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

In this year, no recalculations were performed in this sector.

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

In further submissions it is planned to investigate the possibility of disaggregating data for non-energy and energy use of NG for the 1990 - 2007 period. CO_2 emissions from NG in the chemical industry were reported for this period under 1.A.2.c.

4.4 Metal Industry (CRF 2.C)

This category includes mainly CO_2 emissions from 2.C.1 Iron and Steel Production; 99.8% of CO_2 emissions arise from 2.C.1. CO_2 emissions from iron and steel are identified as a key category (by both level and trend assessments). A small amount of CH_4 is also emitted.

Ferro-alloys were manufactured in limited amounts in a small production unit in the Czech Republic; this process could constitute an unsubstantial source of CO_2 emissions. 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).

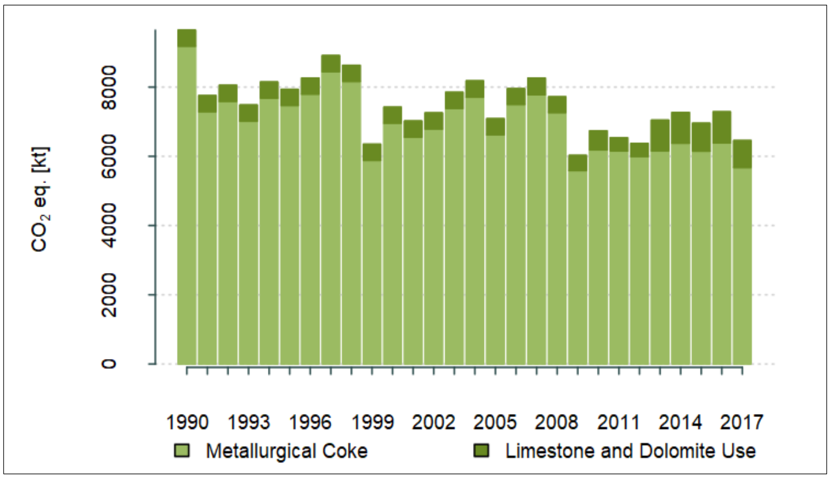


Fig. 4-5 Trend of CO2 emissions in 2.C.1, 1990 – 2017 [kt CO2]

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 Gl. (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. 4-21. 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 Table 1.A(d) under Coke Oven Coke (1990-2017), Other bituminous coal (2014-2017) and Coal Tar as well (2007-2013) as well(please see chapter 3.2.3. for details).

Tab. 4-21 The amounts of metallurgical coke consumed and CO_2 emissions in 1990 – 2017

	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	7281.78
2017	1605	278	NO	926.77	6453.12

The amounts of blast furnace coke consumed and corresponding emissions are given in Tab. 4-21.

Estimation of CH_4 from metal production is based on the IPCC 2006 Gl. 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 Gl. (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 2017.

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 net calorific value was provided for 2016. Howver, the change yelds in decrease of the emissions by less than 0.1%, thus it is really minor.

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 recent years, 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 Gl. (IPCC 2006) does not provide emission factors of this type of ferroalloy. However, IPCC 2006 Gl. 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. 4-22 Evaluation of emission factors used for 2.C.2 emission estimates

Composition of ferrovanadium		IPCC 2006 Gls. EF		EF CO_2 (1.5% of Si)	EF CH_4 (1.5% of 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 Gl. (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 Gl. 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 Gl. (IPCC 2006) using the default CO_2 emission factor 0.2 t CO_2/t of lead. CO_2 emissions in 2017 equalled 11.18 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 Gl. (IPCC 2006) using default CO_2 emission factor 1.72 t CO_2/t of zinc. CO_2 emissions in 2017 equalled 0.5 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)

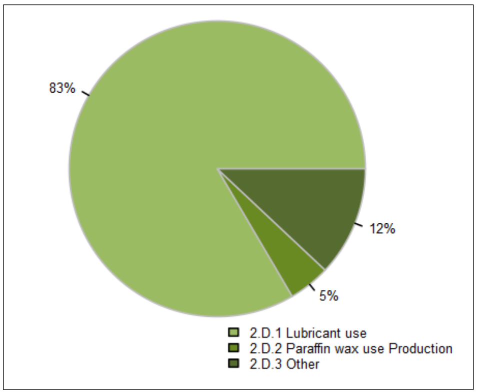


Fig. 4-6 The share of individual subcategories for CO2 emissions in 2.D in 2017 [kt CO2]

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. 83% of 2.D CO_2 emissions are produced from Lubricant Use, followed by Urea used as catalysts (12%) and the use of Paraffin Wax (5%).

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 Gl. 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 2017 were equal to 119 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 Gl. (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 2017 from this category were equal to 6.5 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 Gl. (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 Gl. (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 2017 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 – 2017 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 2017 from this category were equal to 17.1 kt CO_2.

4.5.3.3 Uncertainties and time-series consistency

Solvent Use

Uncertainty of NMVOC emissions is considered to be quite large, based on IPCC 2006 Gl. (IPCC 2006) it is considered as 50%. The uncertainty of activity data is considered based on expert judgement as 25%.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2017.

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

Due to updated activity data and due to use of COPERT 5 model in 1.A.3 the activity data was consequently updated also for the category 2.D.3 Other – Urea Used as catalyst.

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. For this submission, it was verified that SF_6 or other fluorine compounds are not used in category 2.E.3 Photovoltaics.

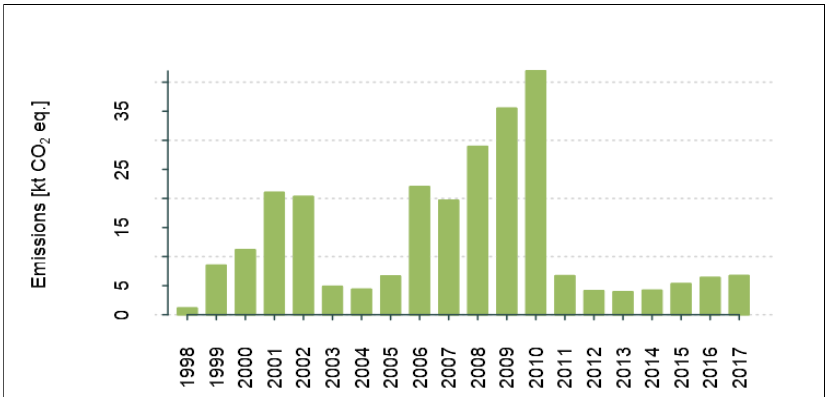


Fig. 4-7 Trend of emissions from 2.E Electronics Industry [kt CO_2 eq.]

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. 4-7 from year 1997, when the use of CF_4 began to 2017. Emissions of F-gases equalled to 6.72 kt CO_2 eq. in 2017. Total emissions of F-gases from 2.E increased in 2017 by 0.33 kt CO_2 eq. compared to previous year.

Tab. 4-23 lists the exact amount of CO_2 eq. emissions from category 2.E.

Tab. 4-23 Emissions from category 2.E. Electronics Industry in time period 1997 - 2017

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
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	19.68
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	
Emissions [kt CO_2 eq.]	28.94	35.50	41.93	6.58	4.29	4.40	4.19	5.32	6.39	6.72	

Tab. 4-24 gives an overview of the emission factors and methodology used for computations of emissions in category 2.E. Electronics Industry in 2017.

Tab. 4-24 Type of CO_2 emissions factors used for computations of 2017 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., 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 (IPCC 2006). 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. 4-25. The default emission factors for the gases HFC-23, CF_4, C_2F_6, SF_6 and NF_3 were chosen from IPCC 2006 Gl., Volume 3, Table 6.3 (IPCC 2006).

Tab. 4-25 Emissions factors used for computations of 2017 emissions from 2.E.1 Integrated Circuit or Semiconductor

F-gas	IPCC 2006 Gl. (IPCC 2006)			
	(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 IPCC 2006 Gl., 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 2017.

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

No recalculations were performed in this sector this year, although research was carried out on SF_6 and other fluorine compound emissions related to the photovoltaics production process. According to information obtained from manufacturers, neither SF_6 nor any other fluorine compounds are used in the production of photovoltaics in the Czech Republic.

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

Although the current survey considered factors ai and di 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)

This category describes emissions of F-gases from the following categories: 2.F.1 Refrigeration and Air Conditioning, 2.F.2 Foam Blowing Agents, 2.F.3 Fire Protection, 2.F.4 Aerosols and 2.F.5 Solvents.

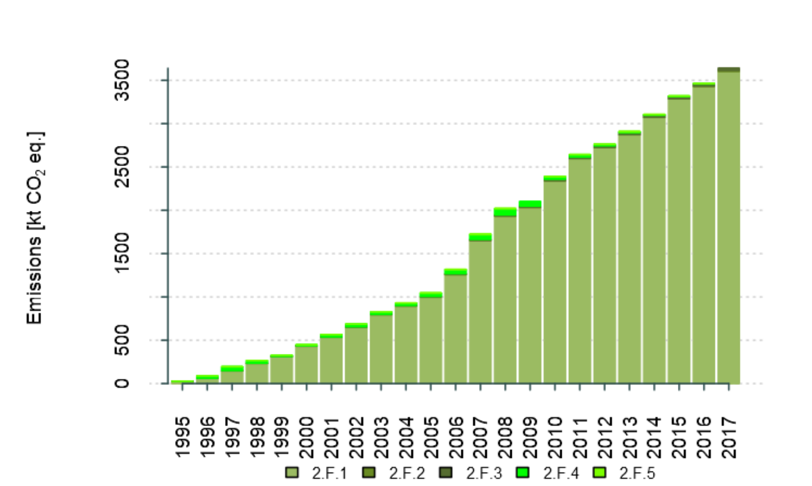


Fig. 4-8 Trend of emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances and share of specific subcategories [kt CO_2 eq.]

The emission trend for category 2.F is depicted in Fig. 4-8. The major share of 99% in the range of actual emissions for year 2017 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 27.15 kt CO_2 eq. in 1995 to 3641.60 kt CO_2 eq. in 2017. 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. 4-26 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. 4-26 Actual emissions of HFCs and PFCs in 1995 - 2017 [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	27.15	27.14	0.01
1996	88.19	87.51	0.68
1997	194.14	193.55	0.59
1998	265.33	264.81	0.52
1999	325.37	324.49	0.88
2000	446.61	444.51	2.10
2001	564.89	561.53	3.36
2002	685.86	682.36	3.50
2003	826.78	820.07	6.71
2004	930.58	921.91	8.67
2005	1046.42	1037.04	9.37
2006	1318.26	1308.41	9.85
2007	1726.28	1715.84	10.44
2008	2021.67	2009.94	11.72
2009	2101.10	2090.49	10.61
2010	2388.88	2381.07	7.81
2011	2643.59	2637.79	5.80
2012	2762.42	2757.66	4.76
2013	2910.40	2906.60	3.81
2014	3107.33	3104.77	2.56
2015	3319.35	3317.83	1.52

Category 2.F - emissions of PFCs and HFCs [kt CO_2 eq.]			
	Emissions of PFCs and HFCs	Emissions of HFCs	Emissions of PFCs
2016	3463.60	3462.57	1.02
2017	3641.60	3640.76	0.84

Tab. 4-27 gives an overview of the emission factors and methodology used for computations of emissions in category 2.F Product Uses as Substitutes for Ozone Depleting Substances in 2017.

Tab. 4-27 Type of emissions factors used for computations of 2017 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

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.

Currently, the national F-gas inventory is based on the method of actual emissions, according to the IPCC 2006 Gl. (IPCC 2006). 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 is 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.

In 2017 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 (only one of them reported data for 2017 in the ISPOP database). Companies used privately constructed distilling machinery to process app. 5 t 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.

The discarded refrigeration appliances contained old refrigerant's media - CFC-12 and HCFC-22, old insulating materials - CFC-11 but also HFCs. According to ISPOP database in the Czech Republic were disposed 6.50 t of HFC-134a, 12.49 t of HFC-125, 2.89 t of HFC-143a, 9.86 t of HFC-32. Appliances containing HFCs are still being disposed in lower 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 5.01 t of HFC-134a, 14.90 t of HFC-125, 2.61 t of HFC-143a, 2.40 t of HFC-32. 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 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.

The major share 40% in the range of actual emissions for year 2017 belongs to the subcategory 2.F.1.a, share 23% belongs to the subcategory 2.F.1.e, share 19% belongs to the subcategory 2.F.1.f, share 12% belongs to the 2.F.1.c, share 5% belongs to the 2.F.1.d and share 0.06% belongs to the 2.F.1.b. Trend of emissions from 2.F.1 is depicted on Fig. 4-9. Category 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.

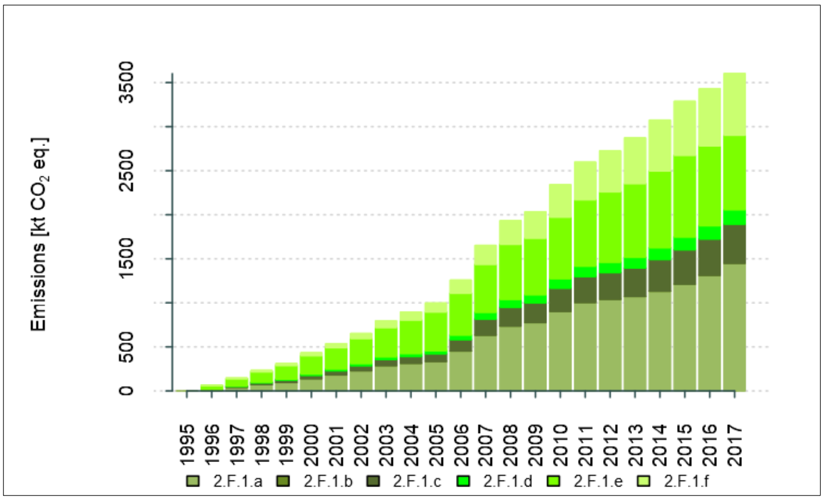


Fig. 4-9 Trend of emissions from 2.F.1 Refrigeration and Air conditioning and share of specific subcategories [kt CO_2 eq.]

An overview of reported gases under specific subcategory is presented in Tab. 4-28. PFCs have not been used in the Czech Republic for many years, but emissions from previous use of PFCs still occur.

Tab. 4-28 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

Source category	Reported F-gases
2.F.1.f Stationary Air Conditioning	HFC-32, HFC-125, HFC-134a, HFC-143a

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 Gl. (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 (Ondrusova, Krtkova 2018).

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.

<u>*INPUT*</u>

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, 38 importers out of 51 reported information related to products with a charge of F-gases less than 3 kg in

2017. 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. 4-29.

Tab. 4-29 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. 4-30. 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. 4-30 Distribution of HFCs and PFCs use by application area used for emission calculations in 2017

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%

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-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. (IPCC 2006). Emissions from subcategories under 2.F.1 are calculated using Tier 2a Method (emission-factor approach) described in IPCC 2006 Gl. (IPCC 2006). The parameters used for emission estimates were established by an expert judgement and Table 7.9 in the input of the calculation model (IPCC 2006). Equations for emission calculation are in accordance with the equations described in the IPCC 2006 Gl. (Equation 7.12, Equation 7.13, and Equation 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 (except 2.F.1.e). Tab. 4-31 depicts emissions of F-gases for the individual sub-applications in 2017 and comparison with levels of emissions in 2016 and in the base year.

Tab. 4-31 Emissions of HFCs and PFCs from subcategories under 2.F.1 in 2017 – comparison to levels of emissions in 2016 and 1995

Source sub-application	Emissions of HFCs and PFCs 2017 [kt CO_2 eq.]	Difference 2017 and 2016 [%]	Emissions 2017/Emissions 1995 [-]
2.F.1.a Commercial Refrigeration	1448.13	10.40	7251
2.F.1.b Domestic Refrigeration	2.03	-6.82	2320
2.F.1.c Industrial Refrigeration	443.07	7.84	8726
2.F.1.d Transport Refrigeration	163.71	8.81	7058
2.F.1.f Stationary Air Conditioning	698.58	8.16	22380

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. 4-32.

Tab. 4-32 Subcategories in which is used notation key NE for gases C_6F_{14}, HFC-134a and HFC-32 with related year

Source category	Reported F-gas	Year
2.F.1.a Commercial Refrigeration	C_6F_{14}	2016, 2017

Source category	Reported F-gas	Year
	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	1996, 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

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 of HFC-134a 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. Total emissions are calculated as a sum of emissions from filling new equipment E_{charge}, emissions during lifetime $E_{lifetime}$ and emissions at the end of life of the equipment $E_{end\ of\ life}$.

Emission factors used for emission estimates for 2.F.1.e are shown in Tab. 4-33.

Tab. 4-33 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	Passenger cars 15 Light duty vehicles 13 Heavy duty vehicles 16 Buses 14	0.50	20.00	10.00	30.00

From 2016, car producers began to use HFO R1234yf as a substitute for HFC-134a in accordance with Directive 2006/40/EC and thus emissions of R1234yf were also calculated. It was estimated that 620.76 t R1234yf was used for filling of new equipment in the Czech Republic. Emissions from filling were 3.10 t R1234yf. Vehicles with R1234yf began to be part of the Czech vehicle fleet and thus operational emissions were also calculated. It was calculated that operational emissions of HFC-134a corresponded to 32.59 t R1234yf in 2017. Unfortunately, the CRF Reporter does not allow to create a node for alternative refrigerant under category 2.F.1.e and thus emissions of R1234yf are reported under category 2.H Other and then these emissions are included in the national inventory.

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 (ŠKODA AUTO Inc., Hyundai Motor Manufacturing Czech Ltd. and TPCA), bus producers (SOR Libchavy Ltd., Iveco Czech Republic Inc. and other) and one truck producer (TATRA TRUCKS Inc.) are currently operating in the Czech Republic. Approximately 60% of all new passenger cars are produced by a single manufacturer.

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 cars 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 Equation 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* $_t$ ** 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 Equation 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 during the equipment lifetime

For this submission, a new approach was introduced for data collection for estimating emissions during the lifetime of the equipment. Detailed data about vehicle stocks in the Czech Republic are obtained from COPERT (software and methodology developed by EMISIA S.A.) for 1995 - 2017. Data from COPERT were provided by the Transport Research Centre (CDV). The data contain information about the numbers of passenger cars, light duty vehicles, heavy duty trucks and buses classified by the fuel type, segment and EURO standard as is summarized in Tab. 4-34.

Tab. 4-34 Information about vehicles fleet of the Czech Republic obtained from COPERT

Type	Fuel	Segment	Euro standard
Passenger Cars	Petrol Diesel LPG Bifuel CNG Bifuel Petrol Hybrid	Mini Small Medium Large SUV	Conventional ECE 15/00-01 ECE 15/02 ECE 15/03 ECE 15/04 Euro 1 Euro 2 Euro 3 Euro 4 Euro 5 Euro 6 2017 - 2019 Euro 6 up to 2016 PRE ECE
Light Commercial vehicles	Petrol Diesel	N1-I N1-II N1-III	Conventional Euro 1 Euro 2 Euro 3 Euro 4 Euro 5 Euro 6 up to 2016 Euro 6 up to 2017
Heavy duty trucks	Petrol Diesel	Articulated (divided according weight) Rigid (divided according weight)	Conventional Euro I Euro II Euro III Euro IV Euro V Euro VI
Buses	Diesel Biodiesel CNG	Coaches articulated > 18t Coaches standard <= 18t Urban biodiesel buses Urban buses articulated > 18t Urban buses midi <= 15t Urban buses standard 15-18t Urban CNG buses	Conventional EEV Euro I Euro II Euro III Euro IV Euro V Euro VI

Information obtained from COPERT and depicted in the above table is too detailed for emission estimates of HFC-134a and thus important input for emission estimates is only taken as the type of vehicle (passenger car, light duty vehicle, heavy duty truck and bus) in the appropriate Euro standard (the Euro standard is not taken into account for buses and heavy duty trucks).

Operational emissions for cars and light duty vehicles are calculated as follows:

- The number of cars or light duty vehicles in an appropriate Euro standard is obtained from COPERT (e.g., 1,332,160 passenger cars (Euro standard 4) were registered in the Czech Republic in 2017).
- The percentage shares of cars or light duty vehicles with AC equipment in each Euro standard group are based on data from COPERT and expert judgement, as in the following table.

Tab. 4-35 AC shares in Euro standard

Type	AC Share
Conventional	10%
ECE 15/00-01	10%

Type	AC Share
ECE 15/02	10%
ECE 15/03	10%
ECE 15/04	10%
Euro 1	20%
Euro 2	60%
Euro 3	85%
Euro 4	95%
Euro 5	95%
Euro 6 2017 - 2019	95%
Euro 6 up to 2016	95%
Euro 6 up to 2017	95%
PRE ECE	10%

- The number of cars equipped with air conditioning is calculated as the total number of cars or light duty vehicles in the Euro standard multiplied by the appropriate percentage share, as in Tab. 4-35.
- 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 vehicle fleet.
- The refrigerant stocks are calculated for cars and light duty vehicles as follows: *HFC-134 stock* $_t$ *= Number of cars or light duty vehicles equipped with air conditioning* $_t$ ** charge* $_t$.
- Emissions are calculated according Equation 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 heavy duty trucks and buses are calculated by the following steps:

- The number of heavy duty trucks and buses for 1995 - 2017 are obtained from COPERT.
- The percentage share of buses equipment with air conditioning is linearly interpolated from 10% in 1995 to 62% in 2017; the percentage share of trucks equipped with air conditioning is linearly interpolated from 50% in 1995 to 92% in 2017. There is a lack of detailed information about percentage shares of heavy duty trucks and buses with air conditioning 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 or trucks with air conditioning* $_t$ ** specific charge* $_t$.
- The emissions are calculated according Equation 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 end of life of the system are calculated in the following steps:

- The number of discarded vehicles (passenger cars, light duty vehicles, heavy duty vehicles and buses) is obtained from the Car Importers Association.
- The average vehicle lifetime is estimated as 15 years for passenger cars, 13 years for light duty vehicles, 16 years for heavy duty vehicles and 14 years for buses. The estimations are based on information from the Car Importers Association, the Automotive Industry Association and the Ministry of Transport.

- The percentage time series of vehicles with air conditioning are based on data from the main Czech car bazaar and expert judgement and are the same as for the estimation of operational emissions (percentage share for passenger cars and light duty vehicles is simplified compared to the approach used for the estimation of operational emissions, mainly because the data on discarded vehicles are not classified according to the Euro standard).
- The specific charge of refrigerant is the same as for the estimation of operational emissions (please see paragraphs above).
- 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 Equation 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. 4-36 gives the emissions of F-gases from mobile air conditioning units in 2017 and comparison with emission levels in 2016 and in the base year for HFC-134a.

Tab. 4-36 Emissions of HFCs and PFCs from 2.F.e in 2017 – comparison to emission levels in 2017 and 1995

Source sub-application	Emissions of HFCs and PFCs 2017 [kt CO_2 eq.]	Difference 2017 and 2016 [%]	Emissions 2017/Emissions 1995 [-]
2.F.1.e Mobile air conditioning	846.35	-6.70	32

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). 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. Total emissions from 2.F.2 amounted to 13.21 kt CO_2 eq. in 2017. Use of HFC for foam blowing was not reported in 2017.

Increased amount of emissions from category 2.F.2 in 2016 and 2017 was driven by emissions from disposal of HFC-134a. Default 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. A similar situation can be observed for emissions from disposal for year 2017.

4.7.2.1 Methodological issues

Emissions from this category are calculated by default methodology and EF described in IPCC 2006 Gl., Equation 7.7 for foam blowing (IPCC 2006).

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). Total emissions from 2.F.2 amounted to 24.89 kt CO_2 eq. in 2017.

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 2017. The emissions from this category were not occurring in 2017. The latest use of HFC-134a in metered dose inhalers was reported in 2015 and thus two years later emissions are not occurring.

4.7.4.1 Methodological issues

Emissions from this category are based on IPCC 2006 Gl., Equation 7.6; EF equals to 50% (default) (IPCC 2006). 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)

Only emissions from the use of HFC-245fa are occurring in 2017 in category 2.F.5; emissions of other gases such as HFC-134a, HFC-152a are not occurring from 2014 and 2007 specifically. According to the F-gas expert HFC-245fa is used only as a solvent in this country. Total emissions from 2.F.5 amounted to 1.63 kt CO_2 eq. in 2017.

4.7.5.1 Methodological issues

Emissions from this category are based on IPCC 2006 Gl., equation 7.5; EF equals to 50% (default) (IPCC 2006).

4.7.6 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see IPCC 2006 Gl., 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 COPERT, 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 climate and 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

Subcategory 2.F.1.e Mobile Air Conditioning was recalculated as a result of methodology changes in the collection of activity data for operation emission estimates. The activity data for operation emission estimates are obtained from the COPERT since this submission.

HFC-134a emission estimates from disposal were updated to year 2006. Data contain information about disposal of passenger cars, light duty vehicles, trucks and buses.

The impact of the recalculation on the total emissions for category 2.F is shown in Tab. 4-37.

Tab. 4-37 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.]	36.01	84.88	169.26	215.26	247.08	332.75	426.96	526.53	637.20	715.71	802.49
Submission 2018	[kt CO_2 eq.]	27.15	88.19	194.14	265.33	325.37	446.61	564.89	685.86	826.78	930.58	1046.42
Difference	[%]	32.67	-3.75	-12.82	-18.87	-24.06	-25.49	-24.42	-23.23	-22.93	-23.09	-23.31
F-gas emissions	**Unit**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Submission 2017	[kt CO_2 eq.]	1062.85	1439.55	1690.49	1763.62	2016.65	2246.16	2384.93	2509.19	2698.25	2927.20	3122.53
Submission 2018	[kt CO_2 eq.]	1318.26	1726.28	2021.67	2101.10	2388.88	2643.59	2762.42	2910.40	3107.33	3319.35	3463.60
Difference	[%]	-19.37	-16.61	-16.38	-16.06	-15.58	-15.03	-13.67	-13.79	-13.16	-11.81	-9.85

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, IPCC 2006 Gl., Volume 3. 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 and 2.G.4 Other. Under the 2.G category are reported SF_6 and N_2O emissions.

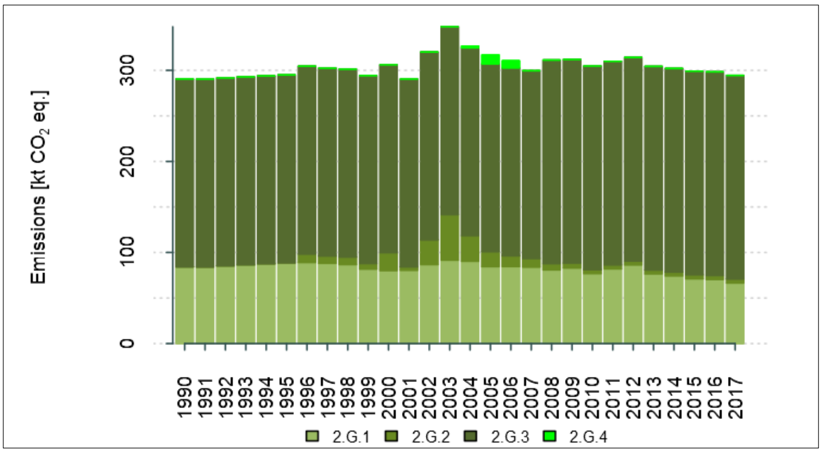


Fig. 4-10 Trend of emissions from 2.G Other Product Manufacture and Use and share of specific subcategories [kt CO_2 eq.]

The emission trend for category 2.G is depicted in Fig. 4-10. The major share of 76% of GHG emissions for year 2017 belongs to category 2.G.3, the share 23% belongs to category 2.G.1 and the share 1% belongs to category 2.G.2. Total GHG emissions from 2.G were lower by 3.94 kt CO_2 eq. in 2017 compared to the previous year.

Tab. 4-38 lists the exact amount of CO_2 equivalent emissions from the individual subcategories in 2.G. Other Product Manufacture and Use for the 1990 to 2017 period.

Tab. 4-38 CO_2 eq. emissions in individual subcategories in 2.G Other Product Manufacture and Use category in 1990 - 2017

	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
2004	90.36	28.13	206.22	1.89

	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
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
2017	66.48	4.39	223.50	NO

Tab. 4-39 gives an overview of the emission factors and methodology used for computations of emissions in category 2.G for year 2017.

Tab. 4-39 Type of emissions factors used for computations of 2017 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 (for more details see chapter 4.7.1). 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, IPCC 2006 Gl., Volume 3 for MV Switchgear and Table 8.3, IPCC 2006 Gl., Volume 3 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 IPCC 2006 Gl., 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 2017.

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

In this year, no recalculations were performed in this sector.

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 submission 2018 - 2016. Category 2.G.2.b Accelerators has been 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 54 accelerators in 2017.

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 (IPCC 2006).

SF_6 emissions from accelerators

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. 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, Equation 8.18 with default charge factor 0.5 kg and emission factor 2 kg/kg SF_6 (IPCC 2006).

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.

4.8.2.3 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see IPCC 2006 Gl., 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 2017.

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

In this year, no recalculations were performed in this sector.

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 Gl., Volume 3, Chapter 8, Equation 8.24 (IPCC 2006). 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.

Data from the Customs Office were obtained in an attempt to improve emission estimates from this category. Customs data contain detailed information about the imported/exported amount of oxides of nitrogen to/from the Czech Republic by a single importer/exporter for 2016 and summary data about import/export for 1993 - 2016. The customs code is related to all the oxides of nitrogen and not only N_2O. According to the data, nitrogen oxides were imported into the Czech Republic by 26 importers (mainly by companies trading in industrial gases and not by the end consumer) and exported by 15 companies in 2016. Every year, exports of nitrogen oxides are many times larger than imports. The total stock of nitrogen oxides in 2016 for the 1993 - 2016 time series is calculated as -20 kt of oxides of nitrogen. It was concluded that customs data are not suitable for N_2O emission estimates in category 2.G.3. Firstly, customs data are related to import/export of all nitrogen oxides and not only N_2O. Secondly, nitrogen oxides are imported by companies trading in industrial gases. These companies sell their products to the end users and thus information about possible use is lacking. Overall, the amount of nitrogen oxides exported every year is larger than the amount of imported nitrogen oxides and thus the total stock is calculated as negative values.

4.8.3.3 Uncertainties and time-series consistency

The uncertainty estimates were based on expert judgment (see IPCC 2006 Gl., 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 2017.

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

No improvement is planned in this category.

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 IPCC 2006 Gl., 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

In this year, no recalculations were performed in this sector.

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 Other (CRF 2.H)

Category 2.H other contains emission estimates of R1234yf which is used as alternative refrigerant to HFC 134a in mobile air conditioning systems. Unfortunately, CRF Reporter doesn't allow creating node for alternative refrigerant under 2.F.1.e category and thus emissions of R1234yf are reported under category 2.H Other. Emissions of R1234yf are accounted in national inventory. For more details please see chapter 4.7.1.

4.10 Acknowledgement

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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° 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 the national estimation of ammonia emissions from manure management the Tier 2 approach is used according to the 3B Manure management EMEP/EEA Emission Inventory Guidebook (EEA 2016). 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 2006 Gl. (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 2017), assessed with and 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	2.31	2.27
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	LA, TA	LA, TA	yes	yes	yes	yes	2.20	2.16
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	LA	LA	yes	yes	yes		0.67	0.66
3.B Manure Management	N_2O	LA, TA	LA, TA	yes	yes	yes		0.65	0.64
3.B Manure Management	CH_4	LA		yes	yes			0.58	0.57
3.G Liming	CO_2	TA		yes		yes		0.12	0.12

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 6.63 % of total GHG emissions incl. LULUCF and indirect emissions (6.52 % excl. LULUCF) in 2017 with 8 433 kt CO_2 eq.; 43 % of emissions came from Managed Agricultural Soils, 35 % from Enteric Fermentation and 19 % from Manure Management. Carbon dioxide emissions from liming and urea application on managed soils contribute 3 % of the total agricultural emissions in 2017. The share of emissions categories on the total emissions is almost the same in 2016 and 2017. During the period 1990 - 2017, 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 1990-2017 (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	15 840	5 601	3 316	5 627	1 188	109
1991	13 732	5 284	3 170	4 830	316	132
1992	11 838	4 740	2 957	3 923	109	109
1993	10 523	4 111	2 693	3 522	104	93
1994	9 540	3 603	2 362	3 379	104	91
1995	9 617	3 506	2 305	3 585	111	109
1996	9 337	3 471	2 264	3 388	113	100
1997	8 922	3 246	2 170	3 344	93	67
1998	8 555	3 041	2 085	3 195	91	143
1999	8 599	3 112	2 117	3 196	88	88
2000	8 393	2 989	2 041	3 202	113	48
2001	8 494	3 013	2 003	3 296	105	77
2002	8 306	2 950	2 011	3 181	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	7 851	2 920	1 997	2 794	79	61
2004	8 065	2 856	1 903	3 159	77	70
2005	7 801	2 799	1 836	3 028	65	74
2006	7 679	2 757	1 810	2 952	78	83
2007	7 835	2 787	1 812	3 033	80	122
2008	7 972	2 819	1 762	3 195	96	100
2009	7 572	2 749	1 635	3 039	65	86
2010	7 386	2 657	1 581	2 975	62	111
2011	7 567	2 664	1 531	3 181	81	111
2012	7 586	2 696	1 523	3 139	117	136
2013	7 744	2 696	1 523	3 263	137	126
2014	7 941	2 752	1 532	3 449	152	57
2015	8 093	2 828	1 552	3 361	164	187
2016	8 482	2 888	1 580	3 635	168	211
2017	8 433	2 939	1 562	3 648	159	124

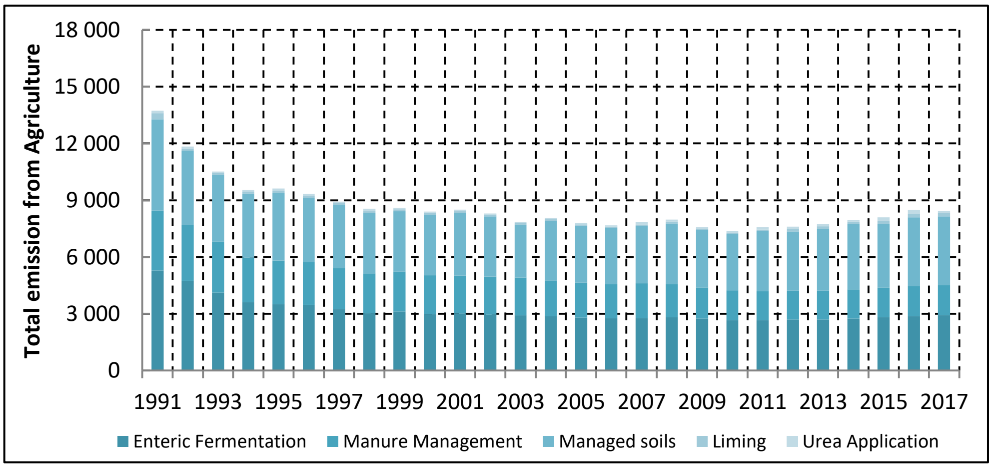


Fig. 5-1 The emission trend of agricultural sector in period 1990-2017 (in Gg CO_2 eq.)

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, decrease by 53 %). 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. This negative environmental trend ended in 2017 when the consumption decreased. 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	61	63	70	64	9	101

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Managed soils (3.D)	Liming (3.G)	Urea Application (3.H)
	Relative share [%]					
2000	53	53	62	57	10	44
2005	49	50	55	54	5	68
2010	47	47	48	53	5	103
2015	51	50	47	60	14	172
2016	54	52	48	65	14	194
2017	53	52	47	65	13	115

An overview of the latest recalculations is given in Chapter 10. The methodology used is in accordance with the IPCC 2006 Gl. (IPCC 2006). According to ERT encouragement the improvement was implemented in the current NIR (Submission 2019). The recalculation was performed for the entire period 1990-2017. This improvement, along with methodological changes, has resulted in a decrease of total emissions in agricultural sector for 0.4 % compared to the previous NIR submission (Submission 2018). 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 1.5. The plan describes the key procedures of inventory compilation, provides a table of personal responsibilities and a timetable of sector-specific QA/QC procedures. This plan consolidates the quality assurance procedures and facilitates effective quality control of the Agriculture inventory. The Institute of Forest Ecosystem Research (IFER) is the sector-solving institution for this category.

The agricultural greenhouse gas inventory is compiled by an experienced expert from IFER, including performance of self-control. 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 1990-2017 (thousands of heads)

	1990	1995	2000	2005[1)]	2010	2015	2016	2017
Cattle	3 506	2 030	1 574	1 397	1 349	1 407	1 416	1 421
Swine	4 790	3 867	3 688	2 877	1 909	1 560	1 610	1 491
Sheep	430	165	84	140	197	232	218	217
Poultry	31 981	26 688	30 784	25 372	24 838	22 508	21 314	21 494
Horses	27	18	24	21	30	33	32	35
Goats	41	45	32	13	22	27	27	28

Trends of the livestock populations in the key categories (cattle, swine, and poultry) are determining for emissions trends in Agricultural sector. Cattle population in 2017 set up only a 41 % share of the population in 1990 and swine population in 2017 set up even less - only 31 % 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 2017, 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 intensive therefore methane emissions are not estimated for them. Enteric fermentation emissions from poultry have not been estimated, the IPCC 2006 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 2 (cattle category) and Tier 1 (other livestock) methodologies presented in the IPCC 2006 Gl. (IPCC 2006) that are linked to the previous methodologies IPCC (1997 and 2000). The contribution of emissions from livestock other than cattle to the total emissions from enteric fermentation was not significant: 4 % 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 2006 Gl. (IPCC 2006)), methane conversion factor of zero is assumed for all juveniles consuming only milk (calves categories) – p.10.30 IPCC 2006 Gl. (IPCC 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 including calves. 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, 1990–2017):

- Calves younger than 6 months of age (male and female)
- Young bulls and heifers (6-12 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, IPCC 2006 Gl. (IPCC 2006)), 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. 2017, 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.

Since 2017 the Czech Statistical Office harmonized the age categories used for cattle with the national legislation. Accordingly, were updated the relevant body weight of calves and young bulls and heifers in the estimation.

Tab. 5-5 Weights of individual cattle categories, 1990–2017, in kg

Categories of cattle	1990 – 1994	1995 – 1998	1999 – 2004	2005 – 2009	2010 – 2015	2016	2017*
Mature cows (dairy and suckler)	520	540	580	585	590	620	620
Heifers > 2 years	485	490	505	510	515	541	541
Bulls and bullocks > 2 years	750	780	820	840	850	850	850
Heifers 1-2 years	380	385	395	395	390	410	410
Bulls 1-2 years	490	510	530	540	560	560	560
Heifers 8-12 months*	275	280	285	285	290	299	265*
Bulls 8-12 months*	325	330	335	340	350	368	300*
Calves female to 8 months*	128	132	133	135	135	139	115*
Calves male to 8 months*	128	132	133	135	135	149	115*

*** Since 2017 the Czech Statistical Office harmonized the age categories with the national legislation (i.e. 0-6 month, 6-12 month) the relevant body weight of calves and young bulls and heifers were used in the estimates.**

Tab. 5-6 Feeding situation, 1990–2017, in % of pasture, otherwise stall is considered

Categories of cattle	1990 – 1994	1995 – 1998	1999 – 2004	2005 – 2009	2010 – 2015	2016	2017*
Dairy cows	10	20	20	22	15	15	15
Suckler cows	10	20	20	50	95	95	95
Heifers > 2 years	30	30	30	35	50	50	50
Bulls > 2 years.	30	40	40	40	25	25	25
Heifers 1-2 years	30	40	40	40	50	50	50
Bulls 1-2 years	30	40	40	40	25	25	25
Heifers 8-12 months*	30	40	40	40	50	50	50
Bulls 8-12 months*	30	40	40	40	50	50	50
Calves female to 8 months*	0	0	0	0	0	0	0
Calves male to 8 months*	0	0	0	0	0	0	0

*** Since 2017 the Czech Statistical Office harmonized the age categories with the national legislation (i.e. 0-6 month, 6-12 month).**

Tab. 5-7 Grazing days for individual cattle categories for the entire period

Categories of cattle	1990 – 1994	1995 – 1998	1999 – 2004	2005 – 2009	2010 – 2015	2016	2017*
Dairy cows	18	36	36	40	27	27	27
Suckler cows	18	36	36	90	171	171	171
Heifers > 2 years	54	54	54	63	90	90	90
Bulls > 2 years.	54	72	72	72	45	45	45
Heifers 1-2 years	54	72	72	72	90	90	90
Bulls 1-2 years	54	72	72	72	45	45	45
Heifers 8-12 months*	54	72	72	72	90	90	90
Bulls 8-12 months*	54	72	72	72	90	90	90
Calves female to 8 months*	0	0	0	0	0	0	0
Calves male to 8 months*	0	0	0	0	0	0	0

*** Since 2017 the Czech Statistical Office harmonized the age categories with the national legislation (i.e. 0-6 month, 6-12 month).**

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 22.53 l/day/head in 2017, with an average fat content of 3.89 %. 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 Breeding in the Czech Republic (annual report).

As the official statistics, specifically from CzSO, provide population values for cows and other cattle, the resulting EFs in the CRF Tables are defined for the categories of "Dairy cows" and "Non-dairy cattle".

The 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).

Tab. 5-8 Milk production of dairy cows and fat content (1990–2017)

	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
2017	370	22.53	3.89

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 (IPCC 2006 Gl. (IPCC 2006)).

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 1990-2017 period to about one half of the former values due to the rapid decreases of the numbers of animals kept.

Tab. 5-9 Activity data and methane emissions from enteric fermentation, cattle category (Tier 2, 1990–2017)

	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	41.78	116.61	96.10	212.71
1991	1165	2195	93.06	41.91	108.45	91.98	200.43
1992	1006	1943	94.85	43.19	95.44	83.92	179.37
1993	902	1609	95.17	42.92	85.88	69.07	154.95
1994	796	1366	97.17	42.90	77.32	58.59	135.91
1995	732	1298	101.21	45.05	74.11	58.46	132.57
1996	713	1275	102.83	45.43	73.37	57.94	131.20
1997	656	1210	100.99	46.26	66.28	55.96	122.24
1998	598	1103	105.53	46.44	63.09	51.22	114.31
1999	583	1074	110.16	49.30	64.23	52.97	117.19
2000	548	1026	112.61	49.79	61.69	51.08	112.76
2001	529	1053	114.51	50.69	60.62	53.38	114.00
2002	496	1024	118.21	51.74	58.67	52.97	111.64
2003	490	984	120.81	52.12	59.23	51.26	110.50
2004	476	952	123.20	52.05	58.63	49.58	108.21
2005	438	960	125.72	53.18	55.04	51.02	106.07
2006	424	950	126.91	53.22	53.81	50.54	104.35
2007	410	981	128.55	53.63	52.75	52.62	105.37
2008	406	996	130.48	54.38	52.91	54.16	107.08
2009	400	964	131.53	54.37	52.55	52.39	104.94
2010	384	966	132.02	52.35	50.63	50.55	101.19
2011	374	970	134.49	52.91	50.28	51.32	101.59
2012	373	981	137.08	52.86	51.15	51.83	102.98
2013	367	985	137.67	53.16	50.57	52.39	102.96
2014	373	1001	140.54	52.71	52.37	52.76	105.13
2015	376	1031	142.90	52.81	53.75	54.44	108.19
2016	373	1043	146.38	53.80	54.53	56.12	110.65
2017	370	1051	148.05	55.25	54.75	58.09	112.84

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 % in 2017). 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 (1990-2017). Considering the rather small numbers in these animal categories, default emission factors (Table 10.10 from IPCC 2006 Gl. (IPCC 2006)) 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 2006 Gl. 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 1990-2017 is presented in Tab.5-10.

Tab. 5-10 Methane emissions from enteric fermentation, other livestock (Tier 1, 1990–2017)

	Sheep	Swine	Goats	Horses	Total
	CH_4 Emissions from Enteric fermentation [kt]				
1990	3.44	7.19	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**
2017	1.74	2.24	0.14	0.62	**4.74**

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.

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:

1) Emissions of methane from enteric fermentation of livestock (a key source) come predominantly from cattle. Therefore Tier 2, as described in Good Practice (Good Practice Guidance, 2000) is applied only to cattle.
2) CH_4 emissions from enteric fermentations of other farm animals are estimated by Tier 1 approach. Because of some features of keeping livestock in the Czech Republic that are similar to the neighbouring countries of Germany and Austria, default EFs for Tier 1 approaches recommended for developed countries were employed.

Increased attention was firstly paid to enteric fermentation. It was stated that cooperation with specialized agricultural experts is crucial to obtain new consistent and comparable data of suitable quality. The relevant nationally specific data 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.

The important revision of cattle weight data (Submission 2018), along with harmonization of this input data with national legislation, resulted in the increase of the country specific emission factors for enteric fermentation as well as the increase of total emission by about 2 % in category enteric fermentation.

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.

Estimated enteric fermentation emission factor for dairy and other cattle were compared with default enteric fermentation factors available for Western Europe region in IPCC 2006 Gl. (IPCC 2006) (table 10.11). While the EF for other cattle is comparable with country specific one (default value= 57, country specific value=55.25), the EF for dairy cattle is rather different: default value = 117, country specific value is 148.05.

Technical update of specific calculation spreadsheet used for generating input data (EFs, GE, Nex rate) of cattle categories was accomplished during summer 2018. The complete set of equations was revised. The new system is robust and safe, and it minimizes risk of technical errors.

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

The ERT encouraged to report the total gross energy intake of non-dairy cattle and a reduced CH_4 conversion rate in CRF table 3.As1.

The emission factor for methane from fermentation (EF) in kg/head p.a. is proportional to the daily food intake and the methane conversion factor Ym. The “gross energy intake” (GE, MJ/head/day) is taken as the main feed ratio for the given type of cattle (there are 10 subcategories of cattle) and Ym is methane conversion factor, which is considered 0.065 for cattle and zero for calves’ categories, respectively. Thus, for non - dairy cattle category the weighted average of methane conversion factor was calculated for each year in the whole time series to meet the encouragement of ERT.

Tab. 5-11 Demonstration of changes in input data caused by Ym estimation (submissions 2017-2019), other cattle category

Item	Before recalculation	After recalculation	Before recalculation	After recalculation	Before recalculation	After recalculation
Submission (year)	2017	2017	2018	2018	2019	2019
EF for Enteric Fermentation	55.34	52.81	56.46	53.80	59.18	55.25
EF for Manure Man.	9.03	9.03	9.17	9.17	9.67	9.34
VS	2.80	2.80	2.87	2.87	2.95	2.84
Nitrogen excretion	66.21	66.21	67.90	67.90	70.05	66.90
Gross energy	130.03	140.86	132.34	144.02	129.57	142.43

As a result of this change in estimation procedures the value of emission factor decreased by about 5 % for non- dairy cattle category. It means that the methane emissions of enteric fermentation decreased by about 0.3 % and the total emissions from agriculture decreased by about 0.4 %. The value of GE estimated for non-dairy cattle increased by about 8 %. The overview of changes in input data is presented in Tab. 5-11 and Tab. 5.12.

Implementation of two different values of Ym factor caused the increase of estimated GE values for category “other cattle”. Results are presented in Tab 5-12.

Tab. 5-12 Results of the recalculations caused by usage of two different values for Methane conversion factor (Ym) to Gross Energy data (GE, MJ/head/day) of other cattle in reported period (1990-2017)

Data	1990	1995	2000	2005	2010	2015	2016	2017
Submission 2018	104.3	111.8	122.2	129.6	128.9	130.0	132.4	
Submission 2019	116.0	122.7	132.3	138.6	140.3	140.9	144.0	142.4

Estimation of emissions factors for enteric fermentation and emissions of nitrous oxide and methane from manure of cattle are based on body weight, mature weight and typical animal mass of diary and non-dairy cattle. Weight data used in national legislation No 377/2013 were applied in the last NIR submission excluding the calves’ categories because of the inconsistency in age categorization. Since 2017 the Czech Statistical Office harmonized the age categories with the national legislation and we accordingly used the relevant body weight of calves in the estimates. There is no possibility to estimate the change of total emissions because the change of age categories influent at the same time the body weight and number of heads in relevant categories. Overview of animal weight data used in submissions 2017-2019 is presented in Tab. 5-13.

Tab. 5-13 Overview of activity data (animal weight) per individual cattle categories in submissions 2017, 2018, 2019

Categories of cattle	An. weight 2017 [kg]	An weight 2018 [kg]	An weight 2018 [kg]	National legislation
Mature cows (dairy and suckler)	590	620	620	650
Heifers > 2 years	515	541	541	600
Bulls and bullocks > 2 years	850	850	850	800
Heifers 1-2 years	390	410	410	470
Bulls 1-2 years	560	560	560	560
Heifers 8-12 months*	290	299	265*	265*
Bulls 8-12 months*	350	368	300*	300*
Calves female to 8 months*	135	139	115*	115*
Calves male to 8 months*	135	149	115*	115*

**** Since 2017 the Czech Statistical Office harmonized in reporting the age categories with the national legislation (i.e. 0-6 month, 6-12 month) the relevant body weight of calves and young bulls and heifers were used in the estimates.**

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.

5.2.2 Manure Management (CRF 3.B)

This chapter describes the estimation of CH_4 (47 % share on emissions from Manure management category) and direct (37 %) and indirect (16 %) N_2O emissions from animal manure management. Total emissions from manure management (CH_4 and N_2O) equalled 1 562 Gg CO_2 eq. in 2017. 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 1990-2017 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 and milk quality).

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. 5-14.

Tab. 5-14 Overview of emissions from manure management (1990-2017, kt CO_2 eq)

	Total emissions in category [kt CO_2 eq.]	CH_4 emissions [kt CO_2 eq.]	Direct N_2O emissions [kt CO_2 eq.]	Indirect N_2O emissions [kt CO_2 eq.]
1990	3 315	1 695	1028	592
1995	2 305	1 180	734	390
2000	2 042	1 031	659	351
2005	1 836	943	586	308
2010	1 581	756	564	260
2015	1 552	727	573	252
2016	1 580	741	582	257
2017	1 562	734	576	252

5.2.2.2 Methodological issues

5.2.2.2.1 Animal Waste Management System

During the 1990-2017 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 and milk quality).

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. 5-14.

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. 5-15. The country specific distribution of manure for other livestock categories is presented in Tab. 5-16.

Tab. 5-15 Overview of the Czech country specific AWMS systems for cattle category (1990-2017)

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 (Weighted AVG)				

Dairy cows	Fraction of Manure Nitrogen per AWMS [%]			
	Liquid	Daily spread	Solid	PRP
1990	45	1	42	12
1995	43	1	39	17
2000	44	1	38	17
2005	49	1	34	16
2010	43	1	32	24
2011 – now	42	1	32	25

Tab. 5-16 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

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 (IPCC 2006 Gl. (IPCC 2006)), see Tab. 5-17. Data about the usage of manure in anaerobic digesters are not available for the period 1990-2017.

Tab. 5-17 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.

In relation to the decreasing trend in the animal population (especially cattle and swine) the methane emissions from manure management rapidly declined during 1990-2012. The slow increase started from 2014. The trend in methane emissions form manure management is presented in Fig. 5-2.

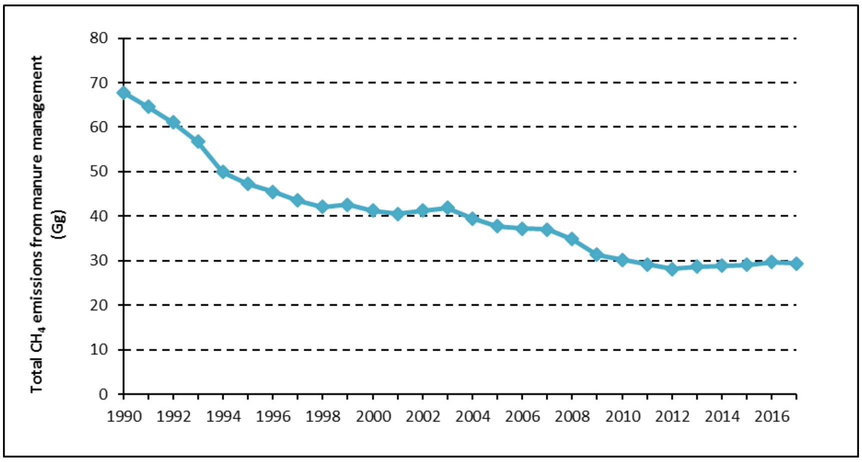


Fig. 5-2 The trend in methane emissions from manure managent in period 1990-2017 (in Gg)

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 (1990-2017). Gross energy (GE) values are estimated based on the national study Kolář *et al*. (2004) and IPCC 2006 Gl. (IPCC 2006) 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. 5-18).

Tab. 5-18 Gross Energy (GE, MJ/head/day) of cattle in reported period (1990-2017)

	1990	1995	2000	2005	2010	2015	2016	2017
Dairy cows	226.8	237.4	264.1	294.9	309.7	335.2	343.4	347.28
Other cattle	116.0	122.7	132.3	138.6	140.3	140.9	144.0	142.4

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 Gl. (IPCC 2006)) and correspond to the Czech climate zone. The parameters recommended in Dämmgen *et al.* (2012) were utilized for the emission estimation (Tab. 5-19). 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. 5-20.

Tab. 5-19 List of parameters for methane emission factor estimation in manure management in the Czech conditions

Parameters (IPCC 2006 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 396 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.

The equations for determination of emission factors and estimation of methane emissions were taken from the IPCC 2006 Gl. (IPCC 2006)):

1. The Eq. 10.22 (IPCC 2006 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 (IPCC 2006 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 (IPCC 2006 Gl., p. 10.41) :

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

Tab. 5-20 Overview of VS Parameter (kg dry matter/head/day), EF (kg CH_4/h/yr) and methane emissions (Gg) from manure management, Cattle category (1990-2017)

	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	18.09
1991	4.03	13.39	15.61	2.26	7.89	17.31
1992	4.10	13.65	13.74	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	10.40
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	5.50	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	9.31
2016	6.33	22.29	8.31	2.87	9.17	9.56
2017	6.41	22.55	8.34	2.84	9.34	9.82

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. 5-21)

Tab. 5-21 Default emission factors used to estimate CH_4 emissions from manure management (Table 10.15 and 10.14 IPCC 2006 Gl.)

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 2006 Gl. 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 2006 Gl. (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. 5-22. The Eq. 10.32 and 10.33 (IPCC 2006 Gl. (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, IPCC 2006 Gl.) are used for different AWMS.

Tab. 5-22 Example of Input data used for calculation of Nex for dairy cattle in 2017

Input data	Country specific value, 2017	Sourse
Protein, milk, %	3.46	Annual book of cattle breeding
Protein, feed, %	16.5	Task force of reactive nitrogene, 2015
Milk production, l/head	22.53	Annual book of cattle breeding
N intake, kg N/head/yr	181.37	IPCC 2006 Gl., eq 10.32
N milk, kg N/head/yr	44.60	IPCC 2006 Gl., eq 10.33
N weight gain, kg N/head/yr	0	IPCC 2006 Gl., eq 10.32
N excreted, kg N/head/yr	136.78	IPCC 2006 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. 5-23.

Tab. 5-23 The Czech national Nex (nitrogen excretion) values used to estimate N_2O emissions from manure management (1990-2017)

	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	65.93

	Nitrogen excretion (Nex)	
	Dairy cattle	Non-dairy cattle
	[kg/head/year]	
2015	132.55	66.21
2016	136.12	67.90
2017	136.78	66.90

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, IPCC 2006 Gl.). Relevant input data is available in Tab. 5-24. 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. 5-24 Input data and nitrogen excretion (Nex) for other animal categories, input data, Submission 2019

Livestock type	Typical animal mass [kg/head]	Nex rate [kg/head/yr]	Nex [kg/head/yr]
Sheep	49	0.85	15.2
Swine	59	0.68	14.64
Poultry			
Broilers	2	1.10	0.8
Other poultry	2	0.95*	0.7
Horses	498	0.26	47.2
Goats	19	1.28	8.9

** * 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 2017 is reported in Tab. 5-25.

Tab. 5-25 Nitrogen production in manure distributed by individual AWMS (kg N/yr)

AWMS	Nitrogen Production in Manure [kg N/yr]
Liquid systems	61 886 572
Daily spread	1 209 174
Solid storage	60 633 429
Pasture range and paddock	26 126 954
Other	14 206 817
Totals	164 062 946

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 “NA” notation key is reported in the CRF tables for N lost through volatilization and runoff and “NE” for emissions (recommendation of the ERT review from 2016).

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. 5-3).

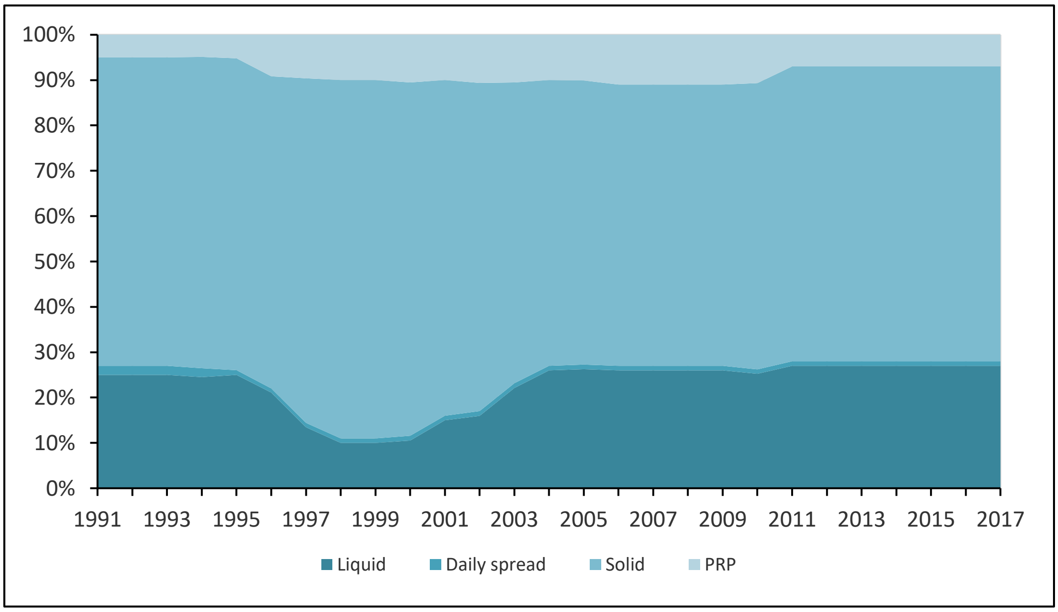


Fig. 5-3 Development of Manure Managements systems share used for calculations.

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 calculated by Tier 2 methods for both cattle categories. Default values (Table 10.14, IPCC 2006 Gl.) are lower than country specific ones:
Dairy cattle, methane emission factor for manure management:

Default value = 21, country specific value (Submission 2019) = 22.55

Non-dairy cattle, methane emission factor for manure management:

Default value = 6, country specific value (Submission 2019) =8.34.

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 2006 Gl. (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 (Submission 2019) = 0.60,

Non-dairy cattle, Nex rate:

Default value= 0.33, country specific value (Submission 2019) = 0.46.

Tier 2 procedures are used for estimation of VS parameters for cattle. Country specific values were compared with default value available in IPCC 2006 Gl. (Table 10A-4 a 10A-5):

Dairy cattle, daily volatile solid excreted (VS):

Default value = 5.10, country specific value (Submission 2019) = 6.41

Non-dairy cattle, daily volatile solid excreted (VS):

Default value = 2.66, country specific value (Submission 2019) = 2.84

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. 5-26. Overestimation of N_2O emissions in the Manure Management category is probable.

Tab. 5-26 Comparison of Nitrogen excretion data estimated in NIR (Submission 2019) 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 , used in NIR Kg N/head/year
Dairy cattle (Tier 2)	84	105	136.1
Other cattle (Tier 2)	70	55	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 (Svoboda, P. 2016). 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

No recalculation was performed in this submission.

There was a technical error in copying Nex rate data of goats and horses from the local calculation spreadsheet to the CRF reporter. However, the estimated emissions were correct. The error in activity data as inserted in CRF were updated.

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 by 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. 5-27 N_2O emissions from Agricultural Soils in period 1990-2017 in kt N_2O

Year	Total emissions	Synthtic fertilizersA	Animal manureb	Sewage sludgec	Crop residuesd	Mineralr Soil	PRP	Atmosph. deposition	Leaching
1990	18.9	6.6	3.0	0.004	3.9	0.04	0.8	1.4	3.2
1995	12.0	3.6	1.9	0.01	2.9	0.04	0.7	0.8	2.0
2000	10.7	3.3	1.7	0.02	2.5	0.05	0.6	0.8	1.8
2005	10.2	3.3	1.6	0.02	2.3	0.07	0.6	0.7	1.7
2010	10.0	3.6	1.3	0.04	2.0	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	12.2	4.6	1.4	0.04	2.6	0.01	0.8	0.8	2.0
2017	12.2	4.5	1.3	0.04	2.8	0.01	0.7	0.8	2.0

In 2017, 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 (the minimal level) and then slowly increasing. The emissions from managed soils decreased from 1990 to 2017 by about 35 %. Tab. 5-27 and Fig. 5-4 present the N_2O emissions of Agricultural soils by the individual sub-categories.

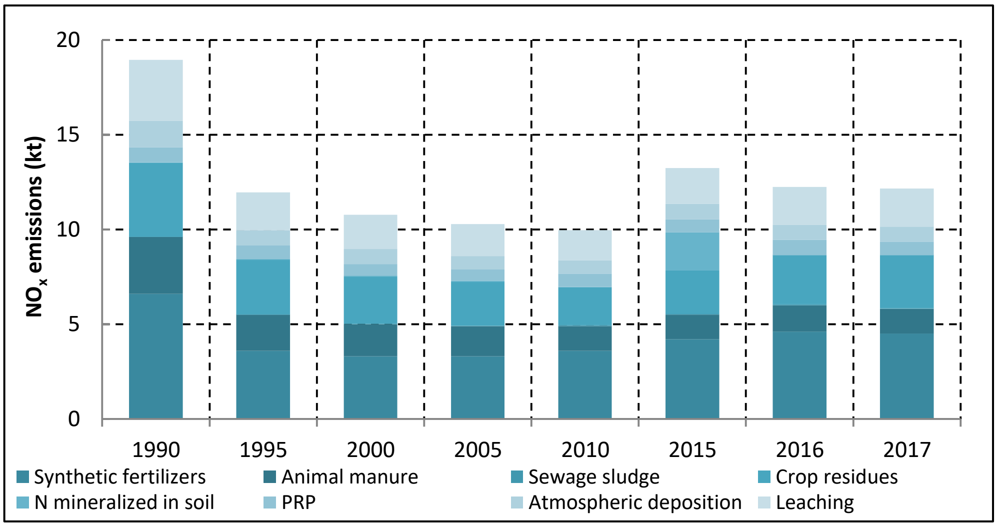


Fig. 5-4 N_2O emissions of Agricultural soils by the individual sub-categories

Although agricultural soils are the key source, emissions of N_2O are estimated and analysed using Tier 1 approach of the IPCC 2006 Gl. (IPCC 2006) 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 Methodological issues

Although agricultural soils are the key source, emissions of N_2O are estimated and analysed using Tier 1 approach of the IPCC 2006 Gl. (IPCC 2006). 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, 1990-2017);
- Managed manure nitrogen available for application to the soil (NIR data, Eq.10.34);
- Annual yields (harvest/production area), CzSO data, Statistical Yearbooks, 1990-2017)
- 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, 2002-2017, retrospective analysis for the period 1990 – 2001)
- Amount of N in mineral soils that is mineralised, in association with loss of soil C in Cropland remaining Cropland category (LULUCF, NIR data)

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. 5-28. The IPCC default fraction values are used to estimate N_2O emissions (IPCC 2006).

Tab. 5-28 The emission factors for the estimation of the direct emissions from managed soils (Table 11.1, IPCC 2006 Gl.)

Direct emissions	Synthetic fertilizer	EF_1 = 0.01 kg N_2O-N/kg N
	Animal Waste	
	Sewage Sludge	
	N-crop residues	
	Mineralized N	
Pasture, range & paddock manure	Cattle, pigs, poultry	EF_3 = 0.02 kg N_2O-N/kg N
	Sheep, others	EF_3 = 0.01 kg N_2O-N/kg N

Synthetic N fertilizers (F_{SN}, CRF 3.D.1.1)

The application of agricultural fertilizers was formerly intensive in the Czech Republic, but decreased radically 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. Hopefully this negative trend ended in 2017 when only 286 kt of fertilizers was applied (2 % decreasing). This trend is presented in the Fig. 5-5.

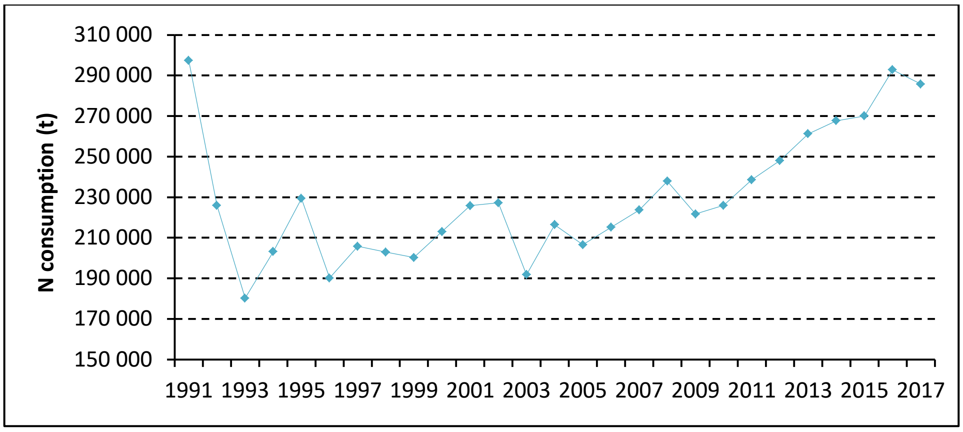


Fig. 5-5 Consumption of synthetic fertilizers during reporting period

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 (IPCC 2006 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., IPCC 2006 Gl.) were utilized to estimate the emissions from sewage sludge (FSEW).

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. 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. 5-6).

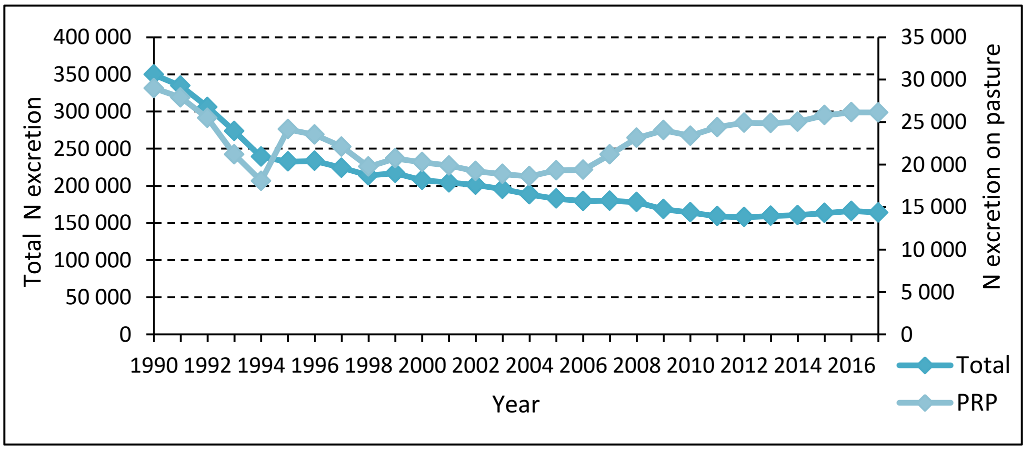


Fig. 5-6 Trend in the total amount of nitrogen excretion and nitrogen excretion from pasture during the reporting period

Two default emission factors (Tab. 5-29) are used to estimate emissions from different animal categories (Table 11.1, IPCC 2006 Gl.). The fraction of livestock N excreted and deposited onto soil during grazing ($Frac_{GRAZ}$) varied from 0.083 in 1990 to 0.159 in 2017.

Tab. 5-29 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. 5-31). 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 IPCC 2006 Gl.is available.

Overview of the annual yield of agriculture products is presented in Tab. 5-30. Production of grains, pulses, fodder and soya beans are almost steady state while the production of potatoes and sugar beet is growing.

Tab. 5-30 Annual yield of agricultural products (t/ha) during the reporting period

	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
2017	5.50	2.34	29.42	66.56	9.97	2.41

Tab. 5-31 Default value of input factors used in estimation of FCR, Table 11.2 (IPCC 2006 Gl.), calculated data – Submission 2019

	Grains	Pulses	Potatoes	Sugar beets	Fodder	Soya beans
Dry mater	0.88	0.91	0.22	0.22	---	0.91
R_{AG} calculated	1.25	1.49c	0.14	0.12	0.30	1.49
$AG_{DM,}$ calcul.	6.88	3.50	4.00	7.72	2.99	3.59
$Frac_{Remove}$	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 (IPCC 2006 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. 5-31.

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 (IPCC 2006 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. 5-33): 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. 5-32.

Tab. 5-32 The IPCC default parameters/fractions used for indirect emission estimation (Table 11-3, IPCC 2006 Gl.)

Parameters/Fractions	Default values
$Frac_{GASM}$	0.20
$Frac_{GASF}$	0.10
$Frac_{LEACH-(H)}$	0.30

Tab. 5-33 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 IPCC 2006 Gl.

The quantitative overview and emission trends during period 1990-2017 are shown in Fig. 5-1 and trend in N_2O emissions from agricultural soils is summarized in Tab. 5-2. During 1990-2017 the total emissions from Agricultural soils decreased by 35 % (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 for previous submission (see Chapter 5.4.5., NIR 2018).

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.

During the QA/QC process the technical errors were identified in a supporting calculation spreadsheet that was used for nitrogen estimation from Crop residues and N- fixing forage (see chapter 5.4.5.).

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

The technical errors were identified in a supporting calculation spreadsheet that was used for nitrogen estimation from Crop residues and N- fixing forage. The recalculation was done for the whole time series. The correction increased the emissions from Crop residues by 4 % and by 0.8 % of the total emissions from Agriculture soils. Results of the technical corrections is presented in Tab. 5-34.

Tab. 5-34 Overview of N_2O emissions from Crop residues, before and after correction of technical error (period 1990-2017 in kt N_2O)

Year	Crop residues Emissions, before corrections	Crop residues Emissions, after correction	Change , em. increase after correction
1990	3.7	3.9	+0.02
1995	2.6	2.9	+0.03
2000	2.2	2.5	+0.03
2005	2.2	2.3	+0.01
2010	1.9	2.0	+0.01
2015	2.3	2.3	0
2017		2.8	-

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. 5-35). 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 2017 the liming in forests equals almost 3.6 %.

Tab. 5-35 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]d
1990	2650	27	2676	2 409	267
1995	248	2	251	226	25
2000	209	47	255	230	26
2005	143	3	145	131	15
2010	135	5	140	126	14
2015	353	18	371	334	37
2016	366	18	379	341	38
2017	345	13	358	322	36

The quantification followed the Tier 1 method (Eq. 11.12, IPCC 2006 Gl.), with an emission factor of 0.12 t C/t $CaCO_3$ 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. This increasing ended in 2017 when the amount applied was by about 6 % lower than in 2016. 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 2017 reached more than 358 thousand tons, while 3.4 %, 13 thousand tons, 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 in 2016.

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

No recalculation was performed in this submission.

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

The analysis of uncertainties is in progress.

5.8 Urea Application (CRF 3.H)

5.8.1 Source category description

Adding urea to soils during fertilization leads to a loss of CO_2 that was fixed in the industrial production process. Urea is converted into ammonium, hydroxyl ion and bicarbonate, in the presence of water and urea enzymes. This source category is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector).

5.8.2 Methodological issues

Tier 1 and Eq. 11.13 are utilized to estimate CO_2 emissions. Domestic production records for urea were used to obtain an approximate estimate of the amount of urea applied to soils on an annual basis (Tab. 5-36). 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 2015 is based on farmers' fertilizer records and annual intake of nutrient from Urea. The application of urea to agricultural land in 2017 reached almost 169 kt of urea. The reason of such significant decrease (- 41 %) is the general trend to decrease the usage of mineral fertilizer in the agriculture sector in the Czech Republic.

Tab. 5-36 Estimated consumption of urea (IPPU) applied to managed soils in Czech Republic during reporting period (MA, 2018)

	1990	1991	1992	1993	1994	1995	1996
Consumption of Urea [kt]	148	180	148	127	124	149	137
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Consumption of Urea [kt]	92	195	120	65	106	87	83
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Consumption of Urea [kt]	96	101	113	166	137	117	152
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
	151	185	171	78	255	287	169

5.8.2.1 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 %.

5.8.3 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).

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

No recalculation was performed in this submission.

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

The analysis of uncertainties is in progress.

6 Land Use, Land-Use Changes and Forestry (CRF Sector 4)

6.1 Overview of sector

The emission inventory of the Land Use, Land Use Change and Forestry (LULUCF) sector includes emissions and removals of greenhouse gases (GHG) resulting from land use, land-use change and forestry. The inventory was originally based on application of the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003, further also abbreviated as GPG for LULUCF) and the reporting format adopted by the 9th Conference of the Parties (COP) to UNFCCC. The reporting guidelines were revised at the 19th COP in 2013 by decision 24/CP.19. It demands that, starting in 2015, Parties included in Annex I to the Convention should apply the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) that are linked to the previously used methods outlined in Chapter 3 of GPG for LULUCF (IPCC 2003). In addition, decision 24/CP.19 encourages the use of the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC 2014a) in preparing the annual inventories under the Convention due in 2015 and beyond. The current LULUCF reporting is also guided by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC 2014b). This material is used, together with IPCC (2006), to prepare the assessment and reporting of annual changes in carbon stocks and associated CO_2 emissions and removals from the Harvested Wood Products (HWP contribution), which 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 representation and land-use change identification at the level of the individual cadastral units. Although the Czech LULUCF inventory remains 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 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 2017. The currently reported estimates changed in comparison with the previously reported values as a result of several refinements in methodology, activity data and adopted emission factors affecting emission estimates for some categories that resulted in recalculations for the entire reporting period. The current and previously reported sectoral estimates of greenhouse-gas emissions and removals are shown in Fig. 6-1. The newly implemented improvement and changes led to changed estimates for the individual years compared to the previously reported emission removals: the mean difference for the comparable years

1990-2017 is 11.6%. The data shown in Fig. 6-1 include emissions and removal for all land use categories and estimate of the HWP contribution. Detailed information on the implemented changes and performed recalculations is provided below for the individual LULUCF categories.

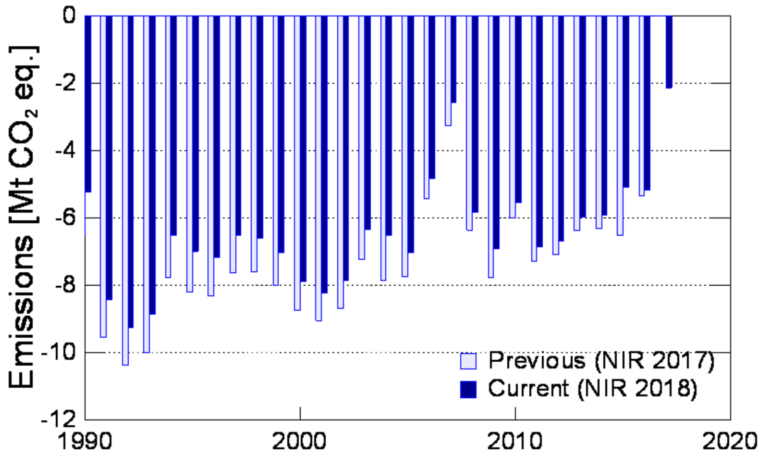


Fig. 6-1 The current and previously reported estimates of emissions for the LULUCF sector. The values are negative, corresponding to net removals of green-house gases.

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, 2017.

Tab. 6-1 GHG estimates in Sector 4 (LULUCF) and its categories in 1990 (base year) and 2017

Sector/category	Emissions 1990 kt CO_2 eq.	Emissions 2017 kt CO_2 eq.
4 Total LULUCF	-5 226	-2 135
4.A Forest Land	-4 618	-1 619
4.A.1 Forest Land remaining Forest Land	-4 208	-948
4.A.2 Land converted to Forest Land	-409	-671
4.B Cropland	186	36
4.B.1 Cropland remaining Cropland	90	12
4.B.2 Land converted to Cropland	96	23
4.C Grassland	-140	-379
4.C.1 Grassland remaining Grassland	48	-131
4.C.2 Land converted to Grassland	-188	-248
4.D Wetlands	22	21
4.D.1 Wetlands remaining Wetlands	(0)	(0)
4.D.2 Land converted to Wetlands	22	21
4.E Settlements	1 035	584
4.E.1 Settlements remaining Settlements	(0)	(0)
4.E.2 Land converted to Settlements	1 035	584
4.F Other Land	(0)	(0)
4.G Harvested Wood Products	-1 713	-779

Note: Emissions of non-CO_2 gases (CH_4 and N_2O) are also included.

In 2017, the net GHG flux for the LULUCF sector, estimated as the sum of emissions and removals, equalled -2 135 kt 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 2017, the removals realized within the LULUCF sector decrease the GHG emissions generated in other sectors by 1.7%. Correspondingly, for the base year of 1990, the total emissions and removals in the LULUCF sector equalled -5 225 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 2.6% 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 (2017)

Category	Gas	KC A1	KC A2	KC A1[1]	KC A2[1]	% of total GHG[1]
4.A.1 Forest Land remaining Forest Land	CO_2	LA, TA	LA, TA	yes	yes	0.79
4.G Harvested wood products	CO_2	LA, TA	TA	yes	yes	0.61
4.A.2 Land converted to Forest Land	CO_2	LA, TA		yes		0.53
4.E.2 Land converted to Settlements	CO_2	LA, TA	LA		yes	0.46

KC: key category
[1] including LULUCF

Of the main categories listed in Tab. 6-1, four were identified as key categories according to the IPCC 2006 Gl. for 2017. One is 4.A.1 Forest Land remaining Forest Land with a contribution of 0.79%, 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. The second is 4.G Harvested wood products, the third is 4.A.2 Land converted to Forest Land. Additionally, 4.E.2 Land converted to Settlements was identified as a key category. Its contribution reached a more marginal share of 0.46%, which, however, still qualifies it among the key categories by the level assessment for 2017.

6.1.3 Coverage of pools and methodological tiers

The current inventory submission of the LULUCF sector includes all the mandatory categories and carbon pools, as well as emissions related to HWP. The specific information related to methodological tiers and pools included in the category estimates is provided under the individual chapters by the IPCC land use categories (Chapters 6.4 to 6.9) and the category of HWP contribution (Chapter 6.10).

6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The reporting format requires the estimation of GHG emissions into the atmosphere by sources and sinks for six land-use categories and, since reporting year 2013, also for the land-unspecific category of Harvested wood products (4.G). The land-use categories are Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land. Each of these categories is divided into lands remaining in the given category during the inventory year, and lands that are newly converted into the category from a different one. Accordingly, IPCC 2006 Gl. (IPCC 2006) outline the appropriate methodologies for estimation of green-house gas emissions.

Consistent representation of land areas and identification of land-use changes constitute the key steps in the inventory of the LULUCF sector in accordance with the IPCC 2006 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 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 (IPCC 2006 Gl. (IPCC 2006)) imply that, for the reported period of 1990 to 2017, the required land use should be available for the period starting from 1969. Information on land use was obtained from the Czech Office for Surveying, Mapping and Cadastre (COSMC), which administers the database of “Aggregate areas of cadastral land categories” (AACLC). The AACLC data were compiled at the level of the individual cadastral units (1992-2017) 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 2017, the total number of cadastral units varied between 13 027 and 13 091.

To identify the administrative separation and division of cadastral units within a given year, two approaches were employed. Previous to 2004, the cadastral units were crosschecked by comparing the areas in subsequent years using a threshold of half-hectare difference. Starting in 2004, the explicit change of land use was quantified within and for each year directly by the data provider, i.e., COSMC, at the request of the inventory team. The latter approach does not require reconciliation of individual cadastral units between the consecutive years, as it adopts the addressed land use change information available in the national database of COSMC.

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 content of the IPCC land use categories is summarized in Table 6-3 and it can also be found in the respective 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.

<table>
<tr><th>IPCC land-use category</th><th>CRF coding</th><th>Czech national cadastral (COSMC) ID code and land-use category</th></tr>
<tr><td>Forest land</td><td>4.A</td><td>10. Forest land
- Land with forest stad and land, where forest stands wete 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 state forest administration [Forestry Act 289/1995])</td></tr>
<tr><td>Cropland</td><td>4.B</td><td>2. Arable land
- Land of arable soil according to the Agriculcure Act
3. Hop fields
- Land of hop field according to the Agriculcure Act
4. Vineyards
- Land of vineyard according to the Agriculcure Act
5. Gardens
- Land for permanent and dominant production of vegetable, flowers and other garden products or land with fruit trees and shrubs close to residential and industrial buildings
6. Fruit orchard
- Land of fruit orchard according to the Agriculcure Act</td></tr>
<tr><td>Grassland</td><td>4.C</td><td>7. Permanent grassland
- Land of permanent grassland according to the Agriculcure Act</td></tr>
<tr><td>Wetlands</td><td>4.D</td><td>11. Water area
- Land of watercourse and riverbeds, water reservoir, marsh, wetland or swamp
(22). Other area – waterlogged area
- Land of Other area that is waterlogged (marsh, wetland or swamp)</td></tr>
<tr><td>Settlements</td><td>4.E</td><td>13. Built-up area and courtyard
- Land with building including courtyard, common yard,
14. Other area
- Land not classifying under 2, 3, 4, 5, 6, 7, 10, 11 and 13, such as transport infrastructure, manipulation areas, depot, landfill, photovoltaic power station and others
(21). Other area – unfertile land
- Land not suited for production and other use</td></tr>
<tr><td>Other land</td><td>4.F</td><td>NO since 2018 NIR submission, earlier represented by (21) Other area – unfertile land</td></tr>
</table>

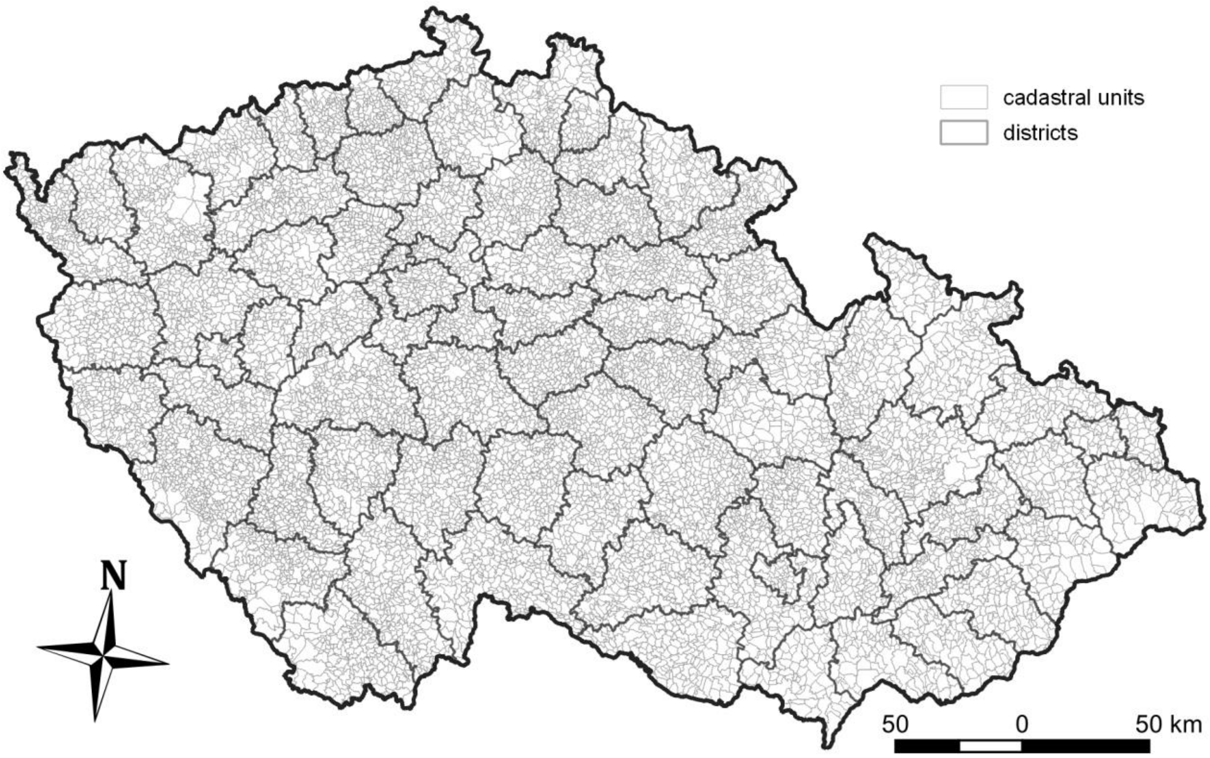


Fig. 6-2 Cadastral units (grey lines; n = 13 084 in 2017) and districts (black lines; n=79), the basis of the Czech land use representation and land use change identification system.

6.2.3 Land-use change identification

The critical issue of any LULUCF emission inventory is the quantitative determination of land-use change. This inventory adopts two approaches for identifying and quantifying land-use changes on an annual basis: i) until 2003 by balancing the six major land-use areas for each of the individual or integrated cadastral units on use of the subsequent years of the available period and ii) since 2004, using the within-year explicitly addressed land-use conversions registered and estimated by COSMC, the authorized administrator of cadastral information in the country. Although both the approaches are in principle identical, the later approach is more accurate, as it captures virtually all changes within each individual cadastral unit, including theoretically possible bi-directional changes involving the same pair of land use categories within one particular year. In practice, the actual effect of the more advanced, latter approach is not significant under the conditions of the Czech Republic. However, it greatly improves the transparency of the system and the data are basically readily usable as supplied by the data provider (COSMC) without further processing. The resolution of the implemented land use representation and land use change identification system is demonstrated in Fig. 6-3. In the example of the cadastral unit of Kácov (ID 656305), it can be observed that during 2011, two land-use categories lost their land, while the other two increased their area. However, as shown in the table, there were six specific land-use changes involved in these land use changes, where Forest land and Grassland were partly converted to Settlements and Cropland. The latter approach and more detailed data available since 2004 also allowed an explicit estimation of changes associated with the category of Other land representing unfertile land with no specific type of land use, which was considered to be constant until 2003 (Fig. 6-4). All identified land-use transfers estimated at the individual cadastral unit level are summarized by each type of land-use change on an annual basis to be further used for estimation of the associated emissions.

Year (date)	ID CU (Name)	Forest land	Cropland	Grassland	Wetlands	Setttlements	Other land	Total
1.1.2011	661635 (Kácov)	1992637	2627349	1186759	376350	1124451	291370	7598916
31.12.2011	661635 (Kácov)	1979724	2633115	1181825	376350	1136533	291371	7598918
Difference		-12913	5766	-4934	0	12082	1	2

Conversion type	Area (m^2)
Forest land - Cropland	977
Forest land - Settlements	11936
Cropland - Settlements	247
Grassland - Cropland	4897
Grassland - Settlements	38
Settlements - Cropland	139

Fig. 6-3 Example of land-used change identification for 2011 and cadastral unit 661635 (Kácov); all spatial units are given in m^2.

6.2.4 Complementing time-series

The above described calculation of land-use changes at the level of individual cadastral units was performed for 1993 to 2017, because the data on that spatial resolution has been available only since 1992. For the years preceding 1993, i.e., for land-use change attributed to 1970 to 1992, an identical approach to that described above was used, but with aggregated cadastral input data at the level on the individual districts. Due to the IPCC default time period of 20 years used for reporting the converted land, the source information contains data on land use in the Czech Republic since 1969.

6.2.5 Land use representation and land use change identification system - status and development

Development of the Czech LULUCF land use representation and land use change identification system as described above involved collaboration with the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz), which administers the source information on land use used in the LULUCF emission inventory[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 the basic IPCC land use categories. The inventory team is working in collaboration with COSMC on further consolidation of the system to provide the specific information required for KP LULUCF activities.

6.3 Land- use definitions and the classification systems used and their correspondence to the land use, land-use change and forestry categories

The IPCC land use categories were linked to the Czech cadastral classification system, namely that of “Aggregate areas of cadastral land categories” (AACLC), centrally collected and administered by COSMC, as described in detail in Section 6.2 above. The specific attribution and linking of cadastral land use

[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.*

categories to IPCC land use categories is summarized in Table 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 2017 period are shown in Fig. 6-4. A largest quantitative change is associated with the Cropland and Grassland land-use categories.

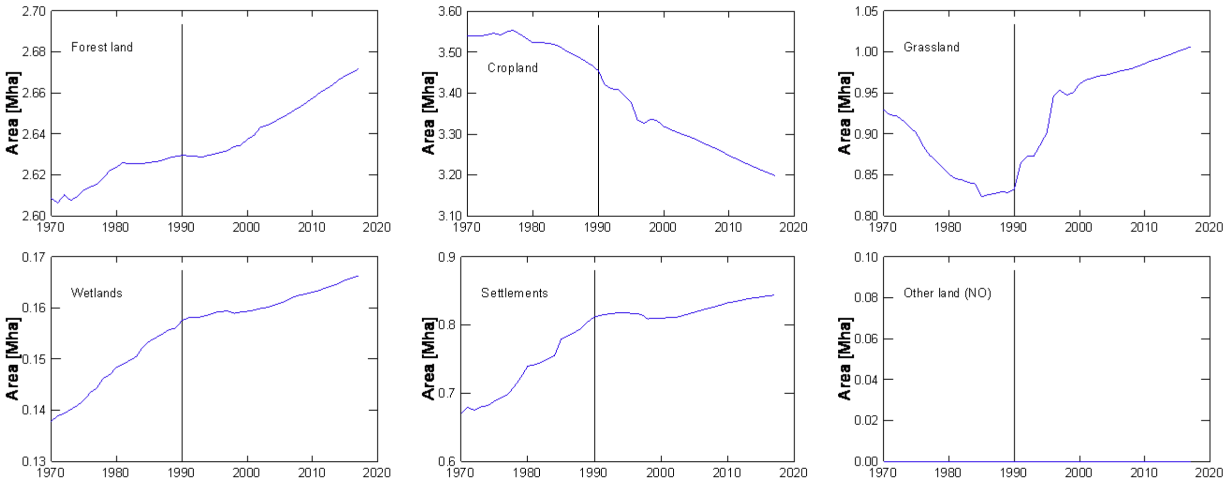


Fig. 6-4 Trends in areas of the six major land-use categories in the Czech Republic between 1970 and 2017 (based on information from the Czech Office for Surveying, Mapping and Cadastre).

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 2017.

	1990	**Initial (1989)**						***Area (kha)***
	Category	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	
Final (1990)	Forest Land	2628.60	0.50	0.36	0.00	0.02	0.00	**2629.48**
	Cropland	0.03	3454.59	0.29	0.02	0.06	0.00	**3454.99**
	Grassland	0.08	8.81	823.58	0.03	0.01	0.00	**832.50**
	Wetlands	0.01	0.41	0.40	155.95	0.78	0.00	**157.54**
	Settlements	0.28	3.71	3.70	0.06	804.11	0.00	**811.86**
	Other Land	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Area (kha)	2629.00	3468.01	828.33	156.06	804.97	0.00	**7886.37**
	2017	**Initial (2017)**						***Area (kha)***
	Category	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	
Final (2017)	Forest Land	2669.18	0.59	0.43	0.04	1.42	0.0	**2671.66**
	Cropland	0.06	3197.90	0.42	0.03	0.33	0.0	**3198.74**
	Grassland	0.06	3.63	1001.84	0.03	0.99	0.0	**1006.55**
	Wetlands	0.03	0.28	0.13	165.68	0.16	0.0	**166.28**
	Settlements	0.44	2.52	0.61	0.12	840.10	0.0	**843.80**
	Other Land	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	Area (kha)	2669.77	3204.92	1003.43	165.90	843.01	0.0	**7887.03**

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 a product of that analysis (for the base year 1990 and the latest reporting year 2017), namely the areas of land-use change among the major land-use categories in the form of land-use change matrices for the individual years. This is available for all years of the reporting period. It is important to note that the annual totals for the individual years in the matrices do not necessarily correspond to the areas that appear in the CRF Tables, which account for the progressing 20-year transition period that began in 1970. This is the recommended assumption of IPCC 2006 Gl. (IPCC 2006) for estimation of changes in soil carbon stock.

6.4 Forest Land (CRF 4.A)

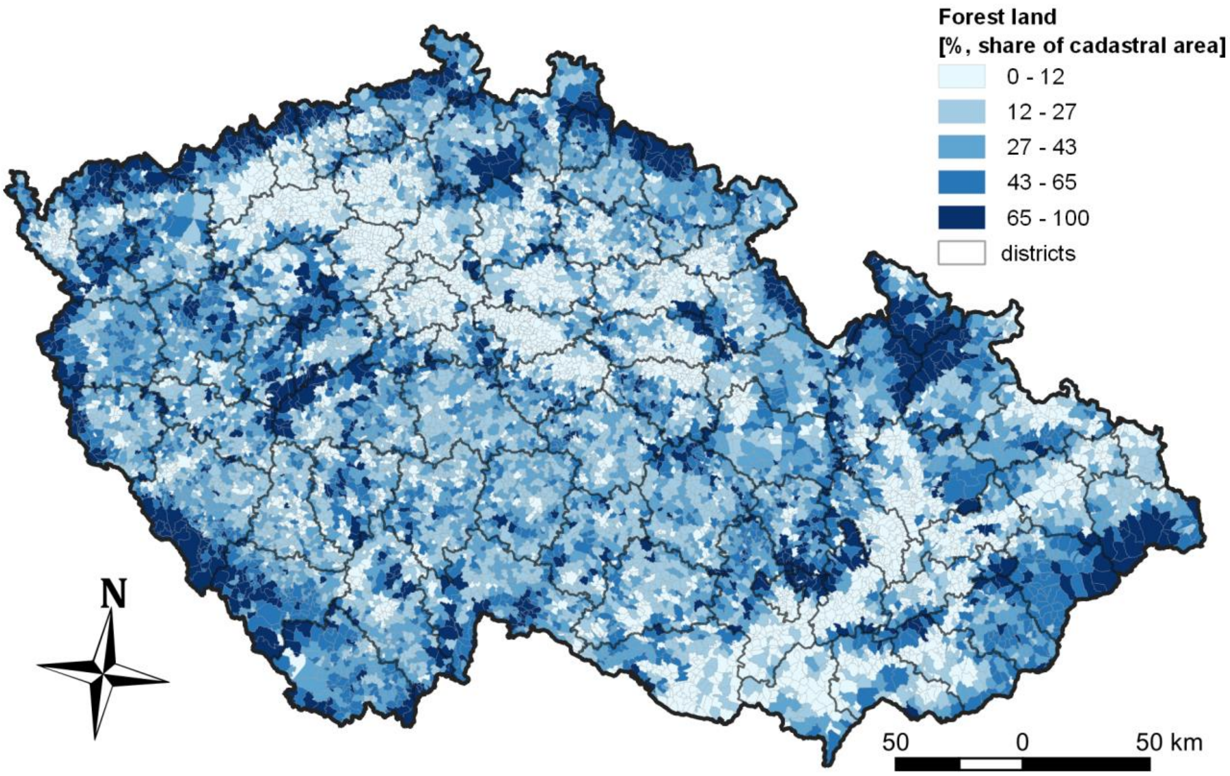


Fig. 6-5 Forest land in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2017).

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 (IPCC 2006 Gl. (IPCC 2006), 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, 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 actually (temporarily) unstocked cadastral forest land, such as forest roads, forest nurseries and land under power transmission lines, these are discounted in all emission estimates involving Forest Land using the annually updated information on the ratio of

[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

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 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 state, which is mandatorily requested under the Czech Forestry Act (289/1996). In 2017 (1990), the area of Forest Land equalled 2 672 (2 629) th. ha, whereas the stocked forest area (timberland) corresponded to 2608 (2 583) thousand ha, representing 97.6 (98.2)% of the cadastral forest land in the Czech Republic. Hence, the temporarily unstocked area, not accounted 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 34.1% of the area of the country (MAF, 2018). The tree species composition is dominated by conifers, which represent 71.9% of the timberland area. The four most important tree species in this country are spruce, pine, beech and oak, which account for 50.3, 16.3, 8.4 and 7.2% of the timberland area, respectively (MAF, 2018). Broadleaved tree species have been favoured in afforestation since 1990. The proportion of broadleaved tree species increased from 21% in 1990 to 27% in 2017. 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 699 mil. m^3 (under bark) in 2017 (MAF, 2018).

Several sources of information on forests are available in the Czech Republic. The primary source of activity data on forests used for this emission inventory is the forest taxation data in Forest Management Plans (further denoted as FMP), which are administered centrally by the Forest Management Institute (FMI), Brandýs n. L. and supervised (since 2012) by Czech Forests, s.e. With a forest management plan cycle of 10 years, the annual update of the FMP database is related to 1/10 of the total forest area scattered throughout the country. The information in FMP represents an ongoing national stand-wise type of forest inventory. The auxiliary source of information corresponds to data from the statistical (sample based, tree level) National Forest Inventory (NFI). The first NFI cycle (NFI1) was performed during 2001-2004 by FMI and its aggregated results were released three years later (FMI, 2007). The second NFI cycle (NFI2) ran during the years 2011 to 2015. Its results have been gradually released during 2016 and 2017. The other auxiliary statistical information on forests at a county level is provided by the Czech landscape inventory (CzechTerra; www.czechterra.cz). It run as a project funded by the Ministry of Environment (Černý 2009, SP/2d1/93/07) complementing its first cycle (CZT1) in 2008/2009. The second CzechTerra cycle (CZT2) was conducted in 2014/2015 as part of the project funded by the Czech Science Foundation (GA ČR 14-12262S). These results were published by the end of 2015 (Cerny et al. 2015, Cienciala et al. 2015). Some of these data have already implemented in this emission inventory report. However, the emission inventory is still primarily based on the FMP data, which represent the main data source used for 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 used, specifically for other carbon pools, such as standing and ground deadwood and litter.

The FMP data were aggregated in line with the country-specific approaches at the level of the four major tree species (i-beech: all broadleaved species except oaks, ii-oak: all oak species, iii-pine: pines and larch, iv-spruce: all conifers except pines and larch) and age-classes (10-year intervals). For these categories, growing stock (merchantable volume, defined as tree stem and branch volume under bark with a minimum diameter threshold of 7 cm), the corresponding areas and other auxiliary information were available for each inventory year. It can be observed that the area of broadleaved species has steadily increased during the reporting period, mainly at the expense of spruce (Fig. 6-6). In addition to the four major categories by predominant tree species, clear-cut areas are also distinguished (Fig. 6-6), forming another, specific sub-category of Forest Land. A clear-cut area is defined as a temporarily unstocked area following final or salvage harvest of forest stands. It ceases to exist once it is reforested, which must occur within two years according to the Czech Forestry Act. There is no detectable carbon stock change for this category and it is introduced solely for the purpose of consolidated, transparent and consistent reporting of forest land. In 2017, clear-cut areas represented 1.2% of timberland area within Forest Land.

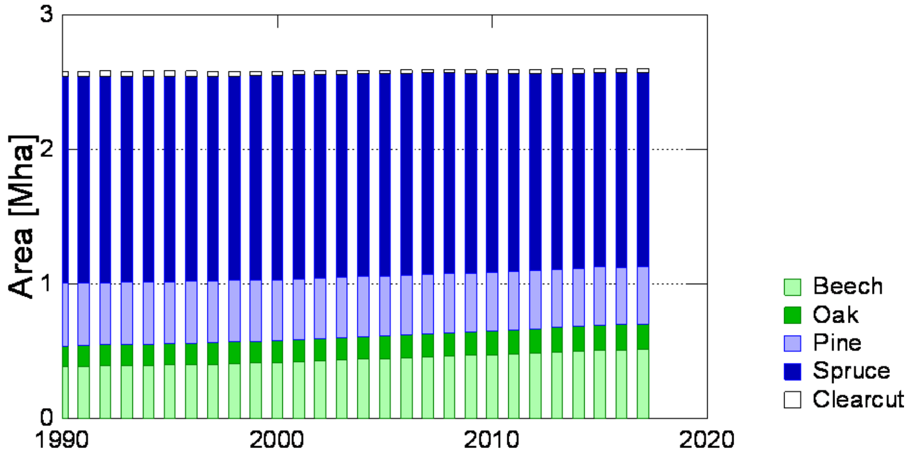


Fig. 6-6 Activity data – area for the four major groups of species and clearcut area during 1990 to 2017.

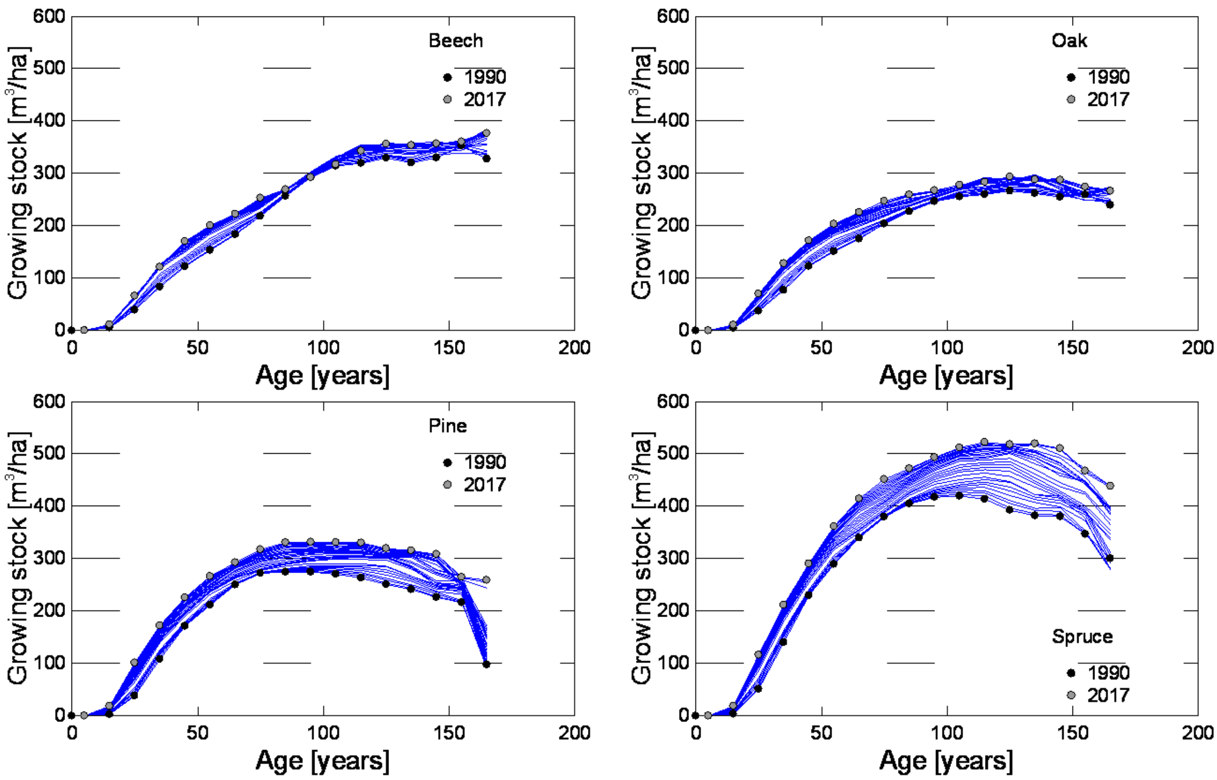


Fig. 6-7 Activity data – mean growing stock volume against stand age for the four major groups of species during 1990 to 2017; each line corresponds to an individual inventory year. The symbols identify only the situation in 1990 and 2017.

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

19.4 mil. m^3 (under bark) in 2017. This is the highest ever harvest volume recorded in the country, surpassing the previous all-time high of 18.5 mil. m^3 harvested in 2007 (all data refer to under-bark volumes, MAF 2017). Note, however, that 60.5% of the harvest volume attained in 2017 is due to the mandatory sanitary fellings in reaction to the unprecedented bark-beetle outbreak (see below) that is expected to drive the harvest volumes to even higher levels in 2018 and 2019.

The Czech emission inventory also includes the harvest loss due to disturbance events. Specifically, the harvest loss volume estimate is officially reported by the Czech Statistical Office (CzSO), which have become available since 2009. This complements the previously employed harvest loss estimates increasing the reported harvest by an extra 5 and 15% applied to final and salvage logging volumes, respectively (see Section 6.4.2 below). Salvage logging operations are predominantly related to stands affected by windstorms, snow and bark-beetle calamities in this country. On this basis, the Czech emission inventory includes an explicit estimate of disturbance, which includes the categories of natural disasters, pollution, insects and other effects (CzSO, J. Kahuda, personal communication 2013). Therefore, the total applicable harvest is linked to the actual share of salvage logging that is annually reported by CzSO and elsewhere (MAF 2018). In 2017, the applicable volume of total annual harvest drain (incl. harvest loss) reached 21.5 mill. m^3, up from the earlier maximum of nearly 21 mill. m^3 estimated for 2007. The harvest drain applicable for the emission inventory for the entire reporting period since 1990 to 2017 is shown in Fig. 6-8. The information on reported harvest, share of salvage logging, quantity of harvest by disturbance type and applicable additonal harvest drain is also provided in Tab. 6-5. Tab. 6-7 also shows total harvest drain disintegrated by species groups for 1990 and 2017.

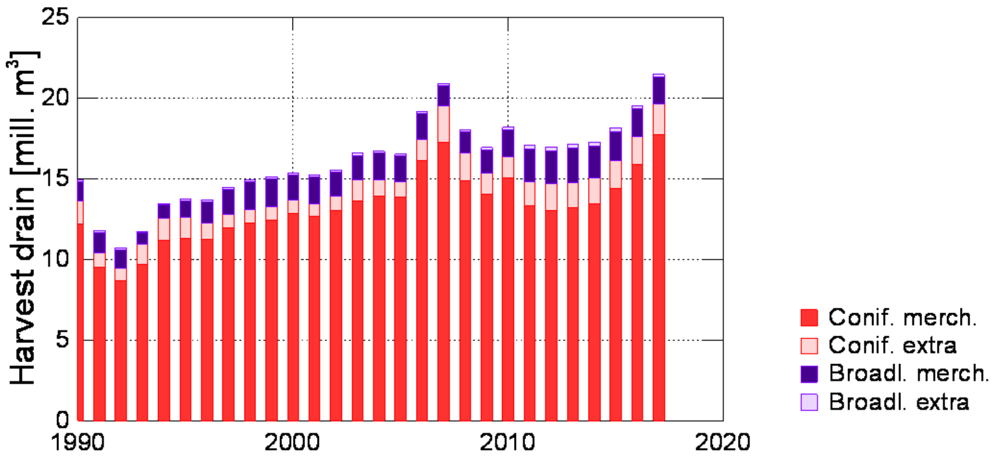


Fig. 6-8 The applicable total annual harvest drain for coniferous (Conif.) and broadleaved (Broadl.) tree species, which includes both the reported quantities of merchantable wood for the two categories (Conif. merch, Broadl. merch.) and the associated harvest loss (Conif. extra, Broadl. extra) for the entire reporting period of 1990 to 2017.

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 information IFER, CzSO).

Variable	Unit	Year 1990	2000	2005	2010	2015	2016	2017
Reported base harvest	Mm^{-3}	13.3	14.4	15.5	16.7	16.1	17.6	19.4
Share of salvage logging	% of reported harvest	71	14	17	39	50	53	61
- abiotic/natural	Mm^{-3}	NA	2.39	2.30	4.07	4.39	2.64	4.35
- pollutants	Mm^{-3}	NA	0.08	0.04	0.03	0.03	0.03	0.02
- insect outbreaks	Mm^{-3}	NA	0.32	0.98	1.79	2.31	4.42	5.85
- other	Mm^{-3}	NA	0.50	1.22	0.57	1.43	2.31	1.52
Additional loss (IFER, CzSO)	Mm^{-3}	1.62	0.92	1.04	1.48	2.00	1.90	2.10
Total harvest loss	Mm^{-3}	14.9	15.4	16.6	18.2	18.2	19.5	21.5

As apparent from Tab. 6-5, the most worrisome disturbance type requiring salvage logging was insect outbreaks in the country in 2017, specifically considering the apparent trend in these data. 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 the two recent decades and compared to late 1980s and early 1990s, when the region suffered from significant air pollution impacts. The resiudal of that period can be traced in soils, which still remain regionally aciditified 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 infomation in Tab. 6-5, does not discern the underlying factors such as sensitivity to drought or unfavourable soil chemistry, but reports on the final visible phenomena of affected trees (Cienciala et al., 2017). In this context it is important to understand that the inventory team is not in position to conduct any verification of the national information on distrurbace type and additional harvest (Tab. 6-5), the information provided centrally by CzSO, as suggested 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 6-3 above.

6.4.2.1 Forest Land remaining Forest Land

Carbon stock change in category 4.A.1 Forest Land remaining Forest Land is given by the sum of changes in living biomass, dead organic matter and soils. The carbon stock change in living biomass was estimated using the default method[4] according to eq. 2.7 of the IPCC 2006 Gl. (IPCC 2006). 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 IPCC 2006 Gl. (IPCC 2006)). The key input to calculate the carbon increment is the volume increment (I_v) data. In the Czech Republic, these values have been traditionally calculated at FMI[5] (FMP database administrator; see also Acknowledgment) and reported to the national and international statistics. The calculation is performed at the level of the individual stands and species using the available growth and yield data and models. The increment data were partly revised in the earlier NIR (2008) to unify two different base information sources (Schwappach, 1923; Černý et al., 1996) for increment estimates and to employ only the latest source

[4] Alternative approaches of the stock-change method (Eq. 2.8; IPCC 2006) were also analyzed (Cienciala et al. 2006a) for this category. However, for several reasons the default method was finally adopted and is discussed in the cited study.

[5] Since 2012, Czech Forests, s.e. has co-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.

across the entire reporting period. This procedure was implemented to comply with the reporting requirements of consistent time series. No change, apart from entering the actual increment for the latest reported year, has been made to the increment in the inventory submissions thereafter (Fig. 6-9).

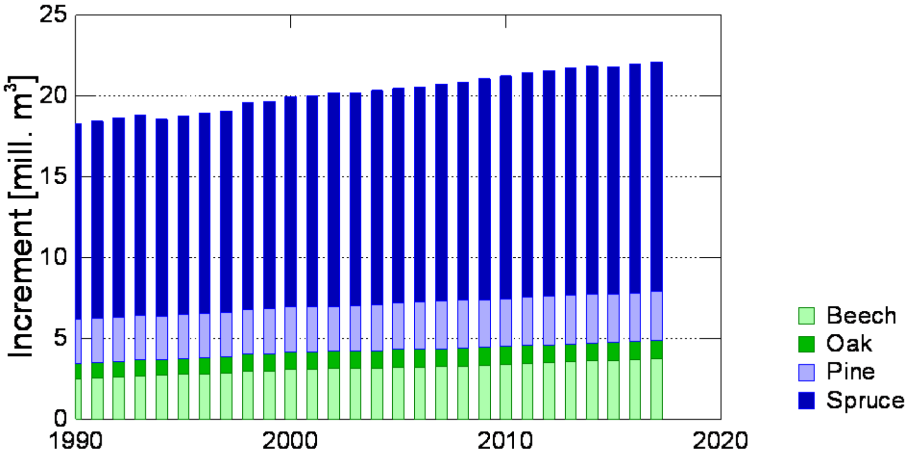


Fig. 6-9 Current annual increment (Increment, mill. m^3 underbark) by the individual tree species groups as used in the reporting period 1990 to 2017 (source data FMI).

The merchantable volume increment (I_v) is converted to the biomass increment (G_{Total}), biomass conversion and expansion factors applicable for increment ($BCEF_i$) using Eqs. 2.9 and 2.10 (AFOLU, 2006) as follows:

$$\Delta C_G = \sum_j (A_j \times G_{Total_j} \times CF_j) \qquad (1)$$

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:

$$G_{Total} = \sum \{I_V \times BCEF_i \times (1+R)\} \qquad (2)$$

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 2017 shown) for beech, oak, pine and spruce species groups, respectively

Variable or conversion factor	Unit	Year 1990	Year 2017
Species group		Beech, Oak, Pine, Spruce	Beech, Oak, Pine, Spruce
Area of forest land remaining forest land (*A*)	kha	381; 156; 466; 1539	517; 189; 427; 1454
Biomass conv. & exp. factor, incr. ($BCEF_i$)	Mg m^{-3}	0.741; 0.862; 0.524; 0.595	0.737; 0.850; 0.526; 0.598
Carbon fraction in biomass (*CF*)	t C/t biomass	0.488; 0.488; 0.508; 0.508	0.488; 0.488; 0.508; 0.508
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	7.24; 6.00; 7.17; 9.84

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 from the Czech Republic (Wirth et al., 2004, Wutzler et al., 2008). Since the biomass conversion and expansion factors are age-dependent (Lehtonen et al., 2004, 2007), they respect the actual age-class distribution of the dominant tree species. Hence, the species- and age-dependent $BCEF_i$ values shown in Tab. 6-6 represent annually updated 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. The adopted carbon fraction (*CF*) in woody biomass changed in this (2019) submission. *CF* values values of 0.488 and 0.508 are currently used for broadleaved and coniferous tree species, respectively (Tab. 6-6), representing temperate forest categories as reported by Thimas and Martin (2012). They is in accordance with the values suggested by IPCC 2006 Gl. (IPCC 2006) based on a more extensive literature survey. The ratio of below-ground biomass to aboveground biomass (*R*) was estimated for individual species groups and corresponding actual growing stock volumes based on the recommended values for forests in temperate-zone in Table 4.4 of IPCC 2006 Gl. (IPCC 2006). The applicable corresponding values of *R* are listed for 1990 and 2017 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 the category 4.A.1 Forest Land remaining Forest Land basically follows Eqs. 2.11, 2.12 and 2.13 (AFOLU, 2006). It uses the annual amount of total harvest removals reported by CzSO for individual tree species in the country as well as the associated harvest loss, which is 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 amount of salvage logging (distrurbances). To include the biomass loss associated with harvest, a 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

$$L_{wood\ removals} = H \times BCEF_h \times (1 + R) \times CF \qquad (3)$$

where $BCEF_h$ represents the biomass expansion and conversion factor applicable to harvested volumes, derived from national studies or regional compilations that include the data from the Czech Republic as noted and mentioned above. The application of $BCEF_h$ considers the share of the planned harvested volume and the actual salvage logging that was not planned. In the case of planned harvest volumes, the age-dependent $BCEF_h$ values also consider the mean felling age, which is taken from the national reports of the Ministry of Agriculture. For salvage logging, $BCEF_h$ represents the volume-weighted mean of all age classes for the individual dominant tree species, as the actual stand age of those harvested volumes is unknown. The other factors (*CF, R*) are identical to those described under Tab. 6-6. 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 2017 shown) for beech, oak, pine and spruce species groups, respectively

Variable or conversion factor	Unit	Year 1990	Year 2017
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; 0.39; 1.51; 18.1
Biomass expansion factor ($BCEF_h$)	$Mg\ m^{-3}$	0.782; 0.864; 0.524; 0.587	0.719; 0.833; 0.525; 0.585

The impact of disturbances (Eq. 2.14, AFOLU, 2006) is included in full within 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 also, the available data on salvage logging from CzSO (and MAF 2017) are traceable using disturbance origin by categories including natural disaster, air pollution, insect and other (Tab. 6-5 above). This information is obligatorily reported by the forestry practice, which must always prioritize salvage logging on account of the planned harvest. In this way, the prescribed (planned) logging volume is commonly composed of planned and salvage logging. Consequently, any salvage felling is flexibly allocated to the desired amount of planned wood removals, and it is thereby accounted for in the reported harvest volumes within Eq. 3. This also includes the occasional events of more significant local salvage loggings, when forest managers may request and receive temporary permissions to increase the planned harvest volumes for the affected forestry districts. Due to the above, no distinction is made in terms of disturbance impact on carbon pools in sense of, e.g., Table 2.1 of IPCC 2006 Gl. (IPCC 2006), as disturbance is treated as an integral part (though quantifiable by volume share) of harvest loss in the conditions of the dominantly managed forests in the country (Tab. 6-5 and Fig. 6-8.). Note also that this treatment has no accounting effect on dead organic matter pool, as all aboveground biomass is assumed to be instantaneously oxidized, except 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%, which is based on the differences in estimates earlier provided by IFER and that of CzSO representing the nationally repoted data. The mean difference in these estimates for the period of 2011-2017 is 29%, with CzSO being more conservative.

Newly integrated in this inventory submission is stem mortality estimate at the country level, published by Adolt et al. (2016). Stem mortality represents additional loss of biomass carbon, not included in the harvest estimates. It was assessed based on the two NFI cycles (NFI1 and NFI2), resuting in mean volume mortality per hectare. This inventory used the published aggregated mortality values of 0.16 and 0.34 m^3/ha/year for broadleaed and coniferous tree species, respectively (m^3 under bark as standard for all wood volume units used in the country). These stem mortality estimates were converted to biomass carbon using Eq. 2 (Eq. 2. 10 of IPCC 2006 Gl.) and the set of applicable factors as listed for the individual species groups in Tab. 6-6. The resulting quantity due to mortality was treated as additional carbon loss in the gain-loss method used in this inventory for biomass carbon stock change estimation.

The assessment of the net carbon stock change in organic matter (specifically deadwood) for category 4.A.1 was revised in the previous (2018) inventory submission following the Tier 2 stock-difference method according to Eq. 2.8 of IPCC 2006 Gl. (IPCC 2006). The requitred activity data for deadwood component were taken from the two statistical inventory programs available in the country as described in Section 6.4.1 above, namely NFI1 campaign as of 2001/2004, and the Landscape inventory CzechTerra (Cerny et al. 2015, Cienciala et al. 2015, 2016) – campaigns CZT1 (2008/2009) and CZT2 (2014/2015). These data were collected using identical methodology, avoiding any potential harmonization issue. Specifically for deadwood, data combined carbon stock in standing as well as lying dead trees. The source data are mean standing deadwood biomass and volume of lying deadwood classified in four categories according to degree of decomposition. These categories are defined as follows: i) basically solid wood; ii) peripheral layers soft, central hard; iii) peripheral layers hard, central soft; iv) totally rotten wood. The amount of carbon held in lying deadwood was estimated as the product of the wood volume, density weighted by mean growing stock volume of major tree species (0.433 t/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 data of CzechTerra campaign 2008/2009 (CZT1) are available, providing reference mean carbon stock held in litter (11.1 t C/ha; 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 for this category (IPCC 2006).

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 concerns both mineral and organic soils. The organic soils occur only in the areas of the Spruce sub-category on 4.A.1 Forest Land remaining Forest Land. They represent protected peat areas in mountainous regions dominated by spruce stands, with no 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 Gl. and the emission and combustion factors in Table 2.5 and 2.6, respectively (IPCC 2006). The equation 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 amount of greenhouse gas emissions from fire in tons of gas considered (CH_4, N_2O), A is area burtn (ha), M_B mass of fuel available for combustion (t/ha), C_f combustion factor (-) and G_{ef} 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 is burned. This is less than assumed for the inventory years until 2010 (30%), which corresponds with the trend in current forest management practices in the country. The biomass fraction burned was quantified on the basis of the annually reported amount of final felling volume of broadleaved and coniferous species, $BCEF_h$ and *CF* as applied to harvest removals (above). The amount of biomass burned (dry matter) was estimated as 590 kt in 1990 and 502 kt in 2017. 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 2017 shown) according to Eq. (4).

Variable or conversion factor	Unit	Year 1990	Year 2017
Amount of biomass burnt (AxM_B)	kt	590	502
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 a release of CO_2 in prescribed burning (only CH_4 and N_2O are listed). This is to prevent double counting, as that part of emissions is already included within the harvest loss (Eq. 3). Finally, Table 6-8 also does not list the factors used to estimate gases of

CO and NOx, which are complementarily also estimated using Eq. 4 together with emission factor (G_{ef}) equal to 107 and 3.00, respectively.

The emissions of greenhouse gases due to wildfires were estimated on the basis of known areas burned annually by forest fires and the average biomass stock in forests according to Eq. 2.14 (IPCC 2006). 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 individual gasess as well as carbon fraction were identical as those for prescribed burning listed above. The amount of biomass (dry matter) burned in wildfires was estimated as 10.2 kt in 1990 and 12.9 kt in 2017. The most extreme year of the reporting period was 1997, when about 228 kt of biomass was burned due to wildfires on an area of almost 3.5 th. ha. In 1990 and 2017, the reported forest areas under wildfire were 168 and 170 ha, respectively. During the reporting period since 1990, there has been no single year without reported wildfire. The mean annual forest area affected by forest wildfires reached 600 ha during the 1990 to 2017 period. The full time series of forest wildfires in terms of areal extent and number of fires per year is shown in Fig. 6-10. The associated emissions of non-CO_2 gases can be found in the corresponding CRF Tables.

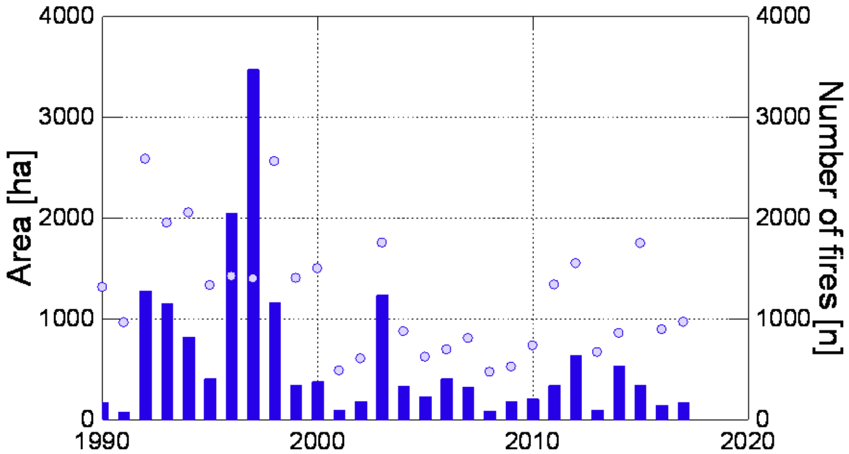


Fig. 6-10 Wildfires on forest land since 1990 – annual area (left; bars) and number of fires per year (right; filled symbol)

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 Gl. (IPCC 2006), the carbon increment is proportional to the extent of afforested areas and the growth of biomass. The revised methodology of land-use change identification (Section 6.2) provides areas of all conversion types updated annually. Land areas are considered to be under conversion for a period of 20 years, according to the default assumption of IPCC 2006 Gl. (IPCC 2006). Under the conditions in this country, all newly afforested lands are considered as intensively managed lands under the prescribed forest management rules as specified by the Czech Forestry Act.

Until 2006, the increment applicable to age classes I and II (stand age up to 20 years) was estimated from the actual wood volumes and areas that were available per major species groups. Using the available activity stand level data categorized by species and age classes and the national growth and yield model

SILVISIM (Černý, 2005), the wood increment was derived for all the age classes above 20 years. For age class one (1-10 years), the increment was simply calculated from the reported areas and volumes, assuming a mean age of five years. The increment of age class two (11 to 20 years) was estimated from linear interpolation between the increment of age classes I and III. For 2007 and the following years, the increment is derived for individual tree species using the ratio of increments for individual tree species to the total stand increment estimated for the 2000 to 2006 period.

Since the specific species composition of the newly converted land is unknown, the increment estimated for the major tree species was averaged using the weight of actual areas for the individual tree species known from the unchanged (remaining) forest land. Expressed in terms of aboveground biomass, the estimated aggregated mean increment for 2017 was 3.28 t/ha, a value matching well those given for temperate forest systems given as defaults in Table 4.12 of IPCC 2006 Gl. (IPCC 2006). The estimation of increments in terms of aboveground biomass is facilitated by the age- and species-dependent $BCEF_i$ values as described in Section 6.2.1 above. The estimated species-specific values of $BCEF_i$ applicable for young trees to 20 years of age were 0.995, 1.247, 0.654 and 0.925 for beech, oak, pine and spruce, respectively. The volume-weighted mean $BCEF_i$ was 0.914 for 2017. The share of below-ground biomass (ratio *R*) is estimated based on species- and volume-specific values provided in Table 4.4 IPCC 2006 Gl. (IPCC 2006). In 2017, the factor *R* applicable for 4.A.2 Land converted to Forest Land was 0.216.

The carbon loss associated with biomass disturbance in term of management and mortality 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 natural disturbance on the land converted to forest land. It actually represents the land of a newly established forest with tree age of 1 to 20 years. As is also apparent from the national statistics, there is no volume of salvage logging reported for this category, which reflects the actual conditions of forest ecosystems of the age concerned.

The net changes of carbon stock in dead organic matter (DOM) were estimated in accordance with the guidance of the Tier 1 method (IPCC 2006), using available country specific information. This approach assumes that deadwood and litter carbon pools increase linearly from zero to the reference default values for the given country-specific conditions. The changes in DOM were estimated separately for deadwood and litter components. For deadwood, conservative values of the transition period for developing deadwood carbon stock (100 years) and the reference mean carbon stock held in deadwood (0.7 t C/ha; CzechTerra landscape inventory 2009 and 2015, Cienciala et al. 2015) were used, respectively. For litter, the default (IPCC 2006) period of 20 years was used together with the country-specific estimate of reference mean carbon stock held in litter (11.1 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 maps 1:5 000 and 1:10 000, as used in the Czech system of forest typology (Macků et al., 2007). This represents the soil organic carbon content to a reference depth of 30 cm, including the upper organic horizon. The carbon content on agricultural soils was prepared so as to match the forest soil map in terms of reference depth and categories of carbon content, although based on interpretation of coarser 1:50 000 and 1:500 000 soil maps (Šefrna and Janderková, 2007). The polygonal source maps were used to obtain the mean carbon content per individual cadastral unit (n = 13 084 in 2017), 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.

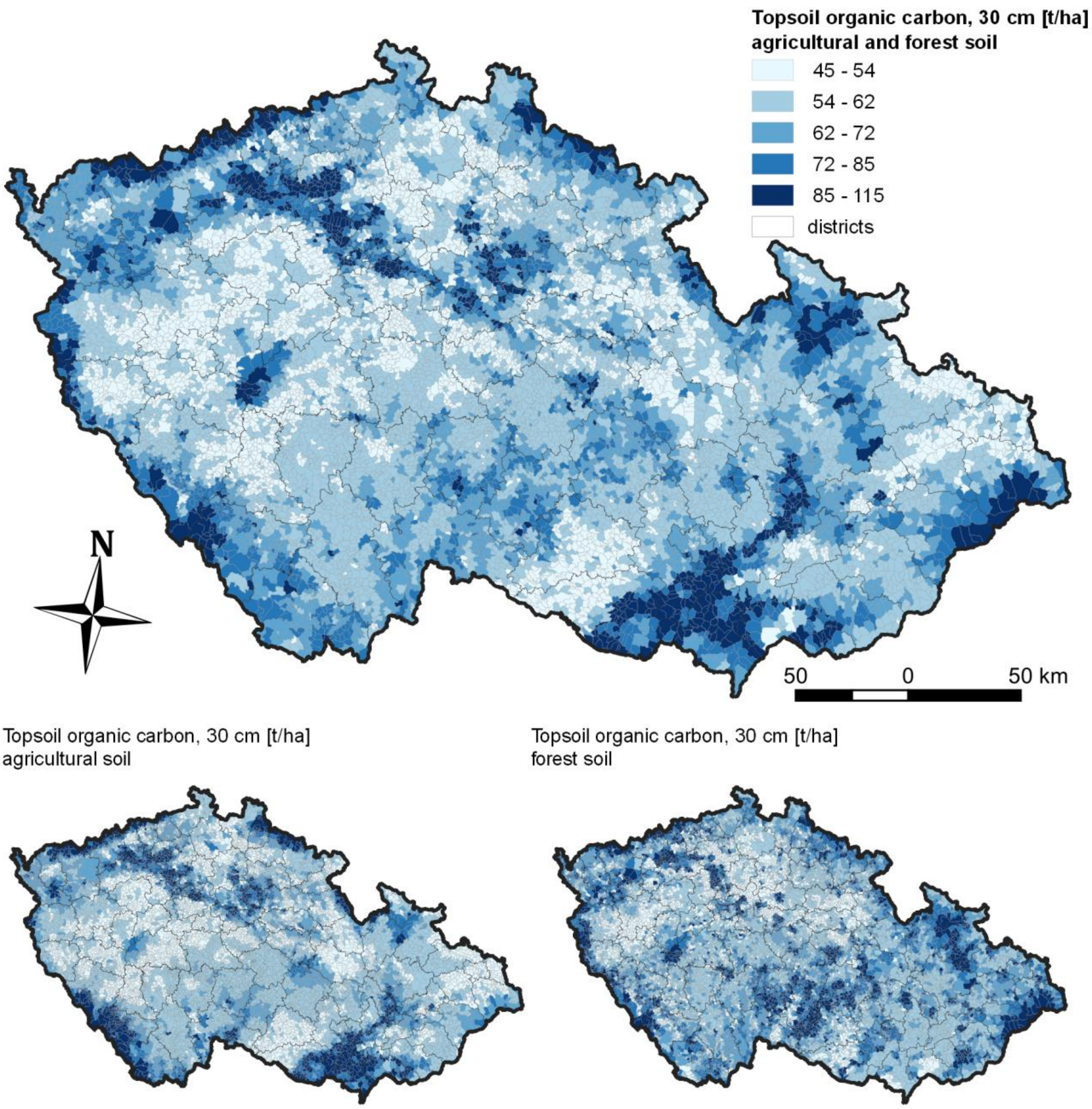


Fig. 6-11 Top - topsoil (30 cm) organic carbon content map adapted from Macků et al. (2007), Šefrna and Janderková (2007); bottom –topsoil carbon content for agricultural (left) and forest (right) soils estimated as cadastral unit means from the source maps. The unit (t/ha) and unit categories are identical for all the maps.

In 2017, the area-weighted mean carbon stock in mineral soil per cadastral unit reached 66.5, 58.5 and 68.2 kg C/ha for Forest land, Cropland and Grassland, respectively.

The net changes in carbon stock in organic soils, occurring only in the sub-category of stands dominated by spruce, were assumed to be insignificant (zero). This is in accordance with the general assumption of the Tier 1 method applicable for forest soils, as no other specific methodology is available for organic soils except for drained ones (IPCC 2006).

Non-CO_2 emissions from burning are not estimated for category 4.A.2 Land converted to Forest Land, as this practice is not employed in this country. The same applies to N_2O emissions from nitrogen fertilization, which is not carried out in this country on forest land.

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 2017.

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 with each of the quantities (Eq. 3.1, Volume 1, Chapter 3, IPCC 2006 Gl.).

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 Gl.).

It should be noted, however, that Eq. 5 is not well applicable for the LULUCF sector. Summing negative (removals) and positive (emission) members (x_i) in the denominator of equation 5 may produce unrealistically high uncertainties and theoretically lead to division by zero, which is not possible. In this respect, this approach is not correct. In previous inventory reports, we stressed this issue and recommended focusing on individual uncertainty components prior the resulting product of Eq. 5.

The adopted uncertainty values are listed below and/or under the corresponding subchapters of other land use categories. In addition to IPCC 2006 Gl. (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) that concern areas of land use (5%), biomass increment (6%), amount of harvest (20%), carbon fraction in dry wood mass (7%), root/shoot factor (30%) and combustin factors used in calculation of emissions from prescribed (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 stem volume mortality estimate is accompanied with uncertainty of 12 % based on Adolt et al. (2016).

The approach of uncertainty combination for individual sub-categories of tree species is based on calculating the mean error estimate from the components of carbon stock increase and carbon stock loss, which are both given in identical mass units of carbon per year. At the same time, we retained the recommended logics of combining uncertainties on the level of the entire land use category or on the level of the entire LULUCF sector according Eq. 5. This is calculated on the basis of CO_2 or CO_2 eq. units and the corresponding uncertainty estimates respect the actual direction of the source and sink categories to be combined.

For 2017, 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 236% and 26%, respectively. Correspondingly, the uncertainty for the entire 4.A Forest Land category reached 142%. The high uncertainty values reported for this year come from the above-decribed issue of combining negative and positive members, the sum of which results in a small value to produce unrealistic uncertainty estimate. This contrasts to uncertainty estimate of the two major individual members, which reach only about 38 % for carbon sink by biomass growth and about 50 % of carbon release due to harvest and mortality.

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 IPCC 2006 Gl., Volume1, Chapter 6).

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.

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 of 4.A Forest land and reporting period. The improvements implemented in this inventory submission are listed below.

- Carbon stock change in biomass:
    - Partly in response to issue L.4 of the last review, the estimates of carbon stock change in biomass was revised, including the newly acquired data on mortality of the Czech National Forest Inventory. Such data were not available earlier and the calculation

assumed no mortality in the conditions of intensive forest management in the country. The updated estimates marginally reduced the estimates in this emission category.

- Partly in response to issue L.16, newly introduced in the previous inventory submission (NIR 2018) was the species-specific 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. In this inventory submission, R-factor was also implemented for the associated conversions from Forest land. The biomass estimates changed accordingly for the entire time series.
- By initiative of the inventory team, new EFs for carbon content in woody biomass following the new scientific literature (Thomas, S.C., Martin, A.R., 2012. Carbon content of tree tissues: A synthesis. Forests 3, 332–352. doi:10.3390/f3020332) that was not available for IPCC 2006 Gl. The new EFs for coniferous and broadleaved species affected the estimates of biomass for the entire time series.

- Carbon stock change estimates for DOM and litter:
  - In response to issue L19 of the last review, new AD for dead organic matter (DOM) were introduced in the previous (NIR 2018) submission. 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). In this submission, these AD and related estimates were slightly revised following the stock difference method (Eq. 2.19 of IPCC 2006) for category 4.A.1 and also used as a reference carbon stock for associated conversions related to forest land (category 4.A.2 and categories 4B21, 4C21 and 4E21).

The effect of these improvements and corrections on the total emission estimates for category 4.A Forest Land is shown in Fig. 6-12. On average, the emission removals decreased by 5.8% compared to the previously reported estimates as assessed on the comparable period of 1990 to 2016.

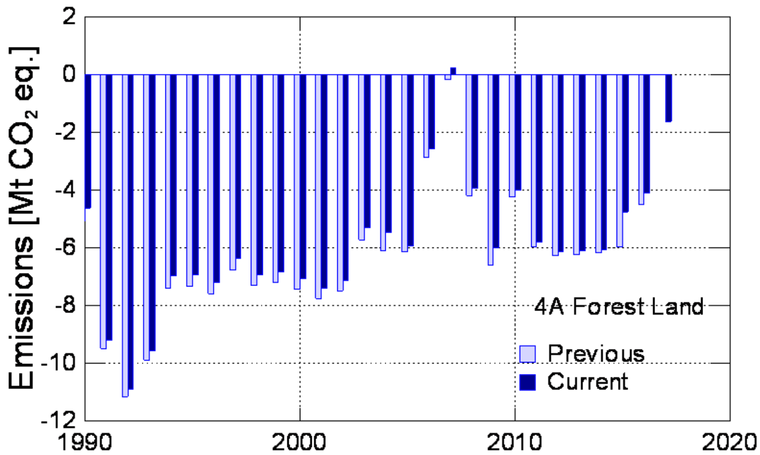


Fig. 6-12 Current and previously reported assessment of emissions for category 4.A Forest Land. The values are negative, hence representing net removals of green-house gases

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 land and Land converted to Forest Land. Other improvements initiated by the inventory team remain under planning. This includes a further refinement in the uncertainty assessment (exploring the Monte-Carlo approaches) and enhancement of QA/QC procedures. Over a longer term, a wider utilization of the data from the statistical inventory programs is planned, including the repeated survey of the Czech National Forest Inventory and CzechTerra landscape inventory.

6.5 Cropland (CRF 4.B)

6.5.1 Source category description

In the Czech Republic, Cropland (Fig. 6-13) is predominantly represented by arable land (92.5% of the category in 2017), while the remaining area includes hop-fields, vineyards, gardens and orchards. These categories correspond to five of the six real estate categories for agricultural land from the database of "Aggregate areas of cadastral land categories" (AACLC), collected and administered by COSMC.

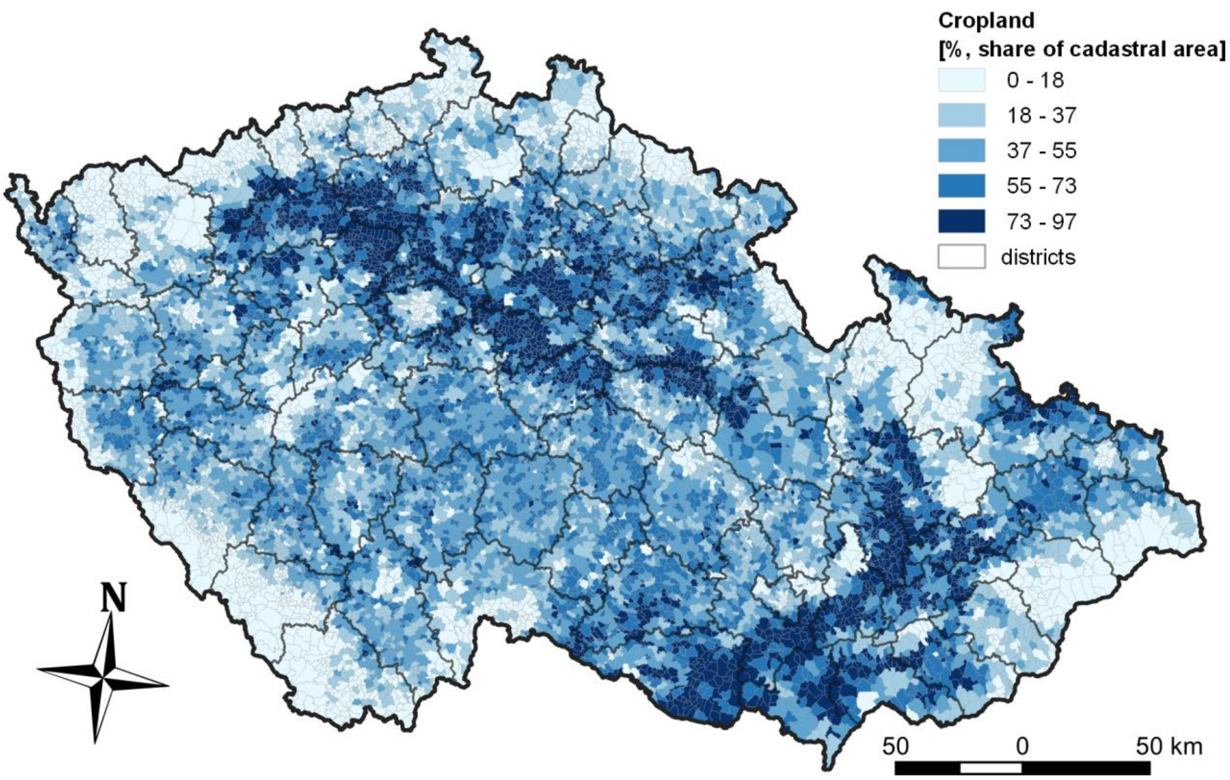


Fig. 6-13 Cropland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2017).

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 2017. It can be expected that this trend will continue. The conversion of arable land to grassland is actively promoted by state subsidies. Conversion to grassland concerns mainly lands of less productive regions of alpine and sub-alpine regions. In addition, there is a growing demand for land for infrastructure and settlements.

6.5.2 Methodological issues

The emission inventory of Cropland concerns sub-categories 4.B.1 Cropland remaining Cropland and 4.B.2 Land converted to Cropland. The emission inventory of Cropland considers changes in living biomass, dead organic matter and soil. In addition, N_2O emissions associated with soil disturbance during land-use conversion to cropland are quantified for this category.

6.5.2.1 Cropland remaining Cropland

For category 4.B.1 Cropland remaining Cropland, the changes in biomass can be estimated only for perennial woody crops. Under the conditions in this country, this 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. 6-14.

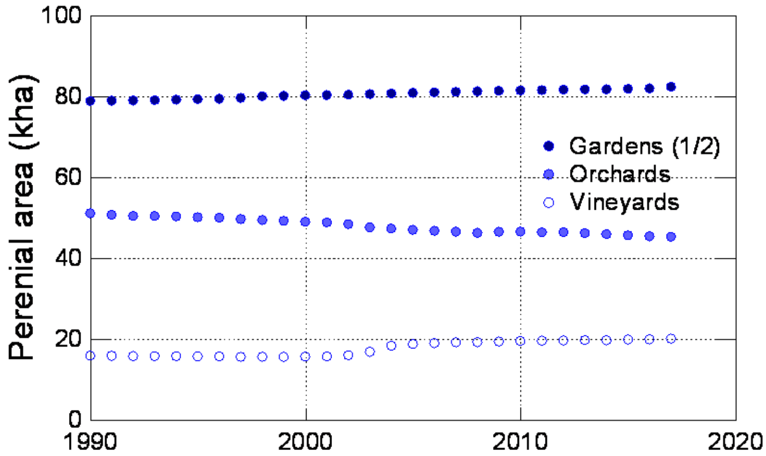


Fig. 6-14 Trend in perennial cropland area in the Czech Republic for the period 1990 to 2017.

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 harves (63 t C/ha), Table 5.1 (IPCC 2006) were applied 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 Gl. (IPCC 2006) as:

$$\begin{aligned} \textit{Annual change of biomass} \\ &= \textit{Remaining area of perenial cropland} \times \textit{C accumulation rate} \\ &- \textit{New perenial cropland area} \times 0.033 \times \textit{biomass C stock at harvest} \\ &- \textit{Lost perenial cropland area} \times 0.5 \times \textit{biomass C stock at harvest} \end{aligned} \qquad (6)$$

The carbon stock change of dead organic matter follows the Tier 1 method asumption of IPCC 2006 Gl. (IPCC 2006) that dead wood and litter stocks are not present on Cropland or are at equilibrium. Hence, no change is assumed for this pool.

The carbon stock change in soil in the category Cropland remaining Cropland is given by changes in mineral and organic soils. Organic soils basically do not occur on Cropland; they occur as peatland in mountainous regions on Forest Land. Hence, emissions were estimated for mineral soils. The estimation procedure was revised in the previous NIR submission (NIR 2018) 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. 6-11). Next, the are of cropland was stratified according to specic management activities that determine attribution of appropriate land use, management and input factors as guided by Table 5.5. of IPCC 2006 Gl. (IPCC 2006). Seven specific categories were defined for Cropland remaining Cropland. They discern non-perenial and perennial vegetation categories and their specific subtypes and lead the choice of 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 2017 shown).

Management activity by vegetation category	Land use F_{LU}	Tillage F_{MG}	Input F_I	Area in 1990 (kha)	Area in 2017 (kha)
I. Non-perenial, arable land, no fallow	0.69	1.03	1	2 884.0	2 777.2
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	82.4
IV. Non-perenial, hop fields	0.69	1.08	0.92	11.3	10.1
V. Perenial, gardens (1/2)	1	1.15	0.92	78.9	82.4
VI. Perenial, orchards	1	1.15	0.92	157.7	164.8
VII. Perenial, vineyards	1	1.08	0.92	15.8	19.8

The estimation follows Eq. 2.25 assuming a 20-year default period for time dependence of stock change factors (D) and using 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. The assumption was made on share of perennial and nonperenial gardes, which was attributed identically by one half of the reported areal extent of gardens. Next, the share of fallow arable was obtained from the periodic Farm Structure Syrveys conducted in 2016, 2013, 2007, 2005, 2003 and Agricultural Census 2010. These surveys are conducted in the European Union member countries following requirements of EU/EC legislation. In the Czech Republic, the survey is conducted on the basis of the 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 CsSO. Tillage factor (F_{MG}) adopted for arable land (no fallow; Tab. 6-9) was derived on the basis of country-specific share of tillage methods, which were reported in Farm Structure Surveys of 2016 and 2010 (CsSO). It represents the weighted mean of F_{MG} as recommended in Table 5.5 of IPCC 2006 Gl. (IPCC 2006) for the share of conventional tillage (66%), low tillage (33%) and zero tillage (direct seeding; 1%). Other factors used correspond to the recommended values of Table 5.5 for the temperate moist region (IPCC 2006).

Until the NIR submission 2014, the Cropland category also included emissions due to liming. Due to the specific trend in lime application in this country, emissions from liming made the former 4.B.1 Cropland remaining Cropland the key category by trend. However, since the 2015 NIR submission, the emissions from liming are excluded from 4.B.1 Cropland remaining Cropland and reported under category 3.G Liming in the sector of Agriculture instead.

Non-CO_2 greenhouse gas emissions from burning (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 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 living biomass in category 4.B.2 Land converted to Cropland was based on quantifying the difference between the carbon stock before and after the conversion, including the estimation of one year of cropland growth (5 t C/ha; Table. 5.9, IPCC 2006), which follows Tier 1 assumptions of GPG for LULUCF and the recommended default values for the temperate zone. For biomass carbon stock on Forest Land prior conversion, the annually updated average growing stock volumes, species-specific volume-weighted biomass conversion and expansion factors (*BCEF*), and other factors such as the below-ground biomass ratio were used as described in the 4.A Forest Land category in Section 6.2.1 above. For biomass carbon stock on Grassland prior to the conversion, the default factor of 6.8 t/ha for above-ground and below-ground biomass was used (Table 6.4, IPCC 2006). A biomass content of 0 t/ha was assumed after land conversion to 4.B Cropland.

The estimation of net carbon stock change in dead organic matter concerns land use conversion from Forest Land. In this case, the input information on standing and lying deadwood was obtained from the available statistical inventories in the country: the National Forest Inventory (FMI 2007) and the recently conducted field campaigns (2009 and 2015) of the CzechTerra landscape inventory (Cerny, 2009; Cienciala et al. 2015, 2016; www.czechterra.cz). They provide data on the mean standing deadwood biomass and volume of lying deadwood classified in four categories according to degree of decomposition. These categories are defined as follows: i) basically solid wood; ii) peripheral layers soft, central hard; iii) peripheral layers hard, central soft; iv) totally rotten wood. The amount of carbon held in lying deadwood was estimated as the product of the wood volume, density weighted by mean growing stock volume of major tree species (0.433 t/m^3), reduction coefficients of 0.8, 0.5, 0.5, 0.2 (Cerny et al., 2002; Carmona et al., 2002) applicable to the above described decomposition categories, respectively, and the carbon fraction in the wood (0.5 t C/t biomass). A default, conservative assumption that no deadwood is present following the land use change was adopted in this calculation.

Estimation of the carbon stock change in soils for category 4.B.2 Land converted to Cropland in the Czech Republic concerns mineral soils. The soil carbon stock changes following the conversion from Forest Land and Grassland were quantified by the country-specific Tier 2/Tier 3 approach and are described in detail in Section 6.4.2.2 above.

The Land converted to Cropland category represents a source of non-CO_2 gases, namely emissions of N_2O due to mineralization. The estimation followed the Tier 1 approach of Eqs. 2.25 and 11.8 (IPCC 2006). Accordingly, direct N_2O emissions were quantified on the basis of the detected changes in mineral soils employing a default emission factor of 0.01 kg N_2O-N/kg N (EF1, IPCC 2006), and C:N ratio of 15. Linked to this, indirect N_2O emissions from atmospheric deposition of N volatized from managed soils were estimated using Eq. 11.10 and the emission factor 0.0075 (EF5, IPCC 2006).

Other non-CO_2 emissions may be related to those from burning. However, this is not an adopted 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 2017, and this also applies to the Cropland land use category. The uncertainty estimation was guided by the Tier 1 methods outlined in the IPCC 2006 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 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). Uncertainty associated with reference soil carbon was 10% and uncertainty of array of individual emission factors used for mineral carbon stock change estimation were taken from Table 5.5 of IPCC 2006 Gl. (IPCC 2006). The adopted uncertainty associated with the emission factors involved in estimation of direct and indirect N_2O emissions was 250% (Table 11.1., IPCC 2006).

For 2017, using the above uncertainty values, the total estimated uncertainty for category 4.B.1 Cropland remaining Cropland was 43%. The corresponding uncertainty for category 4.B.2 Land converted to Cropland was 36%. The overall uncertainty for category 4.B Cropland was estimated to be 27%, using absolute values of quantities estimated in the respective emission categories.

6.5.4 Source-specific QA/QC and verification

The emission estimates are based on the activity data taken from the official national sources and follow the recommendations of the IPCC 2006 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, no recalculation was made to the estimates for the category 4.B.1 Cropland remaining Cropland. However, the estimates of 4.B.2 Land converted to Cropland were altered due to changes made in categories Forest land and Settlemens, which are pronounced in emission estimates for the associated land use conversions to Cropland. These changes resulted in altered emissions for the entire category 4.B Cropland. The above revisions resulted in lower estimates by 14.5 % as compared to those reported in the previous inventory submission when comparing the identical period of 1990 to 2016 (Fig. 6-15).

None of the individual emission categories of Cropland qualifies among the key kategories by quantity or trend in this inventory submission.

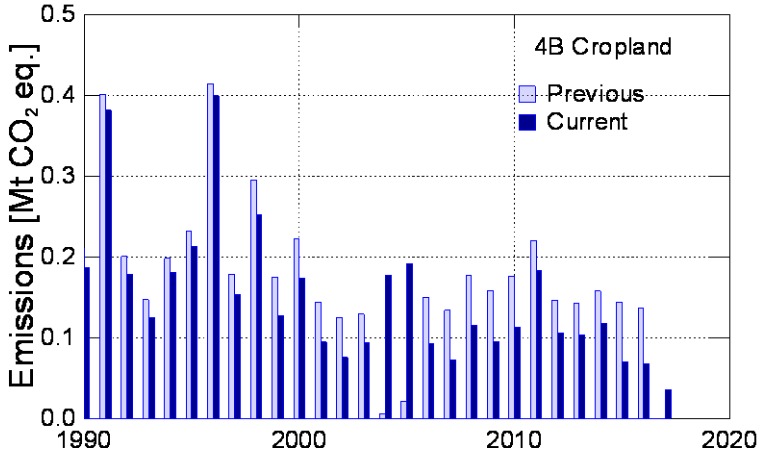


Fig. 6-15 Current and previously reported assessment of emissions for category 4.B Cropland

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 of this category.

6.6 Grassland (CRF 4.C)

6.6.1 Source category description

Through its spatial share of 12.8% in 2017, the category of Grassland ranks third among land-use categories in the Czech Republic. Its area has been increasing since 1990, specifically in the early 1990s (Fig. 6-4). Grassland as defined in this inventory corresponds to the grassland real estate category, one of the six such categories of agricultural land in the database of “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC. This land is mostly used as pastures for cattle and meadows for growing feed.

The importance of Grassland will probably increase in this country, both for its role in production and for preserving biodiversity in the landscape. According to the national agricultural programs, the fraction of Grassland should further increase to about 18% of the area of the country. The dominant portion should be converted from Cropland, the share of which is still considered excessive. After implementation of subsidies in the 1990s, the area of Grassland has increased by 21% (in 2017) since 1990.

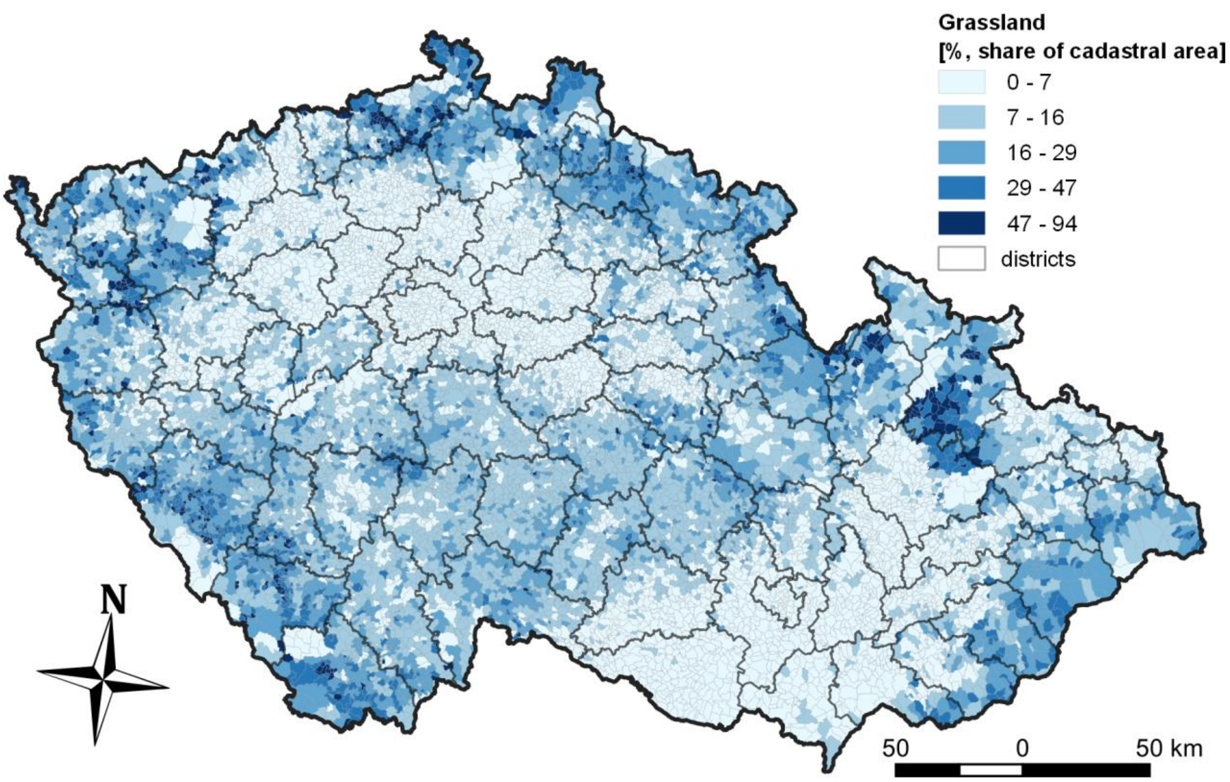


Fig. 6-16 Grassland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2017).

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 Gl. (IPCC 2006). This is a safe assumption for the conditions in this country and any application of higher tier approaches would not be justified with respect to data requirements and the expected insignificant carbon stock changes.

Similarly as for living biomass, the carbon stocks associated with dead organic matter (DOM), including deadwood and litter, are considered to be at equilibrium, i.e., it is assumed that there are no changes in carbon stocks.

The emissions from changes in soil carbon stock were estimated for category 4.C.1 Grassland remaining Grassland. These are given by changes in mineral and organic soils. Organic soils basically do not occur on Grassland; they occur as peatland in mountainous regions on Forest Land. Hence, emissions were estimated for mineral soils. The estimation procedure was revised in 2018 NIR submission 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. 6-11). Next, the are of grassland was stratified according to specic management activities that determine attribution of appropriate management and input stock change factors as guided by Table 6.2. of IPCC 2006 Gl. (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 2017 shown).

Management categories on grassland	Land use F_{LU}	Management F_{MG}	Input F_I	Area in 1990 (kha)	Area in 2017 (kha)
I.a Permanent grassland – improved	1	1.14	1	324.6	329.3
I.b Permanent grassland – nominally managed	1	1.00	-	324.6	329.3
II. Grassland for rough grazing	1	0.95	-	8.3	228.3
III. Grassland not used for production	1	0.70	-	8.0	9.1

The estimation follows Eq. 2.25 assuming a 20-year default period for time dependence of stock change factors (D) and using country-specific mean value for the reference carbon stock values in mineral soils (68.2 t C/ha). The national source of activity data required for the adopted categorization of grassland is COSMC as 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 Syrveys conducted in 2016 and 2013, and from 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 requirements of EU/EC legislation. In the Czech Republic, the survey is conducted on the basis of the 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 CsSO. In absence of data supporting division of permanent grassland into nominal and improved management, that land area was eqally divided into these categories (I.a and I.b in Tab. 6-10), being a subject of further investigation. The emission factors used as listed in Tab. 6-10 correspond to the recommended values of Table 6.2 for grassland management in 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 of 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 the 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 2017. The uncertainty estimation was guided by the Tier 1 methods outlined in 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 2017, using the above uncertainty values, the total estimated uncertainty for category 4.C.1 Grassland remaining Grassland reached 45%. The corresponding uncertainty for category 4.C.2 Land converted to Grassland reached 31%. The overall combined uncertainty for category 4.C Grassland is 34%.

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 IPCC 2006 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, no recalculation was made to the estimates for the category 4.C.1 Grassland remaining Grassland. However, the estimates of 4.C.2 Land converted to Grassland were recalculated due to changes made in categories Forest land and a newly implemented soil estimate applicable to Settlemens, which are pronounced in emission estimates for the associated land use conversions to Grassland. These changes resulted in altered emissions for the entire category 4.C Grassland. The above revisions resulted in higher sink estimates by 15.6 % as compared to those reported in the previous inventory submission when comparing the identical period of 1990 to 2016 (Fig. 6-17).

None of the individual emission categories of Grassland qualifies among the key kategories by quantity or trend in this inventory submission.

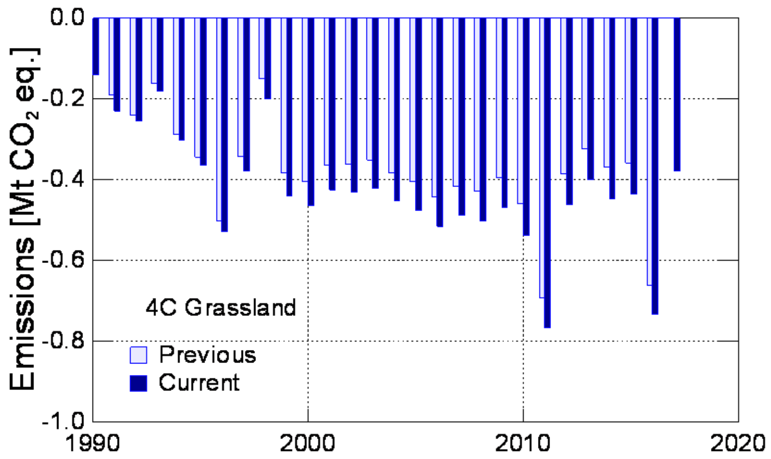


Fig. 6-17 Current and previously reported assessment of emissions for category 4.C Grassland. The values are negative, hence representing net removals of green-house gases.

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. A further improvement in uncertainty estimates are also planned in this category.

6.7 Wetlands (CRF 4.D)

6.7.1 Source category description

Category 4.D Wetlands as classified in this emission inventory includes riverbeds and water reservoirs such as lakes and ponds, wetlands and swamps. These areas dominantly 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 inlcuded under 4.D Wetlands (Tab. 6-3). The specific land use details of the land use category water area are given in 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 watercourse, natural water reservoirs, artificial water reservoirs, wetlands (march, wetland, swamp) and water areas with building.

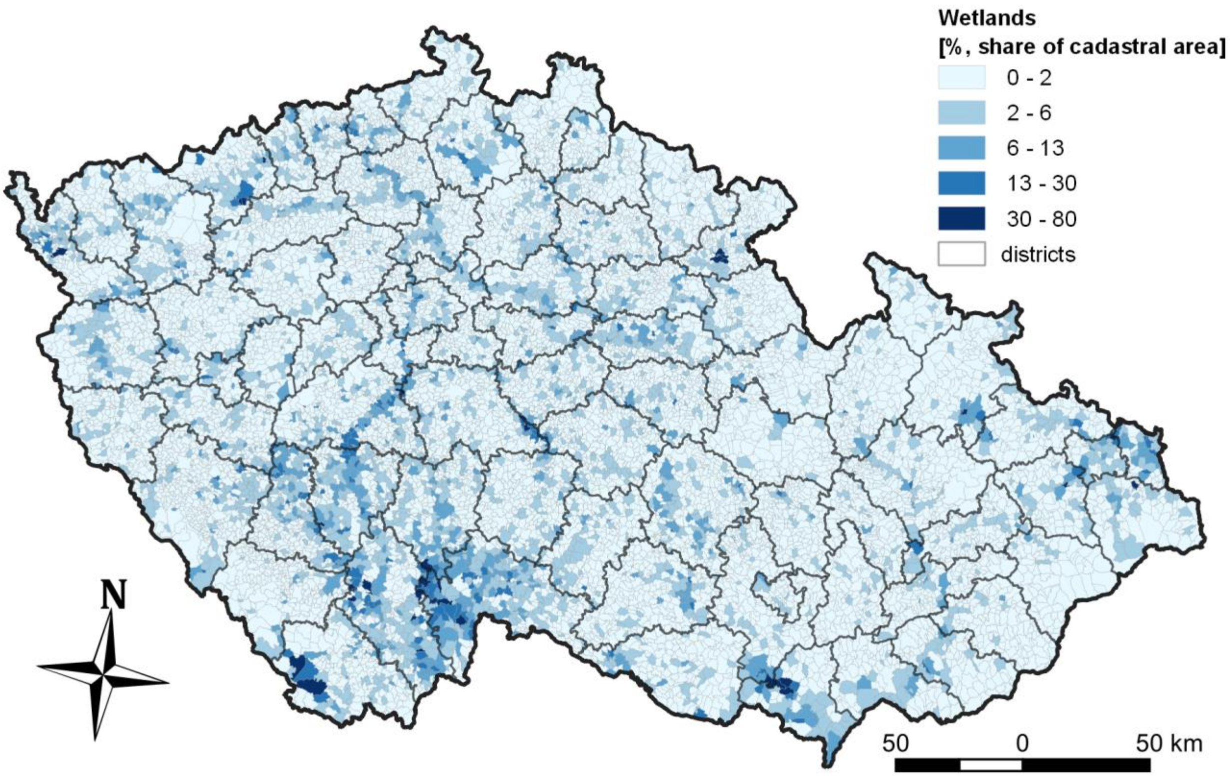


Fig. 6-18 Wetlands – distribution calculated as a spatial share of the category within individual cadastral units (as of 2017).

The area of 4.D Wetlands currently covers 2.1% of the total territory. It has been increasing steadily since 1990 (by 5.5% until 2017) with even a stronger trend earlier (Fig. 6-4). 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[6], specifically in relation to adaptation strategies proposed to deal with changing climate and associated increase frequency and severity of drought in the Czech landscape (e.g., Trnka *et al*. 2015).

6.7.2 Methodological issues

The emission inventory of sub-category 4.D.1 Wetlands remaining Wetlands can address the areas in which the water table is artificially changed, which correspond to peat-land draining or lands affected by water bodies regulated through human activities (flooded land). Both categories are practically not occurring under the conditions in this country. Peat extraction basically ceased in the country in early 1990s following the Act No. 114/92 on nature protection. Peat for industrial use relies on import nowadays (Belarus), with exception of peat used in balneology. Hence, sub-category 4.D.1 Wetlands remaining Wetlands cannot be attributed to neither to flooded land or peat extraction lands. Hence, all wetland areas are reported under category 4.D.1.3 Other Wetlands remaining Other Wetlands. Corresponsingly, the emissions for 4.D.1 Wetlands remaining Wetlands were not explicitly estimated for this sub-category.

[6] *Based on the land-use history, the growth potential could be considered to be rather large. For example, as of 1990, the category included 50.7 th. ha of ponds, which represented only 28% of their extent during the peak period in the 16th Century (Marek 2002)*

Emission estimates in sub-category 4.D.2 Land converted to Wetlands encompasses conversion from 4.A Forest Land, 4.B Cropland and 4.C Grassland. This corresponds to a very minor land-use change identified in this country, which corresponds to the category of land converted to flooded land. The emissions associated with this type of land-use change are derived from the carbon stock changes in living biomass and, for conversion from Forest land, also deadwood. The emissions were generally estimated using the Tier 1 approach and eq. 2.11 of the 2006 IPCC Guidance for LULUCF, which simply relates the biomass stock before and after the conversion. The corresponding default values were employed: the biomass stock after conversion equalled zero, while the mean biomass stock prior to the conversion in the 4.A Forest Land, 4.B Cropland and 4.C Grassland categories was estimated and/or assumed identically as described above in Sections 6.4.2.2 and 6.5.2.2. The latter section also describes the estimation of emissions related to the deadwood component, which was applied identically in this land use category.

6.7.3 Uncertainties and time series consistency

The methods used in this inventory for Wetlands were consistently employed across the whole reporting period from the base year of 1990 to 2017. Similarly as for the other land-use categories, the uncertainty estimation was guided by the Tier 1 methods outlined in IPCC 2006 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 conversion 8%, average biomass stock in cropland and grassland prior conversion 75%, biomass carbon stock after land-use conversion 75%, average amount of standing deadwood 27%, average amount of lying deadwood 20%, carbon fraction of dry woody matter 7%, and average above-ground to below-ground biomass ratio *R* (root-shoot-ratio) 68%. The uncertainty applicable to *BCEF* was 22%, which was derived from the work of Lehtonen et al. (2007).

Since the emission estimate concerns only category 4.D.2 Land converted to Wetlands, the uncertainty is estimated for this category. For 2017, 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 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.

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

The emission estimates for the category 4.D Weltlands changed due to the recalculations made for sub-category 4.D.2 Land converted to Wetlands. The changes reflect the improvements made in the category of Forest land and the land use conversion from that category. The effect of these changes represents an increase of emissions by 3 % relative to the estimates reported in the previous submission (Fig. 6-19).

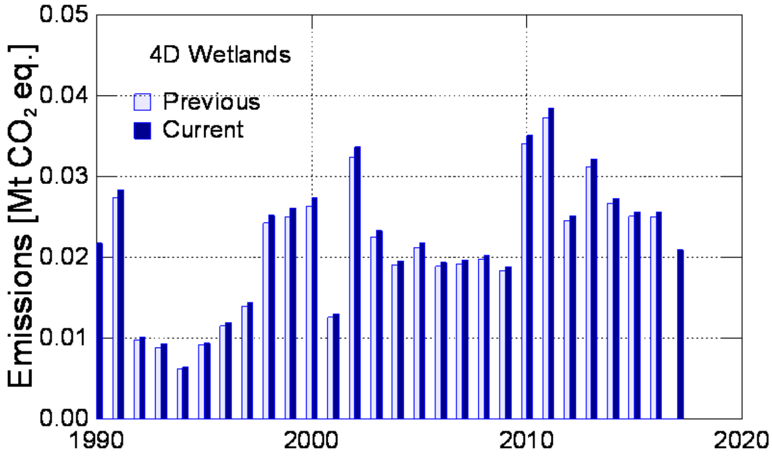


Fig. 6-19 Current and previously reported assessment of emissions for category 4.D Wetlands

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)

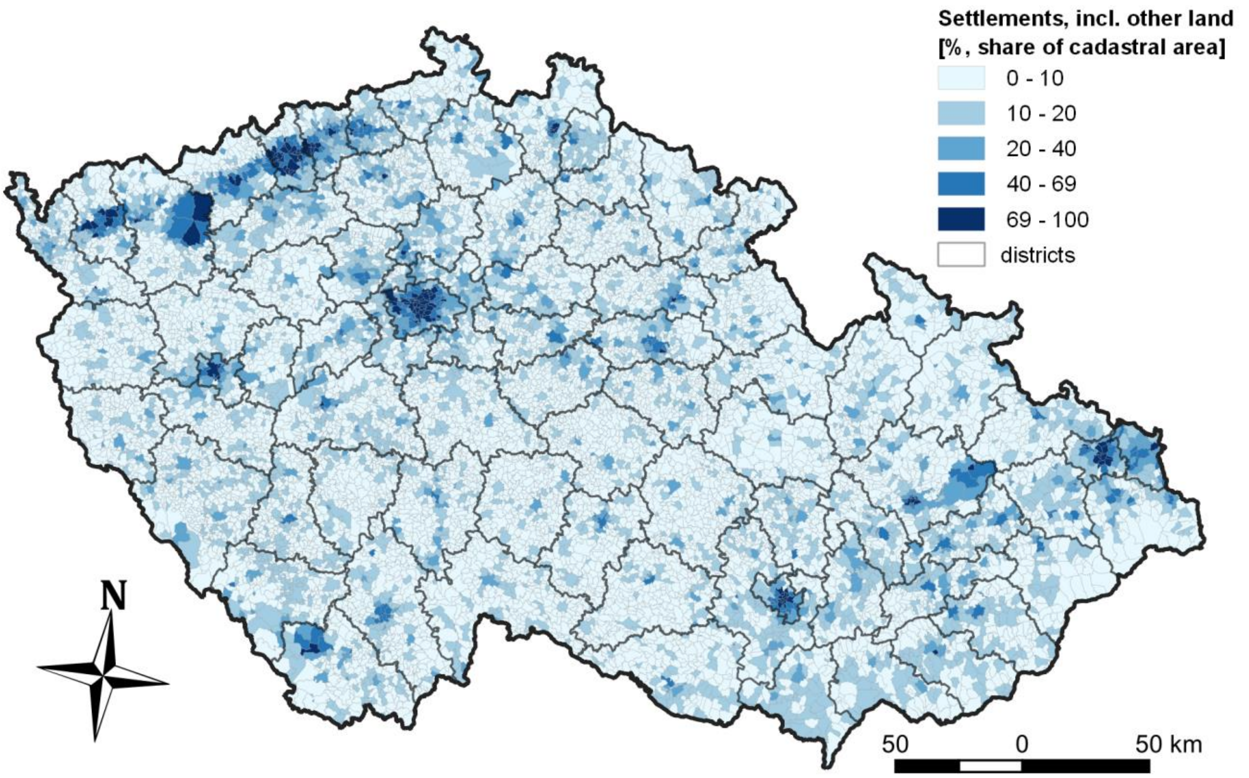


Fig. 6-20 Settlements, incl. other land – distribution calculated as a spatial share of the category within individual cadastral units (as of 2017).

6.8.1 Source category description

Category 4.E Settlements is defined by IPCC 2006 Gl. (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 Gl. (IPCC 2006) default definition. The previous inventory submission (NIR 2018) incorporated additional change to this category, namely merging the land areas previously attributed under the catgory 4.F Other. This decision was substantiated by the fact that in the conditions of the country, these areas mostly do not remain untouched and may undergo land-use change, hence do not meet the condition of no possible management interventions. This makes land attribution more consistent and transparent, enhancing the ability to track land-use conversions. This solution was also endorsed by the latest in-contry expert review team. In this way, the 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 Amendment to Act No. 357/2013 Coll (Act on Cadastre) are covered, including "Unproductive land" that was previously attributed 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). The 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 (as of 2017) represents about 10.7 % of the area of the country. The area of this category has increased since 1990 by about 4%, especially during the most recent years (see Fig. 6-4).

6.8.2 Methodological issues

Following Tier 1 assumption of IPCC 2006 Gl. (IPCC 2006), the carbon stocks in biomass, dead organic matter (dead wood and litter) and soil are considered in equilibrium for category 4.E.1 Settlements remaining Settlements. Hence, the emission inventory for this category concerns primarily 4.E.2 Land converted to Settlements.

Correspondingly, emissions quantified for this category are related to sub-category 4.E.2 Land converted to Settlements. Specifically for Forest land converted to Settlements, the emissions result from changes in biomass carbon stock, dead organic matter (DOM) and soil. The biomass carbon stock change was quantified based on eq. 2.11 (IPCC 2006). Changes in DOM were related to the deadwood carbon pool that is considered lost.

The estimate of soil carbon stock changes involving land-use change to Settlements are newly included in this inventory Submission. For this, a reference value of carbon stock pool in Settlements was derived based on the data from the Landstape inventory CzechTerra (CZT). CZT in its remote-sensing component identified proportions of land cover that constitute the land use category Settlements. These proportions of land cover (area of trees, arable land , grass cover as well as the build-up, paved surfaces) were assessed from a sample of 289 625 categorized grid points) and used to construct the reference carbon stock value applicable for 4E1 Settlements. For this, soil carbon pool values of Forest land, Cropland and Grassland at the level of individual cadastral unit (n>13 000) were linked to the specific land cover types and their spatial representation within Settlements, i.e., trees (13.5 %) , arable land (1.7%) and grass cover (34.8%). The resulting reference carbon stock applicable to Settlements has its area-weighted mean of 33.6 t C/ha (range of 24.4 to 61.2 t C/ha). These carbon pool values allowed estimation of the associated land-use conversions (categories 4.E.2.1, 4.E.2.2 and 4.E.2.3), for sake of consistency adopting the identical time dependence (IPCC 2006 default) period of 20 year for these soil carbon pool changes as in other land use conversion types.

The corresponding values were employed: the biomass stock after conversion equalled zero, while the mean biomass stock prior to the conversion was estimated and/or assumed identically as described above in Sections 6.4.2.2 and 6.5.2.2. The latter section describes estimation of the emissions related to the deadwood component, which was employed identically in this land use category. The carbon stock prior conversion was estimated as described in Section 6.4.2. All biomass is assumed to be lost during the conversion, according to the Tier 1 assumption of IPCC 2006 Gl. (IPCC 2006). An additional contribution to emissions comes from the deadwood component, using the actual areas of the land use change concerned and carbon pool of deadwood. Finally, soil carbon pool estimates applicable for land use conversions to Settlement used the spatially-specific carbon pool values, with the mean of 33.6 t/ha, as described above.

6.8.3 Uncertainties and time series consistency

The methods used in this inventory for 4.E Settlements were consistently employed across the whole reporting period from the base year of 1990 to 2017. The uncertainty estimation was guided by the Tier 1 methods outlined in IPCC 2006 Gl. (IPCC 2006) and described in Section 6.4.3. It utilized primarily the default uncertainty values as recommended by IPCC 2006 Gl. (IPCC 2006). As reported above, uncertainty estimation was revised for this submission, which applies also to this land use category. The following uncertainty values were used: carbon fraction in dry matter 7%, land use areas 3%, reference biomass carbon stock prior and after land-use conversion 75%, average growing stock volume in forests 8%, average amount of standing deadwood 27%, average amount of lying deadwood 20% and average above-ground to below-ground biomass ratio *R* (root-shoot-ratio) 68%. The uncertainty applicable to *BCEF* was 22%,derived from the work of Lehtonen et al. (2007).

The emission estimate concerns only category 4.E.2 Land converted to Settlements; therefore, the uncertainty is estimated only for this category. For 2017, the estimated uncertainty for category 4.E.2 was 80%.

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 IPCC 2006 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

In response to issue L. 19 of the latest review, the estimates for soil carbon pools are newly introduced for Settlements in this inventory submission. They are based on the data from Landscape inventory CzechTerra, which in its remote sensing component identified proportions of land cover that constitute the land use category Settlements. The methodological detail are described in Section 6.8.2 above. This permitted quantification of emissions associated with land-use conversions to Settlements (categories 4.A.2.4, 4.B.2.4 and 4.C.2.4). The effect of these changes on emissions for castegory 4.E Settlements are shown in Fig. 6-21. Specifically, emission estimates increased due to the newly included soil carbon pool change estimates in category .

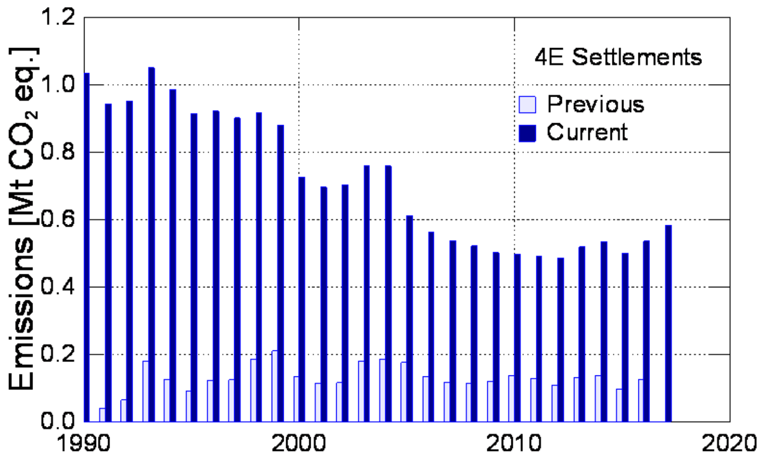


Fig. 6-21 Current and previously reported assessment of emissions for the category 4.E Settlements

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. The inventory team works on verifying carbon stock change estimates in mineral soils. Further improvements are also planned for uncertainty assessment.

6.9 Other Land (CRF 4.F)

6.9.1 Source category description

Since the previous inventory submission (NIR 2018) the IPCC category 4.F Other land is not represented by any land use category within the Czech conditions and the natonal system of land use representation and land use change identificatition. Prior to this submission, category 4.F Other Land represented unmanaged (unmanageable) land areas, matching the IPCC 2006 Gl. (IPCC 2006) default definition. These areas were assessed from the database of “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC. It is part of the AACLC “Other lands” category with the specific land use category “Unproductive land” assessed from the 2006 land census of COSMC. Under that definition, the category 4.F. Other land represented 1.3% of the territory of the country. Since 2018 NIR submission, these areas have fully been included under category 4.E Settlements. The reasons for that decision are described in section 6.8.1 above.

6.9.2 Methodological issues

Since the earlier inventory submission (NIR 2018), no areas have been attributed to category 4.F Other land. Hence, no methodological isues are applicable for this category.

6.9.3 Uncertainties and time series consistency

Since the earlier inventory submission (NIR 2018), no areas have been attributed 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

Since the earlier inventory submission (NIR 2018), no areas have been attributed to category 4.F Other land. Hence, no 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 recently (NIR 2018) adopted attribution 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

Since NIR 2018, the inventory team includes 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 planed 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 the country. Hence, these emissions originate in land use category 4.A Forest land. The eventual fraction of wood from deforested land, i.e., Forest land converted to any other land use category, 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 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 0.023% in 1990 and 2017, 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 HWP contribution under Kyoto Protocol. This conservative approach is, for the sake of transparency, adopted for the HWP estimates under the Convention, too.

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 period 1993-1997

	Production		Import		Export	
Country HWP category	Czech Republic	Slovakia	Czech Republic	Slovakia	Czech Republic	Slovakia
Sawn wood	0.834	0.166	0.868	0.132	0.723	0.277
Wood-based panels	0.716	0.284	0.719	0.281	0.851	0.149
Paper and paperboard	0.655	0.345	0.772	0.228	0.598	0.402

The resulting estimates of the HWP contribution including domestically produced and used wood for the reporting period 1990 to 2017 are shown in Fig. 6-22 below. The emissions fluctuate during the reporting period, where the mean contribution reached -1 010 kt CO_2/year. The actual HWP contribution reached -1 713 and -779 kt CO_2 in 1990 and 2017, respectively.

6.10.3 Uncertainties and time series consistency

The uncertainty estimates use the following inputs: roundwood harvest 20%, sawnwood, wood panel and paper products 15%, wood density factors 25%, carbon content in wood products 10%, half-life factors 50%. Using Eq. 4 for combining uncertainties, this gives an approximate uncertainty estimation of 62% for the HWP contribution, which is general for all 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 2017.

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, limited to those elements relevant for this specific land-use category.

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

No recalculations were made for the category 4.G HWP. Hence, the estimates do not differ between the current and the previous submission (Fig. 6-22). Tho exceptions are years 2015 and 2016, where the current and previous estimates differ due to more up-to-date information available at 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).

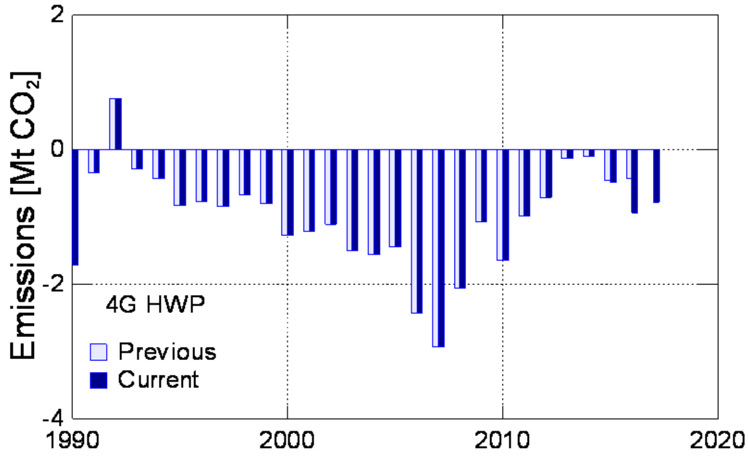


Fig. 6-22 The reported assessment of HWP contribution to emissions in the LULUCF sector for the category 4.G HWP

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

No specific improvements are planned for this category for the next submission.

Acknowledgement

The authors would like to thank Jan Hána, Patrik Pacourek and Miroslav Zeman, Forest Management Institute in Brandýs n. Labem, for compiling the required increment data concerning forests in previous years. Some of the analyses required for this inventory were performed within the CzechCarbo project (VaV/640/18/03), while some of the critical data were obtained from the CzechTerra project funded by the Czech Ministry of the Environment (SP/2d1/93/07) and the Czech Science Foundation (14-12262S). We greatly appreciate the assistance of the staff at the Czech Office for Surveying, Mapping and Cadastre, specifically David Legner, Petr Kokeš, Petr Souček, Zuzana Loulová, Bohumil Janeček and Helena Šandová, related to data on land use areas and advice in related issues. The authors would also like to thank Jan Apltauer, former IFER employee, for his contribution to previous NIRs. Thanks belong to IFER employee Jan Tumajer for revising the HWP.

7 Waste (CRF sector 5)

7.1 Overview of sector

The waste sector comprises emissions from human activities associated with general waste management. Most human and economic activities result in the production of waste; therefore, performance in 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.

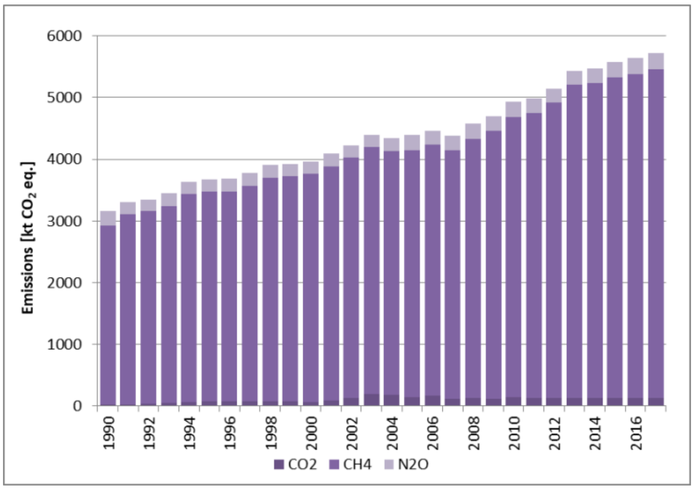


Fig. 7-1 Development of Waste sector by gases, 1990-2017

The sector encompasses several categories. The main source category of this sector is 5.A Solid waste disposal. In 2017, this category emitted approximately 149 Gg of CH_4, equalling 3720 kt 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 slight decline in the share of landfilling (although the effect on emissions is delayed due to the time lag in decomposition processes) but it is still the most frequently used waste disposal method for solid waste. The decline in the share of landfilling is accompanied by an increase in other types of waste management, especially composting, which has grown remarkably in the past few years. 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 because of subsidies for 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 (2017)

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	2.92	2.88
5.D Wastewater treatment and discharge	CH_4	LA, TA	LA	yes	yes	yes	yes	0.69	0.68
5.B Biological treatment of solid waste	CH_4	LA, TA	LA, TA	yes	yes	yes	yes	0.51	0.50

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.

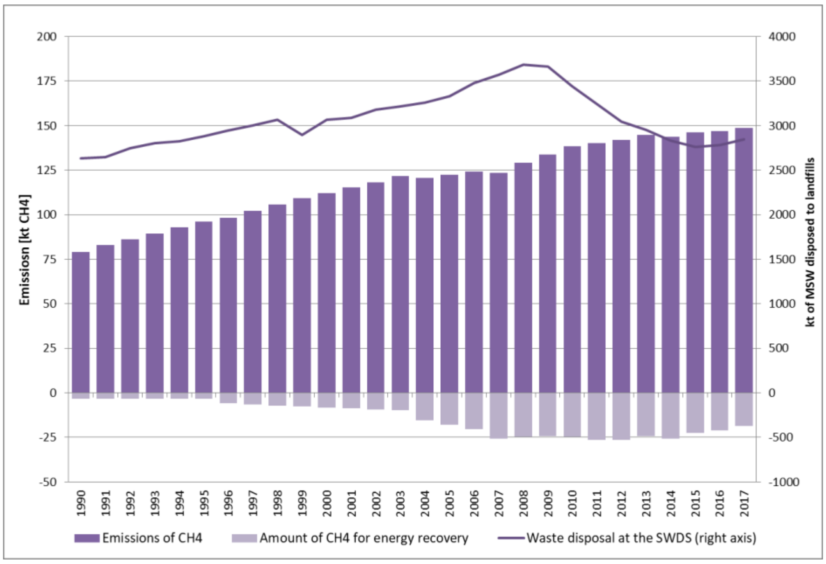


Fig. 7-2 Development of emissions from SWDS and total amount of waste disposed to SWDS 1990-2017

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 accordance with the IPCC 2006 Gl. (IPCC 2006), only CH4 is addressed in this chapter. An overview of this category is shown in Fig. 7-2.

7.2.1.2 Methodological issues

Waste disposal to SWDS

The key activity data for methane quantification from 5.A.1 is the amount of waste, disposed in landfills. The annual disposal is given in Tab. 7-2. The data for annual disposal are obtained from mixed sources, since the application of the FOD model requires data from 1950 to the present day. These historical data are not available in this country and never will be; therefore estimations had to be used for the past. These estimations are described in the working paper (Havránek, 2007), but the method can be simply described as intrapolation and extrapolation between points in time; waste production was correlated with the social product (predecessor of the current GDP) as a test method. The higher of the two estimates was used in the quantification.

The data used for current 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 obligations for this system are based on the national legislation and are controlled by the Czech Environment Inspection. Waste statistics have been developed by the Czech Statistical Office and are subsequently reported to Eurostat. We used ISOH data for the inventory because they are evidence-based and were verified by CENIA during the reporting procedure. In 2018 CENIA ran a cross comparison with SWDS data and found that the ISOH data provide better fits to fees and levies gathered by in the waste management sector and hence are percieved as more accurate.

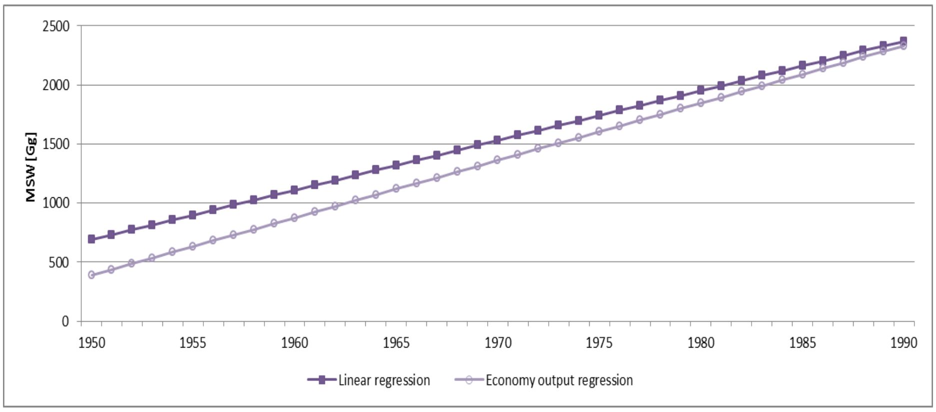


Fig. 7-3 MSW disposal in SWDS in the Czech Republic, 1950-1990

Since 2011, the waste deposited in landfills has decreased slightly for for the first time in modern history, but now growth is once again evident. 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 carried out and specifies the relevant actors and state bodies responsible for the administration and control, and the duties and obligation of all the stakeholders. The main regulations in this area are Act 185/2001 Coll., the "Act on waste" and the main directive relevant for the landfilling Decree 294/2005 Coll. and the "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

There are two official data sources on waste in the Czech Republic. The first is the above-mentioned ISOH, while the second official source of data on waste is the Czech Statistical Office (CzSO) and its data in Eurostat. Data from CzSO are top-down data from a statistical survey and they yield a different picture of landfilling of the waste in this country. This causes confusion during the review process, as the top-down and bottom-up data differ significantly (by about 750 Gg of waste in some years). The CZSO data is compliant with the Eurostat methodology, however the definition of MSW in Eurostat data does not reflect national conditions and obligatory IPCC methodology. Based on a suggestion from ARR, we hybridized our data sources on waste so that we still use ISOH data which contains IW data (but do not differentiate between them as such) but we increased them by a residual factor from CzSO based on their IW statistics to avoid underestimation. More details and explanations can be found in Annex A5.4.

Tab. 7-2 MSW/IW disposal in SWDS in the Czech Republic [kt], 1990-2017

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**	3179	**2009**	3666	**2016**	2783
1996	2943	**2003**	3211	**2010**	3445	**2017**	2843

The Tier 1 FOD approach (first-order decay model) is used for estimation of methane emissions from this source category. 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 IPCC 2006 Gl. (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 compositions (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 monitoring of waste composition. In 2018, the Ministry of Environment funded a new waste composition survey project, which started 2019 and should yield results next year.

As can be seen, the table does not include all possible waste streams that might be deposited in a landfill, where sludge is missing. 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 mostly consists of soil used to cover landfills and is not reported as a waste), the researchers did not include 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 deposited as a waste is included in the 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, in fact, includes 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 in 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, 1950-2017)

	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 individual 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
2009-2017*	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 values. 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 for the earlier years in 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, 1950-2017

	MCF
1950 – 1959	0.6
1960 – 1969	0.6
1970 – 1979	0.8
1980 – 1989	0.9
1990 – 2017	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 considered to be representative for the whole country. However, the IPCC 2006 Gl. (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) does 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, and thus 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 LFG collection systems and combusted for energy purposes. Based on the IPCC 2006 Gl. (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-specific 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 2017, more than 70 facilities were recovering LFG in the country. This year we also encountered a decrease in the recovered amount of methane. We assume that it could be correlated with the decreasing trend in landfilling in recent years and a time delay, but we are not certain.

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 [kt], Czech Republic, 1990-2017

	CH_4 generation	CH_4 recovery	CH_4 emission
1990	91	3.25	79.17
1991	95	3.25	82.79
1992	99	3.45	85.97
1993	103	3.45	89.48
1994	107	3.45	92.95
1995	110	3.45	96.20
1996	115	6.03	98.23
1997	120	6.58	102.01
1998	125	7.12	105.69
1999	129	7.67	109.37
2000	133	8.22	111.94
2001	137	8.76	115.15
2002	141	9.31	118.27
2003	145	9.86	121.75
2004	150	15.58	120.55
2005	154	18.00	122.32
2006	158	20.58	124.04
2007	163	25.93	123.35
2008	168	24.58	129.26
2009	173	24.50	133.68
2010	179	24.66	138.50
2011	182	26.59	140.04
2012	184	26.56	141.99
2013	185	24.20	144.88
2014	185	25.72	143.77
2015	185	22.72	146.15
2016	184	21.30	146.84
2017	184	18.74	148.81

7.2.1.3 Uncertainties and time-series consistency

Overall quantification of the uncertainity for this category is still incomplete. This is considered a high priority and will be conducted in the following years as soon as budget constraints permit. This category entails the difficulty that the uncertainty does permeate through the whole waste management period of 1950-2017 and therefore it cannot be correctly quantified by simple analysis. The combined uncertainty was estimated by expert judgement based on default factors and activity data uncertainties (please, see 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)

7.2.1.4 Source-specific QA/QC and verification

Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. The activity data used for this sector are approved by the data producer, who verifies them before they are used for further calculation.

Since the waste sector is fairly small, external QC is not provided; instead QC is performed by a NIS coordinator and the results are communicated to the sectoral expert.

The activity data from the national agencies and ministries are the subjects of internal QA/QC mechanisms and the NIS team has only limited insights into them. Processes are in place at all state agencies and ministries to ensure that they produce accurate data.

7.2.1.5 Source-specific recalculations, including changes made in response to the review process

There were no recalcluation of this category this year.

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

In coming 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 include the results of a waste composition survey as soon as they become available. We also submitted a project to further develop methodology to include in the calculation aspects that are small but significant in terms of completeness for waste management systems. One of them is burning of landfills which, together with category 5.C, has the potential to somewhat change the results of the inventory.

We would still like to see harmonisation of ISOH and CzSO data on waste management. We plan to recalculate the whole category according to the 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)

The biological treatment of waste includes two categories. Aerobic processes for treating organic waste include 5.B.1 Composting and 5.B.2 Anaerobic digestion. Composting is mostly an aerobic process and thus the production of methane is insignificant. Anaerobic digestion has greatly increased in recent years and there is active state support for this type of waste treatment (i.e. energy production from biogas). However, it is a controlled process mainly directed towards capturing the produced biogas and thus emissions from this source category are also relatively small. An overall survey of this source category is shown in Fig. 7-4.

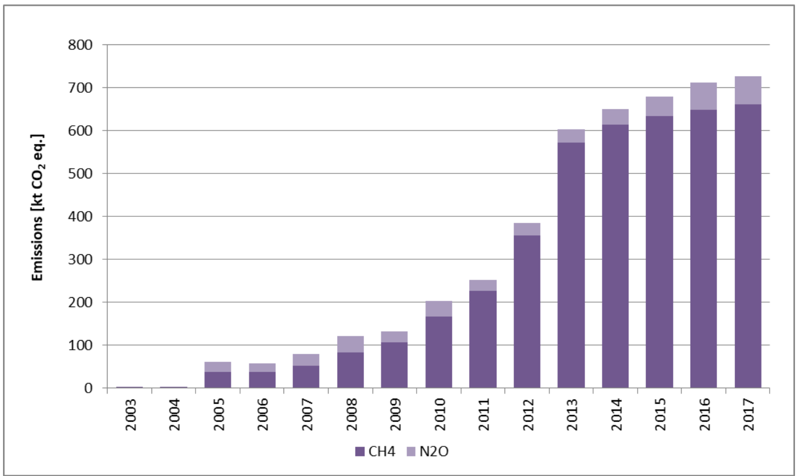


Fig. 7-4 Development of emissions from biological treatment of solid waste, 2003-2017

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 Gl., 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 Gl. were used for both streams. No data is available for either category before 2005, so further research has been launched to determine the reasons for this. Considering that industrial composting is a relatively new field in this country, the data for earlier years could be non-existent because this activity did not occur. The amount of composted MSW is gradually increasing and this is a long term aim of Czech environmental policy. Overall development of the category is shown in Tab. 7-8.

Tab. 7-8 Emissions of GHG from composting [kt], Czech Republic, 2005-2017

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
MSW [kt]	48.76	61.48	79.80	114.44	134.60	144.14	181.91	153.50	202.83	303.11	373.98	420.00	445.35
Other waste [kt]	288.81	222.67	296.39	428.74	221.28	358.24	190.06	228.28	247.04	217.15	249.41	469.30	453.08
Emission factor [kg CH_4/ton]							4						
Emission factor [kg N_2O/ton]							0.24						
Total Composting CH_4 [kt]	1.35	1.14	1.50	2.17	1.42	2.01	1.49	1.53	1.80	2.08	2.49	3.56	3.59
Total Composting N_2O [kt]	0.08	0.07	0.09	0.13	0.09	0.12	0.09	0.09	0.11	0.12	0.15	0.21	0.22
Total composting GHG [kt CO_2 eq.]	57.90	48.74	64.52	93.17	61.04	86.17	63.80	65.48	77.16	89.24	106.92	152.53	154.10

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 involved are employed identically across the whole reporting period from the base year 1990 to 2017.

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. We have submitted a proposal for a project to develop methodology for estimation of household composting.

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 2017. 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 the 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 Gl. (IPCC 2006) states that leakages are very small in controlled AD facilities focused on energy production, ranging between 0-10 percent. A mean value of 5% for all produced methane was used for estimation of the emissions of biogas from AD.

Since data about production are used as activity data, all the possible emissions from AD are calculated, not just emissions from digested waste. Some of the material used in AD might not be waste by definition (e.g. agricultural residues, industrial by-products etc.). An overview of the sector is shown in Tab. 7-9.

Tab. 7-9 Emissions from Anaerobic digestion stations, 2003-2017

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Number of biogas stations [count]	8	10	9	14	21	49	86	115	186	317
Energy [TJ]	142	122	120	325	589	1 129	2 807	4 660	7 547	12 721
	2013	**2014**	**2015**	**2016**	**2017**					
Number of biogas stations [count]	388	404	403	404	404					
Energy [TJ]	21 040	22 472	22 870	22357	22 845					
Conversion [TJ/Gg]	50.009									
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Activity data [Gg CH_4] - R	2.84	2.44	2.40	6.50	11.78	22.58	56.13	93.18	150.91	254.37
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
	2013	**2014**	**2015**	**2016**	**2017**					
Activity data [Gg CH_4] - R	420.72	449.36	457.32	447.06	447.86					
Emissions (default 5%) [Gg CH_4]	21.04	22.47	22.87	22.35	22.39					

7.3.2.3 Uncertainties and time-series consistency

The time series are consistent, since same method, factors and data source are used. Uncertainty in this source category is given by the EF range from -100% to +100%.

Tab. 7-10 Uncertainty estimates for 5.B category

Gas	Category	AD uncertainity [%]	EF uncetrainity [%]	Origin of the parameters
CH_4	5.B.1 Composting	20	NA	AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA)
N_2O	5.B.1 Composting	20	NA	AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA)
CH_4	5.B.2 Anaerobic digestion	20	100	AD Expert judgement M. Havránek; EF IPCC default, verification of AD Jiří Valta (CENIA)

7.3.2.4 Source-specific QA/QC and verification

The QA/QC plan for the sector was updated during 2015 and 2016. Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. The activity data used for this sector are approved by the data producer, 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 four MSW incinerators in the country, which are not accounted for this source category and there are more than 70 other facilities, incinerating or co-incinerating industrial and hazardous waste with a total capacity over 600 Gg of waste. However, most of this capacity is not used.

7.4.1.2 Methodological issues

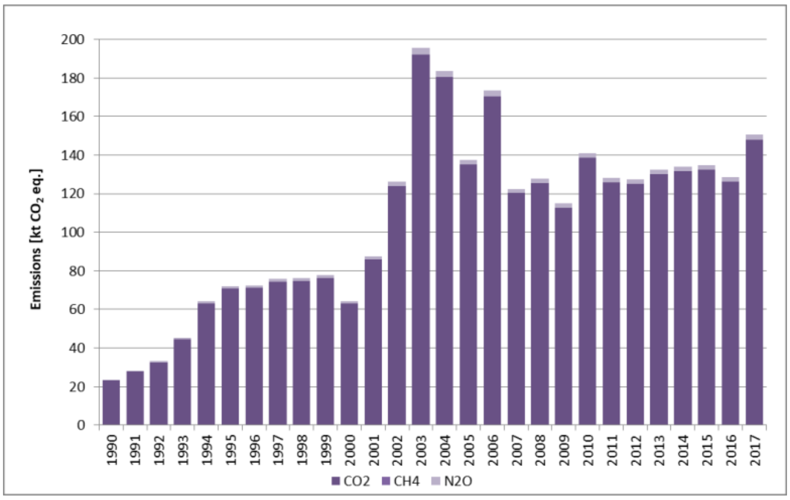


Fig. 7-5 Development of emissions from waste incineration, 1990-2017

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 emission 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 Gl., see Tab. 7-11. 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 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 2006 Gl. (IPCC 2006) (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 given as wet weight. To correct this for carbon content, we used factor 0.9 based on Table 2.4 Section 2.3 of IPCC 2006 Gl. (IPCC 2006) for other waste. Methane and nitrous oxide emission factors are given for wet waste and hence no correction is employed.

Tab. 7-11 H/IW incineration in 1990 – 2017 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 CH_4/Gg]	1.0E-04											
	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Waste incinerated [Gg]	14.10	43.07	38.40	82.34	84.44	76.65	76.27	79.23	80.24	80.66	80.77	90.28
Total CO_2 [Gg CO_2] Fossil	20.83	63.63	56.73	121.67	124.77	113.26	112.70	117.07	118.56	119.19	119.35	133.39
Total CO_2 [Gg CO_2] Bio.	2.31	7.07	6.30	13.52	13.86	12.58	12.52	13.01	13.17	13.24	13.26	14.82
Total CH_4 [Gg CH_4]	8E-06	2E-05	2E-05	5E-05	5E-05	4E-05	4E-05	4E-05	4E-05	5E-05	8E-05	5E-05
Total N_2O [Gg N_2O]	1E-03	4E-03	4E-03	8E-03	8E-03	8E-03	8E-03	8E-03	8E-03	8E-03	8E-03	9E-03

The suggested default emission factors for hazardous waste incineration were 100 kg of N_2O per Gg of incinerated HW and 0.56 kg of methane per Gg of incinerated HW. The biogenic emissions of CO_2 from this category were estimated last year. The approach is based on the default factor for fossil carbon, assuming that the rest of the carbon in the material is non-fossil in origin. 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 the literature and in the bottom ash measurement, where the fraction 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. 7-12 Uncertainty estimates for 5.C category

Gas	Category	AD uncertainity [%]	EF uncetrainity [%]	Origin of the parameters
CO_2	5.C.1 Waste incineration	15	5	AD Expert judgement M. Havránek; EF IPCC default
N_2O	5.C.1 Waste incineration	20	70	AD Expert judgement M. Havránek; EF IPCC default
CH_4	5.C.1 Waste incineration	20	80	AD Expert judgement M. Havránek; EF IPCC default

7.4.1.4 Source-specific QA/QC and verification

The QA/QC plan of the National inventory system was used for the whole waste category. For this particular subcategory, bottom-up data provided by the official sources (Ministry of Industry and Trade, MIT) and also the data from VISOH-ISOH – information system on waste management run by MoE/CENIA was used. However, the inaccuracy or uncertainty of this data is not quantified but is estimated by expert judgment. The compiler cross-checked the data on incineration with the top-down data, produced by other state agencies.

7.4.1.5 Source-specific recalculations, including changes made in response to the review process

No recalculation has been made this year.

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 suspicions 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. Both population and industrial production have been increasing in recent years and hence the trend has been upwards in these years.

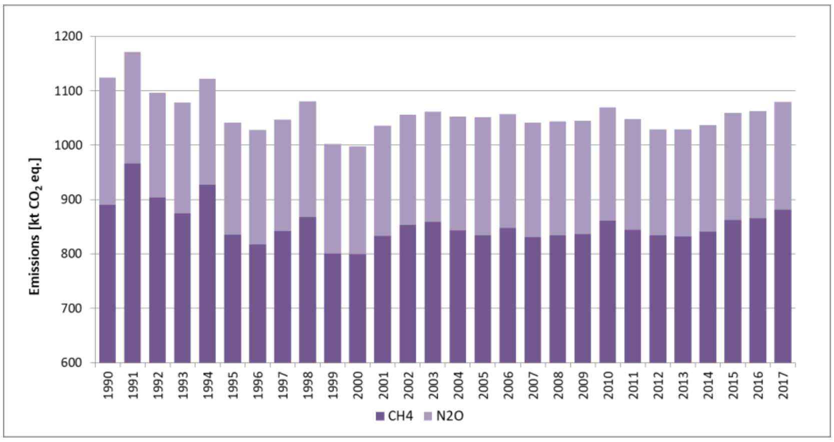


Fig. 7-6 Development of emissions from wastewater treatment and discharge, 1990-2017

7.5.1 Domestic Wastewater Treatment (CRF 5.D.1)

7.5.1.1 Source category description

The treatment of domestic wastewater in the Czech Republic is mostly centralised and more than 85.5 % 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 97.5 % of all the collected water. Anaerobic technology is being increasingly used to produce biogas from sludge.

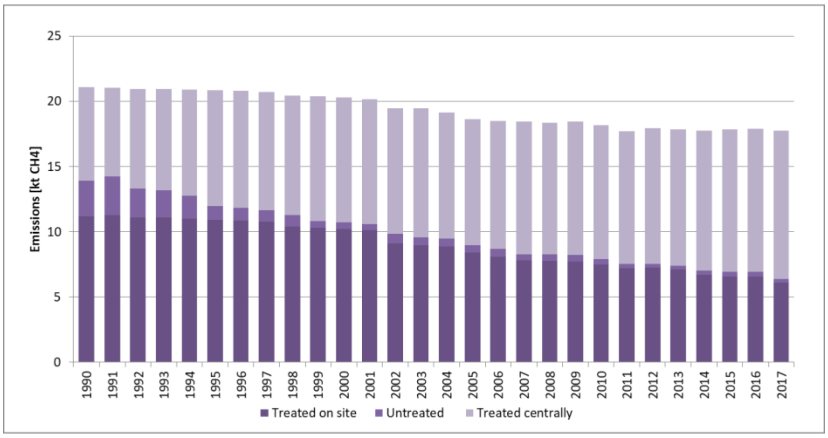


Fig. 7-7 Development of 5.D.1 emission of CH_4 by types of treatment,1990-2017

This category was recalclulated in past years to fully reflect the complexity and pathways that are used to treat wastewater in this country, effectively replacing Tier 1.

7.5.1.1 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 (the biochemical oxygen demand).

The current IPCC 2006 Gl. (IPCC 2006) employs BOD for evaluation of municipal wastewater and sludge and Chemical Oxygen Demand (COD) for industrial wastewater. The new method is based on default Tier 1 where sludge treatment is not considered; however available data about biogas production from sludge treatment are used to reduce TOW (total organic waste). A scheme of TOW flow is given in the following figure (Fig. 7-8).

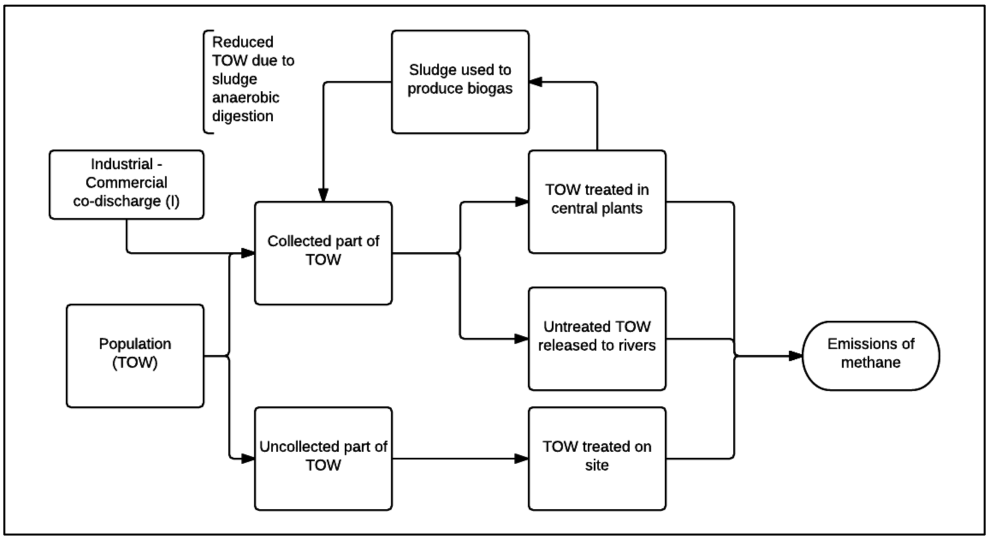


Fig. 7-8 Outline of total organic waste flow in 5.D.1

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. 7-13 to Tab. 7-15:

- The number of inhabitants (source: Czech Statistical Office).
- The organic pollution produced per inhabitant (source: IPCC default value).
- The conditions under which the wastewater is treated (source: Czech Statistical Office, with some specific national factors).
- The amount of proteins in the diet of the population (source: FAO).
- The amount of biogas produced from wastewater treatment plants (source: MIT).

The methodological steps as follows:

- Estimation of the total TOW of the country by using the population and default BOD value production.
- Split total TOW into two streams, one is corresponding to TOW collected by central wastewater treatment plants and, the other to uncollected TOW (mixture of latrines, septic tanks, root treatment plants and household biodisc plants, etc.).
- Uncollected TOW is multiplied by the implied EF based on IPCC 2006 Gl. 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. 7-13 Activity data used for 5.D.1 category, 1990-2017, Czech Republic

	Total population [thous. pers.]	Sewer connection [%]	Water treated [%]		Total population [thous. pers.]	Sewer connection [%]	Water treated [%]
1990	10 363	72.60	72.60	**2004**	10 207	77.90	94.44
1991	10 309	72.30	69.60	**2005**	10 234	79.10	94.60
1992	10 318	72.70	77.80	**2006**	10 267	80.00	94.16
1993	10 331	72.80	78.90	**2007**	10 323	80.80	95.80
1994	10 336	73.00	82.20	**2008**	10 486	81.11	95.32
1995	10 331	73.20	89.50	**2009**	10 492	81.30	95.25
1996	10 315	73.30	90.30	**2010**	10 517	81.90	96.20
1997	10 304	73.50	90.90	**2011**	10 496	82.62	96.83
1998	10 295	74.40	91.30	**2012**	10 509	82.54	97.08
1999	10 283	74.60	95.00	**2013**	10 511	82.82	97.39
2000	10 273	74.80	94.80	**2014**	10 524	83.90	96.90
2001	10 224	74.90	95.50	**2015**	10 553	84.20	97.00
2002	10 201	77.40	92.60	**2016**	10 565	84.70	97.30
2003	10 202	77.70	94.49	**2017**	10 598	85.50	97.50

Tab. 7-14 Parameters used for 5.D.1 category, 1990-2017

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. 7-15 Methane emissions from 5.D.1 category, 1990-2017

	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	11.19	2.71	7.18	0.20	21.08
1991	11.26	2.98	6.82	0.20	21.05
1992	11.10	2.19	7.67	0.20	20.96
1993	11.08	2.09	7.80	0.20	20.96
1994	11.00	1.76	8.15	0.20	20.92
1995	10.91	1.04	8.89	0.20	20.85
1996	10.86	0.96	8.97	0.20	20.79
1997	10.76	0.91	9.05	0.20	20.71
1998	10.39	0.88	9.19	0.20	20.45
1999	10.30	0.50	9.58	0.20	20.38
2000	10.20	0.53	9.57	0.20	20.30
2001	10.12	0.45	9.61	0.20	20.18
2002	9.09	0.77	9.61	0.20	19.46
2003	8.97	0.58	9.93	0.19	19.47
2004	8.89	0.57	9.70	0.21	19.16
2005	8.43	0.55	9.65	0.23	18.63
2006	8.09	0.61	9.78	0.23	18.48
2007	7.81	0.45	10.19	0.22	18.44
2008	7.77	0.50	10.09	0.24	18.35
2009	7.73	0.51	10.22	0.23	18.47
2010	7.50	0.40	10.24	0.25	18.15
2011	7.19	0.33	10.20	0.26	17.73
2012	7.23	0.31	10.40	0.25	17.95
2013	7.12	0.28	10.45	0.25	17.84
2014	6.68	0.34	10.74	0.24	17.76
2015	6.57	0.34	10.95	0.23	17.86
2016	6.37	0.31	11.04	0.23	17.72
2017	6.05	0.29	11.38	0.21	17.73

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. 7-16.

Tab. 7-16 Indirect N_2O [Gg] from 5.D.1 and 5.D.2, 1990-2017, Czech Republic

	Proteins [g/capita/day[7]]	Population [number, thous. pers.]	Fnpr [kg N/kg protein]	Fnon-noc	Find-com	Nefluent [kg N/yr]	EF [kg N_2O/kg N]	Emissions [Gg N_2O]
1990	105.77	10 363				100016115		0.79
1991	92.98	10 309				87463239		0.69
1992	87.37	10 318				82258845		0.65
1993	92.75	10 331				87432447		0.69
1994	88.36	10 336				83338924		0.65
1995	93.14	10 331				87801379		0.69
1996	95.59	10 315				89976569		0.71
1997	93.31	10 304				87730746		0.69
1998	96.91	10 295				91038567		0.72
1999	91.40	10 283				85760989		0.67
2000	90.29	10 273				84634767		0.66
2001	92.84	10 224				86615776		0.68
2002	92.97	10 201				86538394		0.68
2003	92.99	10 202	0.16	1.25	1.25	86564452	0.005	0.68
2004	96.08	10 207				89487156		0.70
2005	99.33	10 234				92760403		0.73
2006	95.26	10 267				89242564		0.70
2007	95.06	10 323				89541327		0.70
2008	93.79	10 430				89260824		0.70
2009	92.58	10 491				88631338		0.70
2010	92.80	10 517				89060048		0.70
2011	90.82	10 497				86989332		0.68
2012	86.86	10 509				83296338		0.65
2013	87.47	10 511				83892749		0.66
2014	87.47	10 525				84005003		0.66
2015	87.47	10 553				84236949		0.66
2016	87.47	10 565				84328266		0.66
2017	87.47	10 589				84521758		0.66

The factors in the table are the default factor values. Factor Fnon-con is an average of the default factor for developed countries (1.4) and developing countries (1.1) to reflect the nature of the Czech wastewater treatment system in transition. The population activity data 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, 2018).

7.5.1.2 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.

[7] *The latest available data is used for 2013-2017;, data for Czechoslovakia are used for 1990-1992.*

Tab. 7-17 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

7.5.1.3 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. Activity data used for this sector are approved by the data producer, who verifies them before they are used for the 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 at all state agencies and ministries to ensure that these state agencies produce the correct data.

7.5.1.4 Source-specific recalculations, including changes made in response to the review process

No recalculation has been made.

7.5.1.5 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

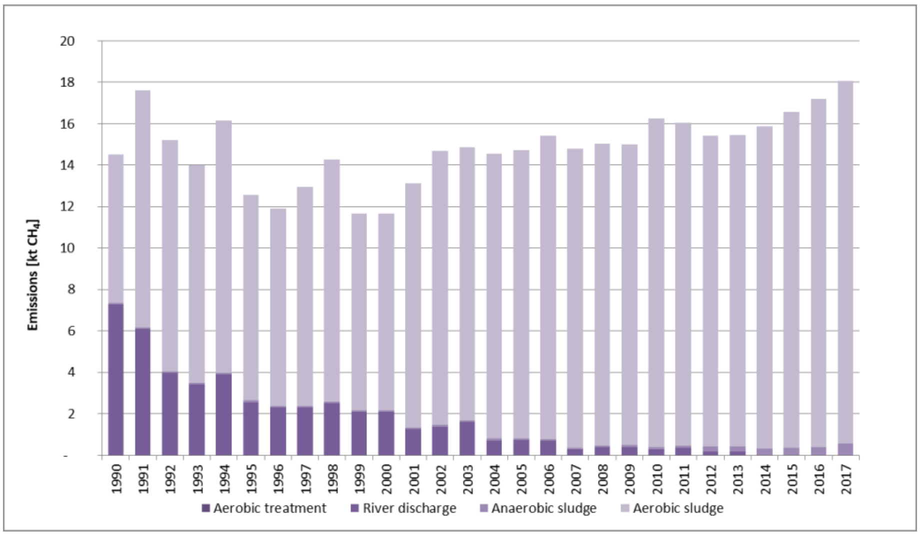


Fig. 7-9 Development of 5.D.2 by types of emission sources

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 larger companies in the country is mostly managed on site, 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 differentiation 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 Fig. 7-10.

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 are based on 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/m3). The approach used is based on the IPCC 2006 Gl. The necessary activity data were taken from 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 on industrial waste water (IWW) treatment. Wastewater is divided into two large 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 this country, we reversed the use of R . Based on R, we estimated the necessary amount of sludge COD which is subtracted from the total. The effect on total emissions is negligible, but we kept the treatment streams separated. Data about R have been obtained on an annual basis since 2003 from MIT renewable statistics; data about R prior to 2003 are based on expert estimates. The detailed flow of quantification is shown in in Fig. 7-11.

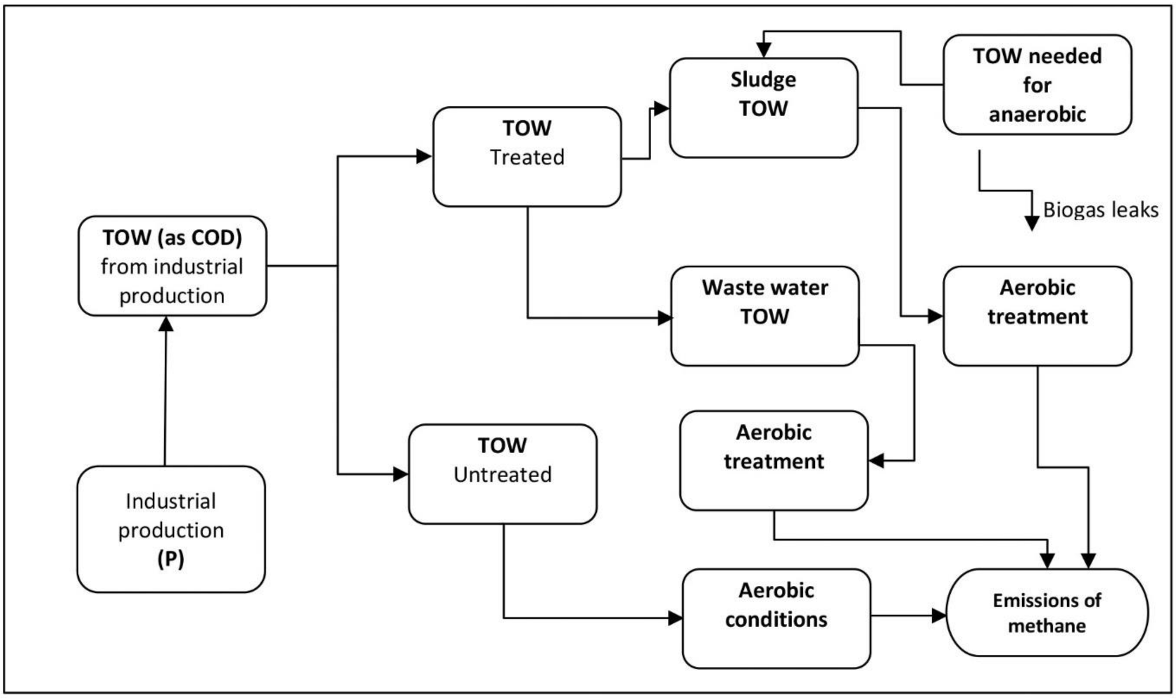


Fig. 7-10 Outline of total organic waste flow in 5.D.2

Tab. 7-18 Industrial production data and used water generation and COD content factors, 1990-2017

	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	0.08	1.33	2.3	0.85	0.27	7.30	0.69	0.71	0.12	0.03	0.57	0.14	0.14	0.05
1991	0.09	1.12	2.2	0.78	0.19	6.45	0.55	0.57	0.08	0.02	0.57	0.12	0.14	0.06
1992	0.09	1.06	2.3	0.59	0.21	6.62	0.56	0.56	0.08	0.03	0.53	0.14	0.14	0.05
1993	0.09	1.14	2.1	0.50	0.23	6.21	0.58	0.52	0.05	0.04	0.52	0.09	0.14	0.05
1994	0.08	1.09	2.2	0.46	0.30	7.17	0.73	0.62	0.04	0.03	0.43	0.10	0.13	0.05
1995	0.08	0.91	2.2	0.44	0.30	7.10	0.67	0.49	0.04	0.03	0.51	0.12	0.14	0.05
1996	0.08	0.87	2.2	0.45	0.33	7.08	0.74	0.47	0.05	0.03	0.60	0.12	0.13	0.05
1997	0.07	0.90	2.2	0.46	0.29	7.00	0.80	0.53	0.05	0.03	0.60	0.13	0.13	0.06
1998	0.06	0.96	2.2	0.49	0.31	7.00	0.83	0.59	0.05	0.03	0.49	0.13	0.13	0.06
1999	0.07	0.95	2.2	0.50	0.31	7.00	0.86	0.47	0.05	0.04	0.42	0.13	0.13	0.06
2000	0.07	0.95	2.2	0.50	0.31	7.00	0.86	0.47	0.05	0.04	0.42	0.13	0.13	0.06
2001	0.06	0.85	2.3	0.53	0.22	7.00	0.87	0.60	0.05	0.05	0.48	0.11	0.13	0.06
2002	0.06	0.87	2.5	0.65	0.20	3.54	0.82	0.67	0.06	0.07	0.52	0.10	0.13	0.09
2003	0.06	0.87	2.5	0.65	0.20	3.54	0.82	0.67	0.06	0.07	0.52	0.10	0.13	0.09

	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
2004	0.04	0.98	2.5	0.65	0.15	3.56	1.26	0.71	0.05	0.07	0.53	0.10	0.12	0.08
2005	0.05	0.98	2.5	0.62	0.16	5.24	1.32	0.71	0.04	0.07	0.57	0.10	0.14	0.09
2006	0.06	1.12	2.3	0.67	0.16	-	-	0.75	0.03	0.07	0.49	0.10	0.09	0.08
2007	0.06	1.12	2.4	0.42	0.17	-	1.10	0.75	0.03	0.08	0.38	0.11	0.11	0.06
2008	0.02	1.12	3.3	0.50	0.17	-	0.60	0.76	0.03	0.08	0.42	0.12	0.12	0.06
2009	0.02	1.12	3.3	0.50	0.17	-	0.60	0.76	0.03	0.08	0.42	0.12	0.12	0.06
2010	0.02	1.12	3.3	0.50	0.18	-	0.60	0.83	0.03	0.08	0.42	0.12	0.12	0.06
2011	0.02	1.23	3.3	0.35	0.15	-	0.55	0.83	0.03	0.08	0.57	0.12	0.11	0.06
2012	0.02	1.23	3.3	0.35	0.15	-	0.55	0.83	0.03	0.08	0.57	0.12	0.11	0.06
2013	0.02	1.23	3.3	0.35	0.15	-	0.55	0.83	0.03	0.08	0.57	0.12	0.11	0.06
2014	0.02	1.19	2.8	0.33	0.15	-	1.25	0.88	0.02	0.08	0.56	0.12	0.12	0.06
2015	0.02	1.24	2.9	0.34	0.16	-	1.31	0.92	0.02	0.09	0.59	0.13	0.13	0.07
2016	0.02	1.28	3.0	0.35	0.16	-	1.34	0.95	0.02	0.09	0.60	0.13	0.13	0.07
2017	0.02	1.36	3.2	0.37	0.18	-	1.43	1.01	0.02	0.09	0.64	0.14	0.14	0.07

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. 7-19.

Tab. 7-19 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 assumed that wastewater that is treated in wastewater treatment plants (i.e. not released untreated into 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 (which is recovered) and emissions. The second part of the sludge is treated aerobically, resulting in emissions.

Tab. 7-20 Emissions of CH_4 [Gg] from 5.D.2, 1990-2017, Czech Republic

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CH_4 emission	14.51	17.62	15.20	14.01	16.15	12.57	11.91	12.97	14.26	11.66	11.66	13.12
Recovered CH_4	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
CH_4 emission	14.68	14.88	14.56	14.74	15.44	14.81	15.02	15.00	16.27	16.05	15.42	15.44
Recovered CH_4	1.60	1.76	1.71	1.54	1.22	1.51	1.74	1.96	2.06	2.38	4.71	4.61
	2014	**2015**	**2016**	**2017**								

CH_4 emission	15.86	16.57	16.89	17.52
Recovered CH_4	6.57	7.00	7.96	10.85

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. 7-21. During recalculation, all the variables were inserted in the equation as parameters with lower and upper ranges and central values (default where appliable). 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 the log scale in the graph as there is three orders of difference). The range now corresponds to the full scale of the uncertainity assessment, 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. 7-21 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

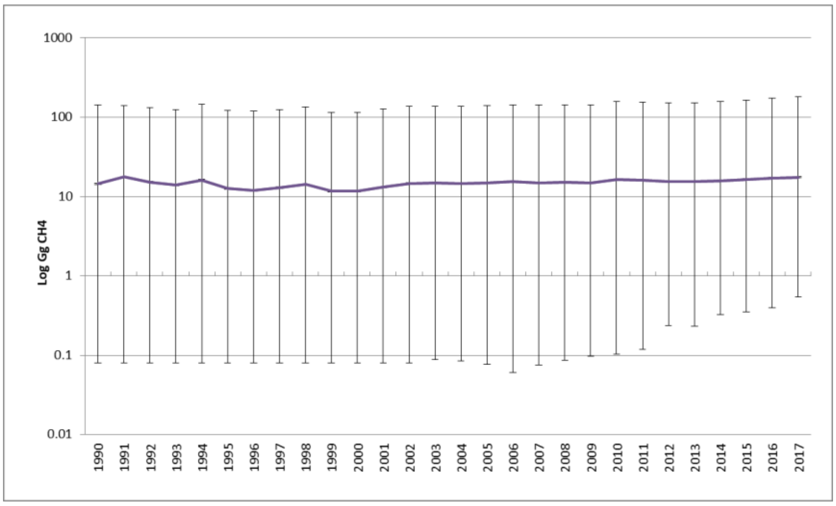


Fig. 7-11 Maximum uncertainty range for 5.D.2 (log scale), 1990-2017

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 the 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 uncertainty analysis 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 with the same data as described there. The results are shown in Tab. 7-22. The 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. 7-22 Long-term stored carbon, 1990-2017, Czech Republic

	Long-term stored carbon [Gg CO_2]	Accumulated Long-term stored carbon (since 1950) [Gg CO_2]
1990	764.52	15558.30
1991	770.00	16328.31
1992	800.96	17129.27
1993	819.98	17949.26
1994	825.79	18775.06
1995	916.63	19691.70
1996	950.10	20641.81
1997	983.00	21624.82
1998	1020.44	22645.27
1999	977.98	23623.25
2000	1054.71	24677.97
2001	1081.95	25759.93
2002	1110.35	26870.29
2003	1116.09	27986.40
2004	1127.13	29113.53
2005	1145.27	30258.81
2006	1177.90	31436.72

	Long-term stored carbon [Gg CO_2]	Accumulated Long-term stored carbon (since 1950) [Gg CO_2]
2007	1248.13	32684.87
2008	1253.01	33937.89
2009	1281.71	35219.60
2010	1203.09	36422.71
2011	1130.60	37553.31
2012	1061.25	38614.57
2013	1027.89	39642.47
2014	984.65	40627.13
2015	959.34	41586.48
2016	967.89	42554.38
2017	990.00	43541.66

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 2017 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 2017 for NMVOC by 59.25%, for CO by 59.44% and for NO_X by 77.45%. SO_x (reported as SO_2) emissions decreased by 93.74% compared to 1990 level. NH_3 increased by 10.88% in 2017 compared to the year 1990 (estimated data). Whole time series were recalculated resulting to an increase in NH3 trend.

Tab. 9-1 Precursor emissions and their trends from 1990 – 2017

	NO_X	NO_X w/o LULUCF	CO	CO w/o LULUCF	NMVOC	SO_X	NH_3
1990	729.98	728.85	2 106.04	2 065.84	509.02	1 756.11	5.72
1991	694.24	693.41	1 987.06	1 957.20	455.18	1 651.74	5.23
1992	653.07	652.10	1 961.46	1 927.07	434.35	1 383.32	9.57
1993	531.47	530.38	1 749.41	1 710.52	407.25	1 304.21	9.07
1994	438.57	437.47	1 678.04	1 638.89	392.61	1 160.71	8.74
1995	371.40	369.97	1 612.46	1 561.33	356.43	1 059.38	5.83
1996	352.39	350.96	1 676.27	1 625.14	357.39	914.86	4.28
1997	323.39	321.75	1 538.19	1 479.57	338.33	694.83	4.68
1998	304.97	303.67	1 308.19	1 261.93	309.99	425.64	4.58
1999	280.33	279.18	1 163.91	1 123.11	292.03	232.22	4.67
2000	281.22	280.16	1 112.26	1 074.62	287.30	232.99	4.73
2001	285.26	284.18	1 096.57	1 058.25	278.94	228.70	4.72
2002	279.30	278.14	1 059.38	1 017.90	276.68	223.40	4.84
2003	281.68	280.15	1 087.68	1 032.87	272.44	218.39	5.02
2004	282.28	280.94	1 068.30	1 020.36	262.77	215.10	4.89
2005	277.69	276.42	979.85	934.36	252.31	208.45	5.10
2006	273.04	271.45	995.68	938.98	253.71	206.75	5.24
2007	271.33	269.28	1 011.75	938.66	247.46	212.04	5.55
2008	254.75	253.15	942.82	885.55	242.68	170.08	5.78

	NO_X	NO_X w/o LULUCF	CO	CO w/o LULUCF	NMVOC	SO_X	NH_3
2009	240.01	238.64	951.90	903.22	243.08	168.75	5.83
2010	233.83	232.39	978.06	926.61	240.53	163.85	5.87
2011	220.70	220.04	920.05	896.54	229.63	167.59	5.92
2012	207.30	206.57	908.66	882.59	224.11	160.18	6.02
2013	191.66	191.02	905.63	882.97	220.59	145.23	6.06
2014	185.24	184.49	869.58	843.06	213.95	134.49	6.09
2015	177.11	176.30	854.26	825.43	211.62	129.38	6.16
2016	167.82	166.98	849.89	819.96	206.68	115.14	6.31
2017	164.63	163.66	854.20	819.52	207.41	109.96	6.35
Trend	**-77.45%**	**-77.55%**	**-59.44%**	**-60.33%**	**-59.25%**	**-93.74%**	**10.88%**
NEC	**286**		**-**		**220**	**265**	**101**

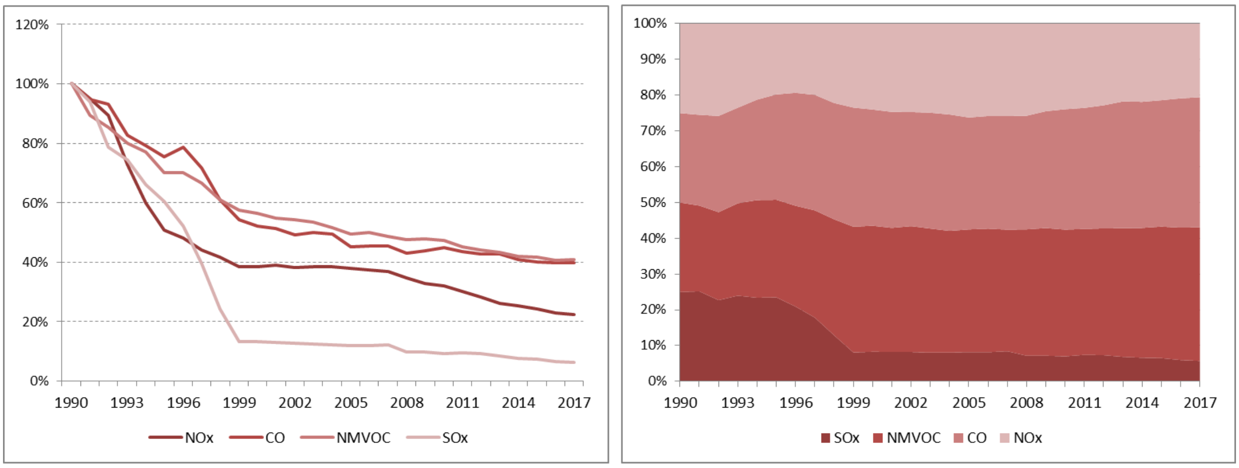


Fig. 9-1 Indexed emissions of precursor gases for 1990-2017 (1990 =100%), [%] (left); Overall trend in percentual share of precursor gases (right)

On Fig. 9-1 can be observed the overall decreasing trend, in percentage of precursor gases, where year 1990 is equal to 100%, further the overall trend in percentual share of total indirect GHG can be examined.

The categories with highest amounts of precursor gases for NO_X are 1.A.3 Transport, 1.A.1 Energy Industries, and 1.A.4 Other sectors; for CO are 1.A.4 Other sectors, 1.A.2 Manufacturing industries and construction and 1.A.3 Transport; for NMVOC are 1.A.4 Other sectors, 2.D Non-energy products from fuels and solvent use and 1.A.3 Transport; for SO_X are 1.A.1 Energy industries, 1.A.4 Other sectors and 1.A.2 Manufacturing industries and construction. 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 2017

	NO_X [kt]	CO [kt]	NMVOC [kt]	SO_X [kt]	NH_3 [kt]
Total emissions	**163.66**	**819.52**	**207.41**	**109.96**	**6.35**
1. Energy	160.85	789.06	131.19	108.28	5.94
1A Fuel combustion	160.51	788.97	124.68	105.36	5.93
1A1 Energy Industries	45.78	11.16	5.60	59.59	0.04
1A2 Manufacturing industries and construction	21.25	111.00	1.67	18.22	0.24
1A3 Transport	56.47	77.31	13.37	0.18	0.92
1A4 Other sectors	36.88	589.35	104.02	27.37	4.73
1A5 Other	0.13	0.16	0.01	0.00	0.00
1B Fugitive emissions from fuels	0.34	0.08	7.55	3.31	0.00
2. Industrial processes and product use	2.67	30.44	70.88	1.67	0.20
2A Mineral industry	0.32	0.00	0.07	0.08	0.03
2B Chemical industry	1.39	0.22	1.05	1.17	0.03

	NO_X [kt]	CO [kt]	NMVOC [kt]	SO_X [kt]	NH_3 [kt]
2C Metal industry	0.83	28.88	0.18	0.36	0.00
2D Non-energy products from fuels and solvent use	-	-	68.91	-	0.00
2G Other product manufacture and use	0.13	1.34	0.68	0.06	0.03
3. Agriculture	-	-	-	-	-
4. LULUCF	0.97	34.68	-	-	-
5.Waste	0.13	0.02	5.34	0.01	0.22

9.2 Production of indirect emissions from precursor gases

9.2.1 Indirect N_2O emissions from nitrogen oxides

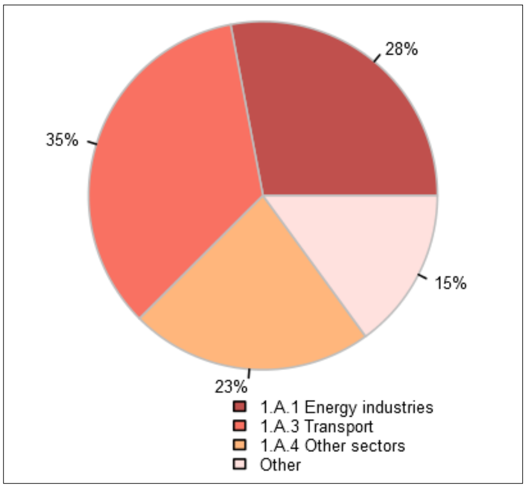


Fig. 9-2 The share of sectors on NOx emissions in 2017

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 728.9 kt to 163.7 kt during the period 1990 - 2017. In 2017, NO_X emissions were 77.4% below the 1990 level. Slightly more than 98% of total NO_X emissions originate from 1. Energy, mainly subsectors 1.A.1 Energy industries (28.0%), with subsector 1.A.1a Public electricity and heat production (26.0%); 1.A.3 Transport (34.5%), with 1.A.3.b Road transportation (32.2%) and 1.A.4 Other sectors (22.5%), mainly from 1.A.4.c Agriculture/Forestry/Fishing (9.7%) (Fig.9-2). Hence the indirect N_2O emissions correspondingly decreased from 3.50 to 0.78 kt in 2017.

9.2.2 Indirect N_2O from ammonia

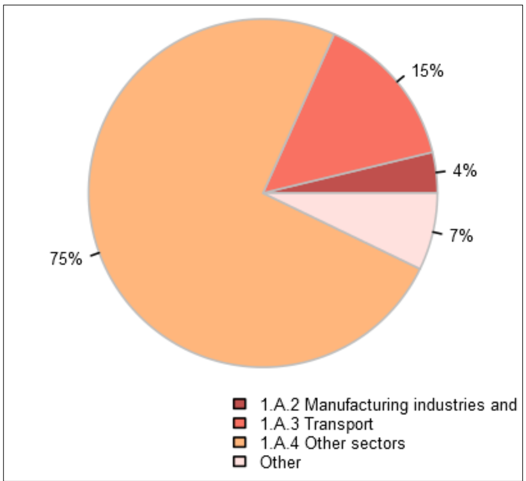


Fig. 9-3 The share of sectors on NO_2 emissions in 2017

Emissions of anthropogenic NH_3 for 2017 are mainly produced from categories: 1.A.4 Other sectors (74.5%), 1.A.3 Transport (14.5%) and 1.A.2 Manufacturing industries and construction (3.8%). Rest (7.2%) includes sectors 1B, 2. and 5. (Fig. 9-3). In 2017, emissions of NH_3 were 6.4 kt. The steady trend of the emissions, with the exception of high peaks to the years 1992-1994, is calculated based on the latest research of NH_3 emissions in the period between 1990 and 2017. Total indirect N_2O emissions from NH_3 for 2017 are 0.08 kt.

9.2.3 Indirect CO_2 from carbon monoxide

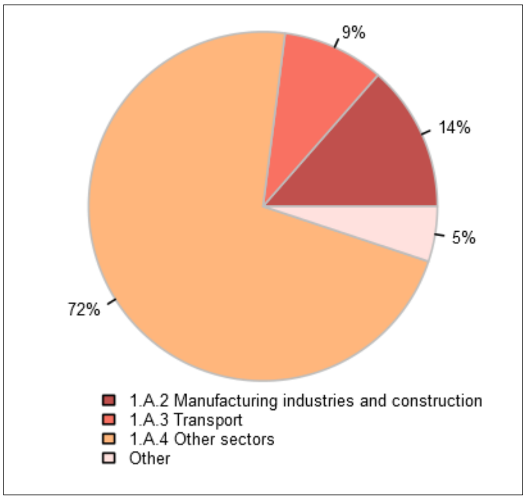


Fig. 9-4 The share of sectors on CO emissions in 2017

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 2065.8 kt to 819.5 kt during the period 1990 - 2017. In 2017, CO emissions were 60.3% below the 1990 level. In 2017, approximately 96% of total CO emissions originated from 1. Energy, subsectors 1.A.2 Manufacturing industries and construction (13.5%); 1.A.3 Transport (9.4%), mostly resulting from 1.A.3.b Road transportation (9.2%) and 1.A.4 Other sectors (71.9%), mainly from 1.A.4.b Residential stationary combustion (68.2%) (Fig.9-4). Further subsector 2.C Metal industry contributes with 3.5% to the total emissions. Total indirect CO2 emissions from CO in 2017 are 708.5 kt, which is 61.7% less than 1990.

9.2.4 Indirect CO_2 from non-methane volatile organic compounds

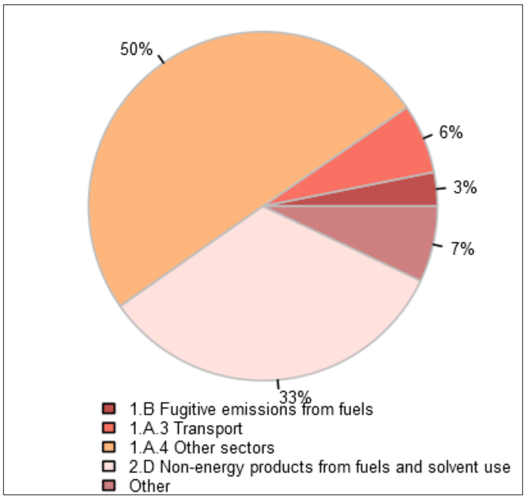


Fig. 9-5 The share of sectors on NMVOC emissions in 2017

NMVOC emissions decreased from 509.0 kt to 207.4 kt during the period between 1990 and 2017. In 2017, NMVOC emissions were 59.3% below the 1990 level. There are three main emission source categories: firstly 1.A.4 Other sectors (50.2%); mostly resulting from 1.A.4.b Residential stationary combustion (47.9%) and secondly 2.D Non-energy products from fuels and solvent use (33.2%), and 1.A.3 Transportation (6.2%) (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 CO2 from NMVOC in 2017 are 170.5 kt, which is 63.2% less than 1990.

9.2.4.1 Indirect CO_2 from 2.D Non-energy products from fuels and solvent use

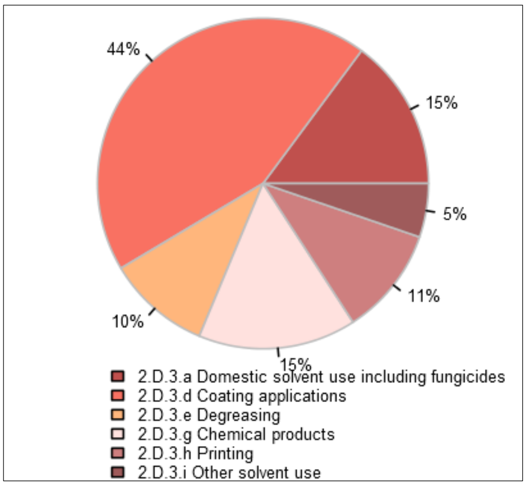


Fig. 9-6 Indirect CO_2 from 2.D Non-energy products from fuels and solvent use

The main NMVOC source categories in 2.D Non-energy products from fuels and solvent use are; 2.D.3.d Coating applications (43.7%), 2.D.3.g Chemical products (15.4%), 2.D.3.a Domestic solvent use including fungicides (14.8%), 2.D.3.h Printing (10.6%), 2.D.3.e Degreasing (10.1%) and 2.D.3.i Other solvent use (5.2%) (Fig. 9-6). The rest are 2.D.3.f Dry cleaning, 2.D.3.b Road paving with asphalt and 2.D.3.c Asphalt roofing together (0.1%).

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 2017 are 490.0 kt, which is 63.9% less than in 1990.

9.3 Production of indirect CO_2 and N_2O emissions from source categories

Estimations of indirect CO_2 and N_2O for the whole time series for each sector can be observed on Tab. 9-3.

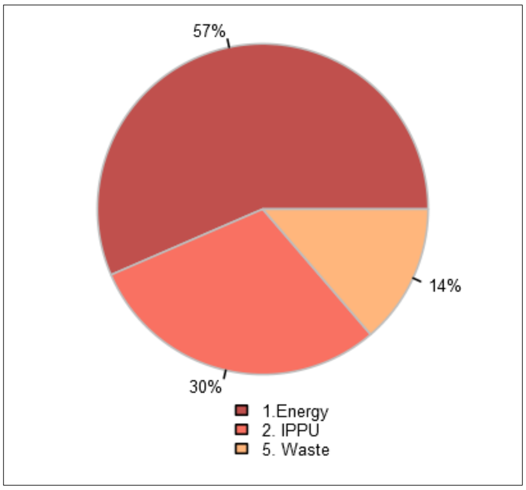
Tab. 9-3 Time series and trend of indirect emissions per sector and total

	Energy		IPPU		Waste		Total	
	CO_2 [kt]	N_2O [kt]	CO_2 [kt]	N_2O [kt]	CO_2 [kt]	N_2O [kt]	CO_2 [kt]	N_2O [kt]
1990	1 299.60	3.53	451.33	0.03	98.39	0.00	1 849.32	3.56
1991	1 173.06	3.36	351.26	0.02	107.05	0.00	1 631.38	3.38
1992	1 111.66	3.16	327.74	0.08	100.23	0.00	1 539.62	3.24
1993	1 098.36	2.57	314.47	0.08	97.46	0.00	1 510.29	2.65
1994	1 044.37	2.12	306.86	0.08	102.70	0.00	1 453.94	2.21
1995	1 025.94	1.80	293.17	0.04	92.43	0.00	1 411.54	1.84
1996	1 011.55	1.71	278.14	0.03	90.25	0.00	1 379.95	1.73
1997	989.39	1.58	272.96	0.02	92.92	0.00	1 355.27	1.60
1998	947.13	1.49	269.81	0.02	95.94	0.00	1 312.88	1.51
1999	861.13	1.38	274.58	0.02	88.19	0.00	1 223.90	1.40
2000	780.26	1.37	292.90	0.03	87.94	0.00	1 161.11	1.40
2001	737.79	1.40	288.96	0.02	91.63	0.00	1 118.39	1.42
2002	688.28	1.36	283.26	0.04	93.96	0.00	1 065.50	1.39
2003	678.00	1.37	278.19	0.04	94.53	0.00	1 050.72	1.40
2004	647.14	1.39	268.49	0.02	92.78	0.00	1 008.41	1.41
2005	698.03	1.37	265.42	0.02	91.81	0.00	1 055.26	1.39
2006	720.74	1.34	285.99	0.02	93.32	0.00	1 100.05	1.37
2007	673.84	1.34	287.39	0.02	91.50	0.00	1 052.72	1.36
2008	668.80	1.26	270.02	0.02	91.82	0.00	1 030.64	1.29
2009	625.56	1.20	243.17	0.02	92.09	0.00	960.81	1.22
2010	631.50	1.17	242.20	0.02	94.71	0.00	968.41	1.19

	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]
2011	627.93	1.11	227.26	0.02	92.93	0.00	948.12	1.13
2012	603.37	1.05	210.65	0.02	91.82	0.00	905.83	1.07
2013	499.81	0.97	214.05	0.02	91.58	0.00	805.44	0.99
2014	493.08	0.94	216.09	0.02	92.50	0.00	801.67	0.96
2015	479.42	0.91	212.96	0.02	94.72	0.00	787.10	0.92
2016	441.63	0.86	215.34	0.02	95.25	0.00	752.22	0.88
2017	400.37	0.85	211.13	0.02	96.98	0.00	708.48	0.86
Trend	**-69.19%**	**-76.05%**	**-53.22%**	**-40.76%**	**-1.44%**	**180.62%**	**-61.69%**	**-75.71%**

All sectors have a decreasing trend in emissions except Waste sector which has a steady CO_2 trend. N_2O in Waste sector shows significant percentage increase, but the fluctuations are within the range of 0.003 kt. Recalculation of the time series is behind the high percentage change.

On Fig. 9-7 is visually presented percentual division of indirect emissions of CO_2 and N_2O between the examined sectors.



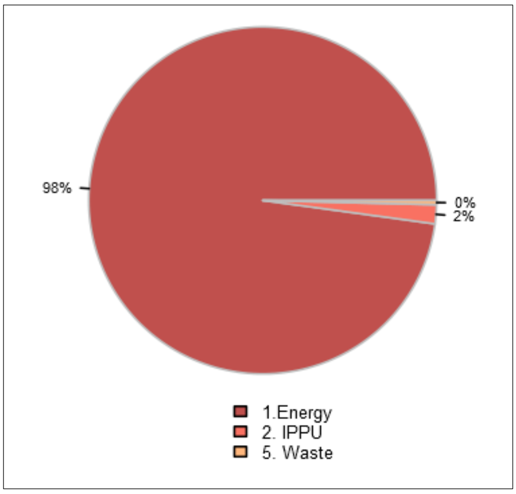


Fig. 9-7 Division of indirect emission of CO_2 (left) and N_2O (right) between the producing sectors for 2017 (in %)

Energy sector covers 56.5% of the total production of indirect CO_2 and 97.8% of the total production of indirect N_2O. 98.0% of the N_2O emissions from Energy are from 1.A Fuel combustion; (35.2%) 1.A.3 Transport, 1.A.1 Energy industries (28.5%) and followed by 1A.4 Other sectors (23.0%).

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 71.9% of the total production from this sector. The most of the remaining emissions from the sector are attributed to category 2.C Metal industry (22.4%).

Indirect N_2O emissions from IPPU are divided between the two categories: 2.B Chemical industry (52.%) and 2.C Metal industry (31.2%). The total share of IPPU sector from the total production of indirect CO_2 is 29.8% and for the indirect N_2O the share is 1.8%.

Almost all the indirect CO_2 emissions from the Waste sector are emitted from category 5.D Wastewater treatment and discharge (99.9%) and almost all the emissions from the indirect production of N_2O are produced from category 5.C Incineration and open burning of waste (99.9%).

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. (IPCC 2006).

For estimation of indirect emissions from NMVOC from category 2.D Non-energy products from fuels and solvent use, it was assumed for years 1990-2017 that the average percent of carbon content is 80% by mass based on IPCC 2006 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 IPCC 2006 Gl. (IPCC 2006) 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 Gl. (IPCC 2006). Source specific QA/QC is conducted in line with the QA/QC plan (Tier 1) of the National Inventory System.

Recalculation of the time series for the gases NOx, CO, NMVOC, SOx and NH_3 caused changes to the precursor gas calculation spreadsheet which were checked by sum checks and by using the previous data sets to compare the results. The sum checks were performed for the totals and for the sectors to ensure no data was lost. Also the transfer of activity data from NFR to CRF form was made more automatic decreasing a chance for inserting errors.

Another sectoral expert provided quality control by comparing CRF values with the calculation spreadsheet values and with the precursor activity data, and by verifying if the spreadsheet equations were in line with the IPCC 2006 Gl.

Changes in the notation keys included elsewhere (IE) in the precursor activity data were discussed with the compiler ensuring the data was allocated correctly to CRF form.

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

Recalculations were made for the whole time series from 1990 to 2017. The highest differences compared to the previous submission are for the years 1990 – 1999 for the both indirect gases; CO_2 and N_2O. The indirect CO_2 emissions trend has increased values between the years 2000 – 2014. The recalculated indirect N_2O trend is steadily lower between the years 2000 – 2016. The trends and impacts can be observed from the Tab. 9-4.

Tab. 9-4 Recalculation of indirect CO_2 and N_2O total emissions between 1990-2016

Submission	2018-2016		2019-2017		Difference [kt]		Difference [%]	
	CO_2 [kt]	N_2O [kt]	CO_2 [kt]	N_2O [kt]	CO_2 [kt]	N_2O [kt]	CO_2 [%]	N_2O [%]
1990	2 121.74	7.08	1 849.32	3.56	-272.42	-3.52	-12.84	-49.72
1991	2 011.15	5.63	1 631.38	3.38	-379.78	-2.24	-18.88	-39.85
1992	1 974.13	4.47	1 539.62	3.24	-434.51	-1.23	-22.01	-27.49
1993	1 923.23	3.89	1 510.29	2.65	-412.94	-1.23	-21.47	-31.71
1994	1 745.20	2.63	1 453.94	2.21	-291.25	-0.42	-16.69	-16.16
1995	1 745.19	2.44	1 411.54	1.84	-333.65	-0.60	-19.12	-24.40
1996	1 717.51	2.47	1 379.95	1.73	-337.57	-0.74	-19.65	-29.92
1997	1 701.54	2.68	1 355.27	1.60	-346.27	-1.08	-20.35	-40.39
1998	1 550.34	2.24	1 312.88	1.51	-237.46	-0.73	-15.32	-32.45
1999	1 400.44	2.11	1 223.90	1.40	-176.53	-0.71	-12.61	-33.75
2000	1 157.65	1.86	1 161.11	1.40	3.45	-0.45	0.30	-24.50
2001	1 116.07	1.83	1 118.39	1.42	2.32	-0.41	0.21	-22.24
2002	1 062.31	1.78	1 065.50	1.39	3.18	-0.38	0.30	-21.58
2003	1 046.13	1.78	1 050.72	1.40	4.59	-0.37	0.44	-21.05
2004	1 005.69	1.71	1 008.41	1.41	2.72	-0.30	0.27	-17.69
2005	1 052.09	1.76	1 055.26	1.39	3.17	-0.37	0.30	-21.23
2006	1 096.81	1.70	1 100.05	1.37	3.24	-0.34	0.30	-19.81
2007	1 048.20	1.65	1 052.72	1.36	4.53	-0.29	0.43	-17.74
2008	1 024.89	1.70	1 030.64	1.29	5.75	-0.41	0.56	-24.39
2009	955.98	1.47	960.81	1.22	4.83	-0.26	0.51	-17.49
2010	963.33	1.43	968.41	1.19	5.07	-0.24	0.53	-16.98
2011	941.60	1.38	948.12	1.13	6.52	-0.25	0.69	-18.39
2012	899.60	1.32	905.83	1.07	6.23	-0.25	0.69	-19.12
2013	802.52	1.20	805.44	0.99	2.92	-0.21	0.36	-17.41
2014	800.68	1.16	801.67	0.96	0.99	-0.20	0.12	-16.96
2015	798.60	1.15	787.10	0.92	-11.49	-0.23	-1.44	-19.90
2016	765.41	1.23	752.22	0.88	-13.20	-0.35	-1.72	-28.21

9.8 Source-specific planned improvements, including in response to the review process

Planned improvements for the future submissions is to continue to provide more 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 Gl. (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 2019

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 - Biomass, 2014 –2016</u>

Computation error in activity data was found in years 2014 to 2016. The changes of activity data in TJ are following:

Tab. 10-1 Updated activity data for combustion of biomass

Biomass		2014	2015	2016
Submission 2016-2018	[TJ/year]	20 424.87	22 863.00	23 383.00
Submission 2017-2019	[TJ/year]	20 577.76	23 011.87	23 893.02

Consequently, emissions were recalculated as well.

1.A.1.c.i – Liquid fuels, 2011 – 2013

Computation error in activity data of Heating oil and other gasoil was found in years 2011 to 2013. Due to it was updated consumption of liquid fuels in this subsector. The activity data changes are following:

Tab. 10-2 Updated activity data for combustion of liquid fuels

Liquid fuels		2011	2012	2013
Submission 2016-2018	[TJ/year]	766.80	639.00	724.20
Submission 2017-2019	[TJ/year]	681.60	596.40	681.60

Consequently, emissions were recalculated as well.

10.1.1.1.2 Recalculations in 1.A.3.b Road transport

Due to recommendations of last reviews CZ introduced programme COPERT 5 for estimates from road Transport. Thanks to this step calculation method in road transport was shifted to Tier 3. Emission estimates for CO_2 are thanks to COPERT on Tier 2 level (demanded by ARR review 2017). Introducing of COPERT solved issues with decrease in the value of the IEF for NO2 in Road transport (initial checks issue: CZ-1A3b-2017-000). Whole time series 1990 – 2017 has been recalculated. Due to methodology of pairing Car Registry and data from Vehicle Technical Control Database the activity data for 2015 – 2017 are only preliminary. Reason is, that new PCs in private ownership must undertake first technical control 4 years after registration, according Czech law. It means we have no record about their activity in 2018. Most precise estimates are for 2015, least precise estimates are for 2017. Due to this fact, every year, will be made recalculation 3 years backwards based on actualized activity data.

10.1.1.1.3 . Recalculations in 1.A.3 Transport

During 2017 CzSO conducted research on fuel consumption in history especially before the year 2000. This led to changes in fuel consumption in some sectors and changes in emission estimates. Some changes were introduced after 2000. There is brief description of changes in fuel consumption:

- Aviation gasoline between 1998 – 2004
- Jet kerosene between 1996 - 2016
- Road gasoline - 1997
- Road diesel between 1990 – 1998
- Railway (diesel) between 1990 – 1997
- Domestic navigation (diesel) between 1990 – 1997

10.1.1.1.4 Updated activity data due changes in official energy balance

Any extensive updates of activity data were not carried out by CzSO in the official energy balance. Mostly, the changes are tiny and for years 2015 and 2016, however in some cases the changes are before 2015 but not before 2010.

1.A.1 – Energy industries

In subcategory 1.A.1.c.i the consumption of some solid fuels (Coke Oven Gas) was updated for years 2016. For this reason, the appropriate recalculation was done.

1.A.2 – Manufacturing industries and construction

In year 2016, the consumption of biomass (Wood/Wood waste) was updated in subcategory 1.A.2.d.

In year 2016, the consumption of natural gas was updated in subcategory 1.A.2.f.

In subcategory 1.A.2.g the consumption of some solid fuels (Bitumenous Coal) and natural gas were updated in years 2010 – 2013 (Solid fuels) and 2016 (Gaseous fuels).

For this reason, the appropriate recalculations were done.

1.A.4 – Other sectors

In years 2014 – 2016, the consumption of some solid fuels (Brown coal briquettes) was updated in subcategory 1.A.4.a.

In subcategory 1.A.4.c, the consumption of some solid fuels (Lignite) was updated for years 2011 – 2016.

For this reason, the appropriate recalculations were done.

Tab. 10-3 Updated activity data after changes in official energy balance

Sector	Type of fuels	Recalculation in years
1.A.1.c.i Manufacture of solid fuels and other energy industries	Solid fuels	2016
1.A.2.d Pulp, paper and print	Biomass	2016
1.A.2.f Non-metallic Minerals	Natural gas	2016
1.A.2.g Non-specified Industry	Solid fuels	2010 to 2013
1.A.2.g Non-specified Industry	Natural gas	2016
1.A.4.a. Commercial/Institutional	Solid fuels	2014 to 2016
1.A.4.c. Agriculture/Forestry/Fishing	Solid fuels	2011 to 2016

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 The subcategory 2.A.4.d Other was recalculated for years 2015 and 2016 due to updated activity data.

10.1.1.2.2 Metal Industry (2.C)

2.C.1 Iron and Steel Production was recalculated for 2016 since new updated net calorific value for bituminous coal is available. The data are officially updated by CzSO.

10.1.1.2.3 Non-energy Products from Fuels and Solvent Use (2.D)

Due to updated activity data and due to use of COPERT 5 model in 1.A.3 the activity data was consequently updated also for the category 2.D.3 Other – Urea Used as catalyst.

10.1.1.2.4 Product Uses as Substitutes for Ozone Depleting Substances (2.F)

Subcategory 2.F.1.e Mobile Air Conditioning was recalculated due to methodology changes in collection of activity data for calculating of HFC – 134a emissions from stock and disposal. For previous submission, activity data for stock were obtained from statistics of Ministry of the Interior of the Czech Republic, Ministry of Transport of the Czech Republic and Automotive Industry Association. For this submission activity data were provided by the Transport Research Centre (CDV). Car fleet data in the Czech Republic are obtained from COPERT (software and methodology developed by EMISIA S.A.). HFC – 134a emission estimates from disposal were updated to year 2006. Data contain information about disposal of passenger cars, light duty vehicles, trucks and buses.

10.1.1.3 Recalcualtions in sector 3 Agriculture

10.1.1.3.1 Enteric Fermentation (3.A)

The ERT encouraged (A24) the Czech Republic "to report the total gross energy intake of non-dairy cattle and a reduced CH_4 conversion rate" in CRF table 3.As1.

Tier 2 is used for estimation of methane emissions from enteric fermentation of cattle. The emission factor for methane from fermentation (EF) in kg/head p.a. is proportional to the daily food intake and the conversion factor. Where the "gross energy intake" (GE, MJ/head/day) is taken as the main feed ratio 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 and 0 for cattle and calves categories, respectively. For non- dairy cattle category the weighted average of methane conversion factor was calculated for each year in the whole time series to meet the encouragement of ERT. The value of emission factor decreased by about 5 % for non- dairy cattle. It means that the methane emissions of enteric fermentation decreased by about 2 % and the total emissions form agriculture decreased by about 1 %. The value of GE estimated for non-dairy cattle increased by about 8 %.

10.1.1.3.2 Enteric Fermentation, cattle category (3.A) and Manure Management, cattle category (3.B)

Estimation of emissions factors for enteric fermentation and emissions of nitrous oxide and methane from manure of cattle are based on body weight, mature weight and typical animal mass of diary and non-dairy cattle. Weight data used in national legislation No 377/2013 were applied in the last NIR submission excluding the calves' categories. Since 2017 the Czech Statistical Office harmonized the age categories with the national legislation and we accordingly used the relevant body weight of calves in the estimates. The change of total emissions due to the change of weight of calves is less than 1 % of the total emissions from Agriculture.

10.1.1.3.3 Manure management – technical error (3.B)

There was a technical error in copying Nex rate data of goats and horses from the local calculation spreadsheet to the CRF reporter. However, the estimated emissions were correct. The error in activity data as inserted in CRF were corrected.

10.1.1.3.4 Management of agricultural soils – technical error (3.D)

During the QA/QC process the technical errors were identified in a supporting calculation spreadsheet that was used for nitrogen estimation from Crop residues and N- fixing forage. The recalculation was done for the whole time series. The correction increased the emissions from management of agricultural soils by 3.7 % and by 1.6 % of the total emissions from Agriculture.

10.1.1.4 Recalculations in sector 4 LULUCF and KP LULUCF Activities

10.1.1.4.1 LULUCF – 4.A.1 Forest Land remaining Forest Land

- Carbon stock change in biomass

Partly in response to issues L.4 of the last review, the estimates of carbon stock change in biomass was revised, including the newly acquired data on mortality of the Czech National Forest Inventory. Such data were not available earlier and the calculation assumed no mortality in the conditions of intensive forest management in the country. The updated estimates marginally reduced the estimates in this emission category.

10.1.1.4.2 4A1 Forest Land Remaining Forest Land and 4A2 Land converted to Forest Land

- Carbon stock change in biomass

Partly in response to issue L.16, newly introduced in the previous inventory submission (NIR 2018) was the species-specific volume-weighted R-factor assigning below-ground biomass based on the carbon-density- and species-specific forest stand values as given in IPCC 2006 Gl., Table 4.4. In this inventory submission, R-factor was also implemented for the associated conversions from Forest land. The biomass estimates changed accordingly for the entire time series.

By initiative of the inventory team, new EFs for carbon content in woody biomass following the new scientific literature (Thomas, S.C., Martin, A.R., 2012. Carbon content of tree tissues: A synthesis. Forests 3, 332–352. doi:10.3390/f3020332) that was not available for IPCC 2006 Gl. The new EFs for coniferous and broadleaved species affected the estimates of biomass for the entire time series.

10.1.1.4.3 4A1 Forest Land Remaining Forest Land, 4A2 Land converted to Forest Land and land-use conversions from Forest land

- Carbon stock change estimates for DOM and litter

In response to issue L19 of the last review, new AD for dead organic matter (DOM) were introduced in the previous (NIR 2018) submission. 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). These AD and related estimates were slightly revised following the stock difference method (Eq. 2.19 of IPCC 2006) for category 4A1 and also used as a reference carbon stock for associated conversions related to forest land (category 4A2 and categories 4B21, 4C21 and 4E21).

10.1.1.4.4 4E1 Settlements, 4E2 Land converted to Settlements and land use conversions from Settlements

- Soil carbon stock change

In response to issue L. 19, estimates for soil carbon pools are newly introduced. They are based on the data from Landscape inventory CzechTerra, which in its remote sensing component identified proportions of land cover that constitute the land use category Settlements. These proportions (area of Forest land, Cropland, Grassland as well as the build-up, paved surfaces) were used to construct the reference carbon stock value applicable for 4E1 Settlements and allowed estimation of the associated land-use conversions (categories 4A24, 4B24 and 4C24).

10.1.1.4.5 KP LULUCF: FM - Forest management

- Carbon stock change in biomass

Partly in response to issues L.4 of the last review, the estimates of carbon stock change in biomass was revised, including the newly acquired data on mortality of the Czech National Forest Inventory. Such data were not available earlier and the calculation assumed no mortality in the conditions of intensive forest management in the country. The updated estimates marginally reduced the estimates in this emission category.

- 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.

10.1.1.4.6 KP LULUCF: FM - Forest management and AR – Afforestation/Reforestation

- Carbon stock change in biomass

Partly in response to issue L.16, newly introduced in the previous inventory submission (NIR 2018) was the species-specific 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. In this inventory submission, R-factor was also implemented for the associated conversions from Forest land. The biomass estimates changed accordingly for the entire time series and concern both FM and AR.

10.1.1.4.7 KP LULUCF: FM - Forest management, AR - Afforestation/Reforestation and D - Deforestation

- Carbon stock change in biomass

By initiative of the inventory team, new EFs for carbon content in woody biomass following the new scientific literature (Thomas, S.C., Martin, A.R., 2012. Carbon content of tree tissues: A synthesis. Forests 3, 332–352. doi:10.3390/f3020332) that was not available for IPCC 2006 Gl. The new EFs for coniferous and broadleaved species affected the estimates of biomass for the entire time series of FM, AR and D.

- Carbon stock change estimates for DOM and litter

In response to issue KL13 of the last review, new AD for dead organic matter (DOM) were introduced in the previous (NIR 2018) submission. 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). These AD and related estimates were slightly revised following the stock difference method (Eq. 2.19 of IPCC 2006) for FM and also used as a reference carbon stock for associated conversions related to forest land, i.e., activities AR and D.

10.1.1.4.8 KP LULUCF: AR – Afforestation

- Soil carbon stock change

In response to issue L. 19, estimates for soil carbon pools are newly introduced for the land use category 4E Settlements. They are based on the data from Landscape inventory CzechTerra, which in its remote sensing component identified proportions of land cover that constitute the land use category Settlements. These proportions (area of Forest land, Cropland, Grassland as well as the build-up, paved surfaces) were used to construct the reference carbon stock value applicable for Settlements. This allowed estimation of soil carbon stock changes for the associated land-use conversion from Settlements to Forest land, which directly concerns AR activity and estimates of emissions and removals from/by soils.

10.1.1.5 Recalculations in sector 5 Waste

10.1.1.5.1 5.A Solid waste disposal

Category 5A Solid waste disposal 2016 was recalculated, because of improved activity data, including data for recovered methane and amount of waste, for the last inventory year became available. Difference of AD is on third digit and did not significantly influence resulting emissions.

10.1.1.5.2 5.C. Waste incineration

Category 5C Waste incineration for 2016 was recalculated due to change in activity data for incinerated waste. Data provider increased 2016 estimate from 76.9 Gg to 80.8 Gg of waste, increasing total CO_2 emissions from 113.7 Gg CO_2 to 119.35 Gg CO_2.

10.1.1.1 Recalculations in prekursors of greenhouse gases

Recalculations of the prekursors were carried out for the whole time series from 1990 to 2016 due to update in the official CLRTAP submission.

10.2 Implications for emission levels

Tab. 10-4 Implications on emission levels on example on 2017 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	124246.14	124598.65	352.52	0.28%	0.27%	0.28%
1. Energy	100280.60	100133.52	-147.08	-0.15%	-0.11%	-0.12%
A. Fuel combustion activities	96249.72	96102.64	-147.08	-0.15%	-0.11%	-0.12%
1. Energy industries	54449.09	54456.02	6.93	0.01%	0.01%	0.01%
2. Manufacturing industries and construction	9396.92	9482.12	85.21	0.91%	0.07%	0.07%
3. Transport	18449.82	18161.45	-288.37	-1.56%	-0.22%	-0.23%
4. Other sectors	13546.23	13596.07	49.84	0.37%	0.04%	0.04%
5. Other	407.66	406.97	-0.68	-0.17%	0.00%	0.00%
B. Fugitive Emissions from Fuels	4030.88	4030.88	0.00	0.00%	0.00%	0.00%
1. Solid fuels	3420.64	3420.64	0.00	0.00%	0.00%	0.00%
2. Oil and natural gas	610.25	610.25	0.00	0.00%	0.00%	0.00%
C. CO_2 transport and storage	NO	NO	NA	NA	NA	NA
2. Industrial processes and product use	15221.74	15573.79	352.06	2.31%	0.27%	0.28%
A. Mineral industry	2816.07	2834.25	18.18	0.65%	0.01%	0.01%
B. Chemical industry	1527.23	1527.23	0.00	0.00%	0.00%	0.00%
C. Metal industry	7311.48	7306.60	-4.89	-0.07%	0.00%	0.00%
E. Eletronic Industry	139.73	137.42	-2.31	-1.65%	0.00%	0.00%
F. Product uses as substitutes for ODS	6.39	6.39	0.00	0.00%	0.00%	0.00%
D. Non-energy products from fuels and solvent use	3122.53	3463.60	341.07	10.92%	0.26%	0.27%
G. Other product manufacture and use	298.31	298.31	0.00	0.00%	0.00%	0.00%
H. Other	NO	0.00	NA	NA	NA	NA
3. Agriculture	8519.68	8482.36	-37.32	-0.44%	-0.03%	-0.03%
A. Enteric fermentation	2957.46	2888.11	-69.35	-2.34%	-0.05%	-0.06%
B. Manure management	1580.18	1580.27	0.09	0.01%	0.00%	0.00%
C. Rice cultivation	NO	NO	NA	NA	NA	NA
D. Agricultural soils	3603.26	3635.12	31.86	0.88%	0.02%	0.03%
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	168.01	168.10	0.09	0.05%	0.00%	0.00%
H. Urea application	210.76	210.76	0.00	0.00%	0.00%	0.00%
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)	-5337.14	-5158.03	179.11	-3.36%	0.14%	0.14%
A. Forestland	-4519.32	-4112.78	406.54	-9.00%	0.31%	0.33%
B. Cropland	124.36	67.07	-57.30	-46.07%	-0.04%	-0.05%
C. Grassland	-661.65	-733.89	-72.24	10.92%	-0.06%	-0.06%
D. Wetlands	25.03	25.53	0.51	2.02%	0.00%	0.00%
E. Settlements	124.06	535.82	411.77	331.92%	0.32%	0.33%
F. Other land	NO,NA	NO,NA	NA	NA	NA	NA
G. Harvested wood products	-430.67	-940.84	-510.17	118.46%	-0.39%	-0.41%
H. Other	NO	NO	NA	NA	NA	NA
5. Waste	5561.26	5567.01	5.75	0.10%	0.00%	0.00%
A. Solid waste disposal	3671.11	3671.11	0.00	0.00%	0.00%	0.00%
B. Biological treatment of solid waste	711.36	711.36	0.00	0.00%	0.00%	0.00%
C. Incineration and open burning of waste	115.99	121.74	5.75	4.96%	0.00%	0.00%
D. Waste water treatment and discharge	1062.80	1062.80	0.00	0.00%	0.00%	0.00%
E. Other	NO	NO	NA	NA	NA	NA
6. Other (As specified in summary 1.A)	NO	NO	NA	NA	NA	NA
Memo items:						
International bunkers	964.06	955.52	-8.54	-0.89%	-0.01%	-0.01%
Aviation	964.06	955.52	-8.54	-0.89%	-0.01%	-0.01%
Navigation	NO	NO	NA	NA	NA	NA
Multilateral operations	NO	NO	NA	NA	NA	NA
CO_2 emissions from biomass	16461.81	16403.24	-58.57	-0.36%	-0.05%	-0.05%
CO_2 captured	NO	NO,NE	NA	NA	NA	NA
Long-term storage of C in waste disposal sites	42554.38	42554.38	0.00	0.00%	0.00%	0.00%
Indirect N_2O	366.48	263.39	-103.09	-28.13%	-0.08%	-0.08%
Indirect CO_2	765.41	752.22	-13.20	-1.72%	-0.01%	-0.01%

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 in recent submission in average by 0.1%, through the whole time period.

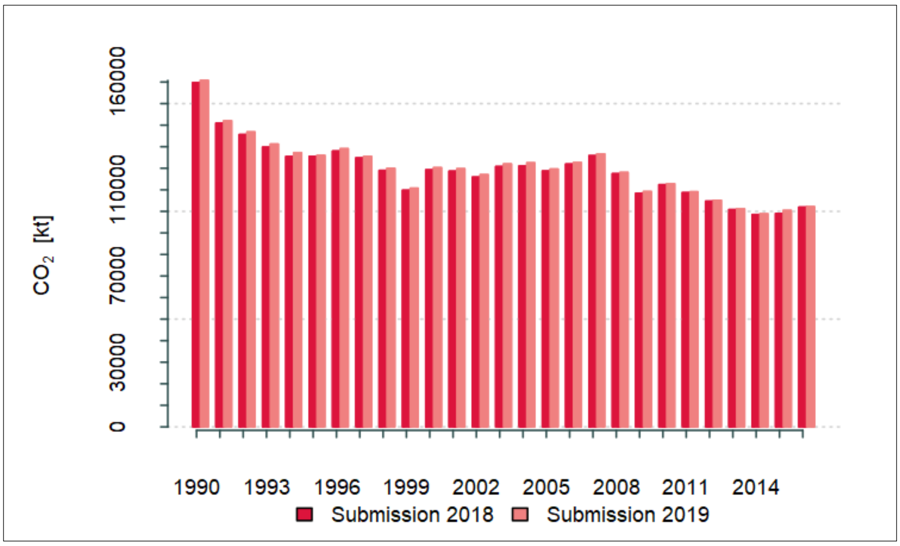


Fig. 10-1 Difference in trends of CO_2 emissions in index form, between the submissions 2018 and 2019, due to recalculations (1990 = 100%)

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 lower in recent submission in average by 0.3%, through the whole time period.

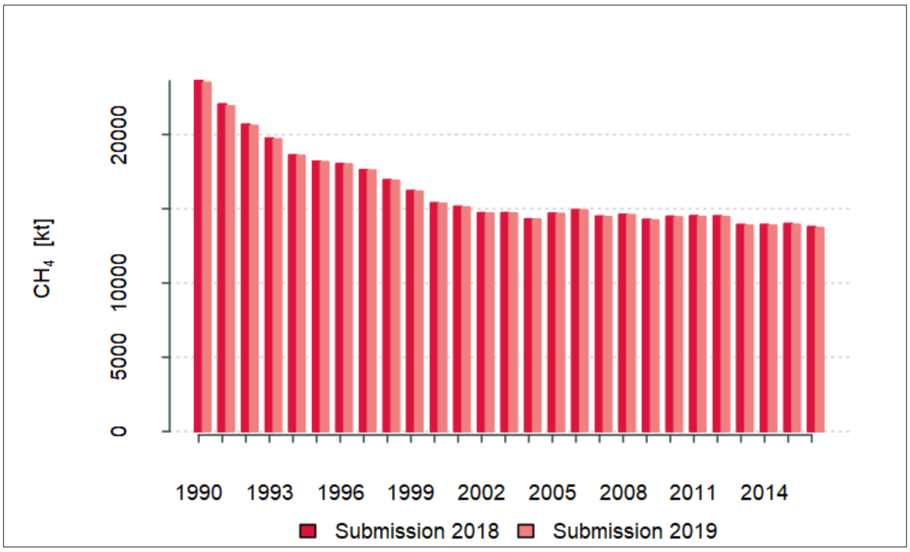


Fig. 10-2 Difference in trends of CH4 emissions in index form, between the submissions 2018 and 2019, due to recalculations (1990 = 100%)

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 in recent submission in average by 0.9%, through the whole time period.

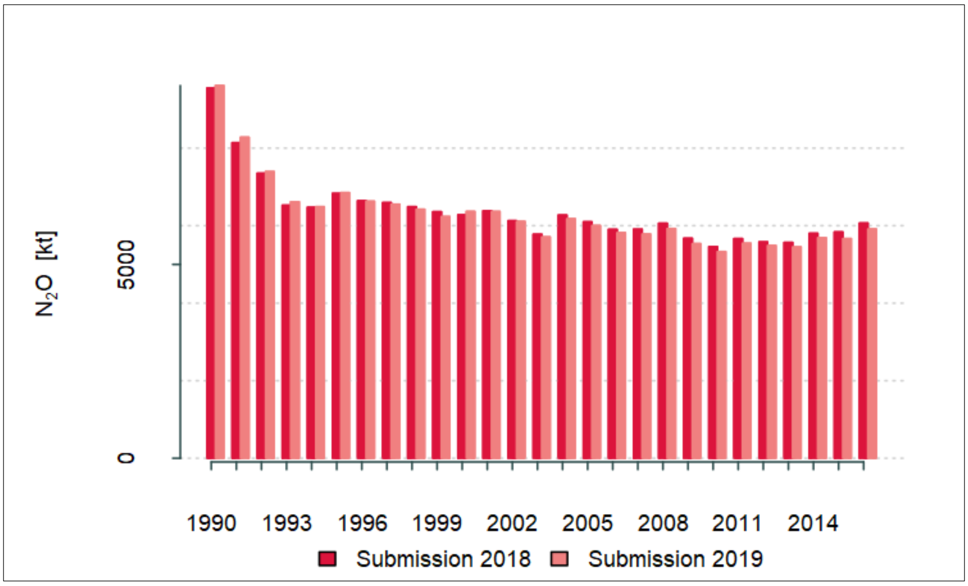


Fig. 10-3 Difference in trends of N_2O emissions in index form, between the submissions 2018 and 2019, due to recalculations (1990 = 100%)

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.

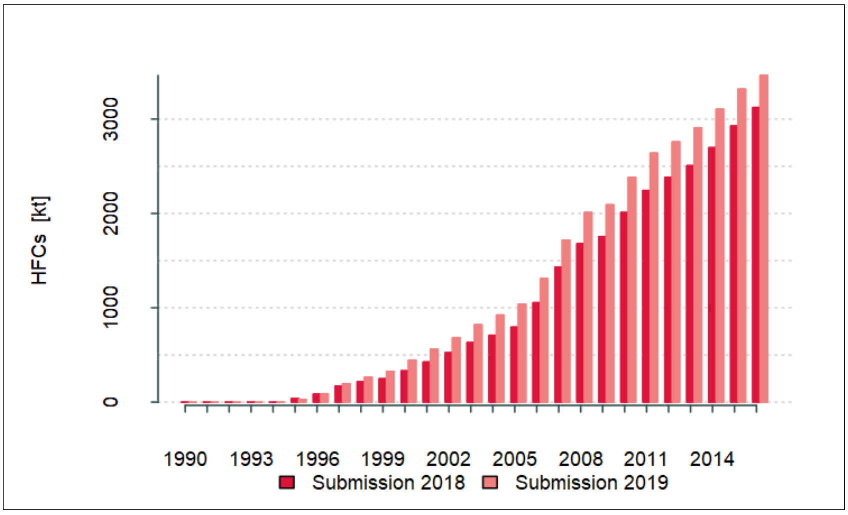


Fig. 10-4 Difference in trends of HFCs emissions in index form, between submission 2018 and 2019, due to recalculations (1990 = 100%)

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

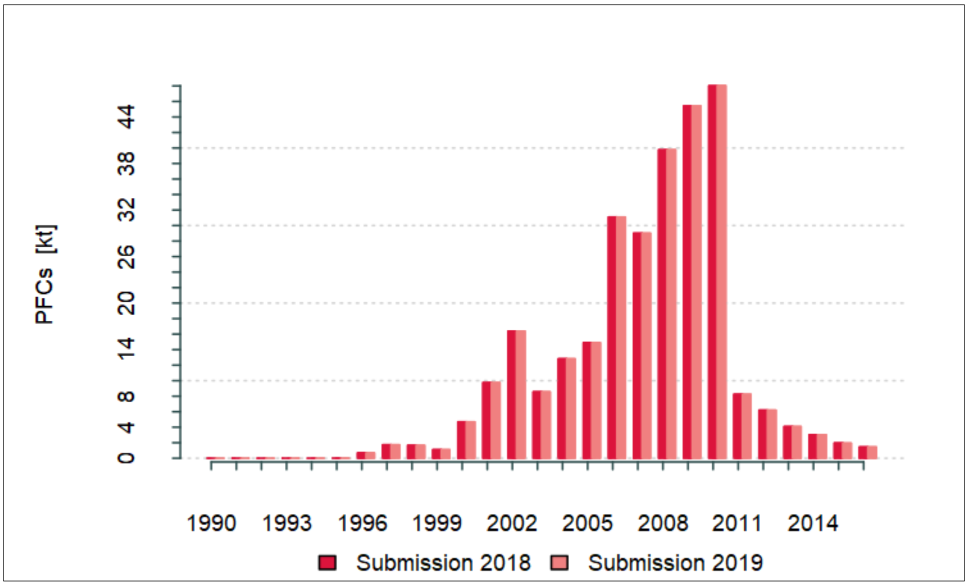


Fig. 10-5 Difference in trends of PFCs emissions in index form, between submission 2018 and 2019, due to recalculations (1990 = 100%)

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.

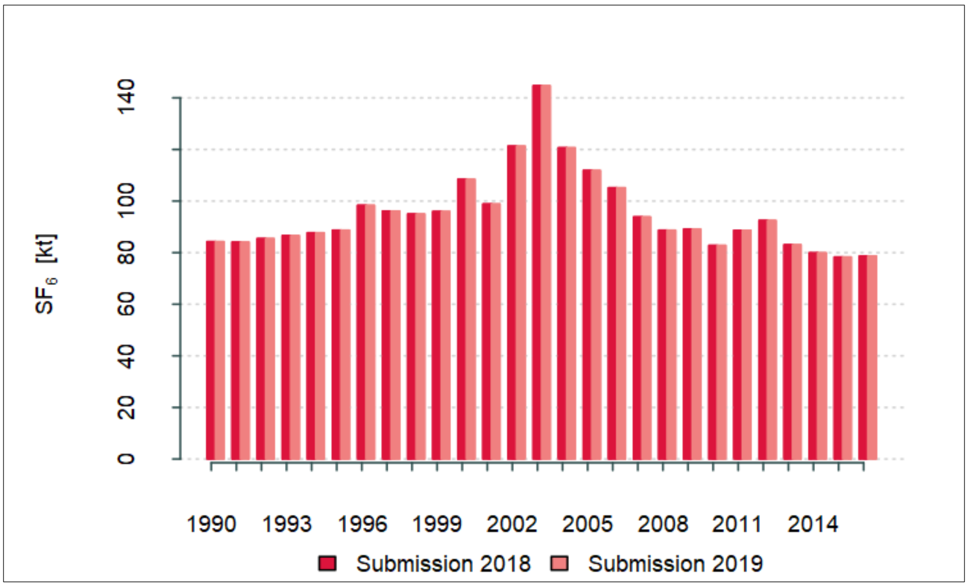


Fig. 10-6 Difference in trends of SF_6 emissions in index form, between submission 2018 and 2019, due to recalculations (1990 = 100%)

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 0.7% through the whole time period.

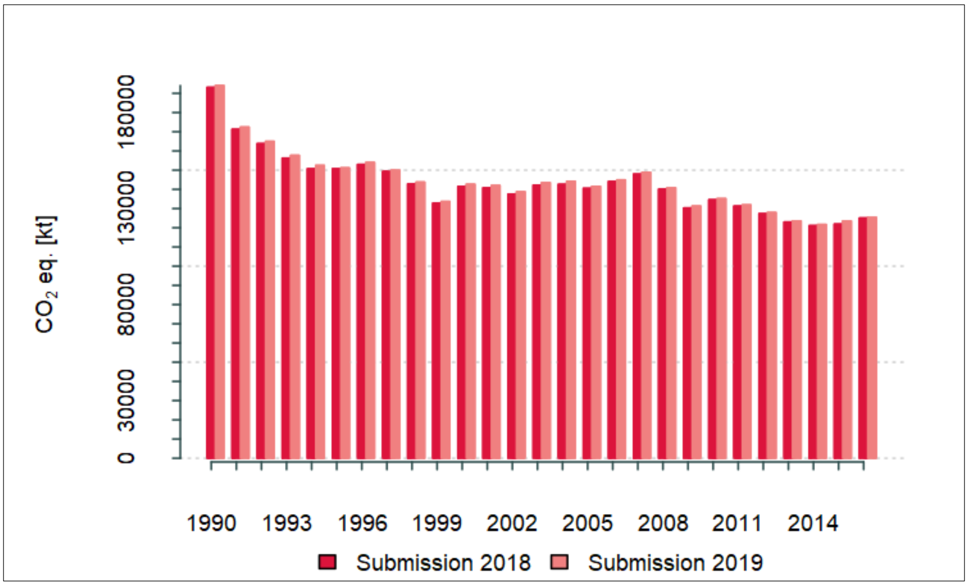


Fig. 10-7 Difference in trends of total emissions including LULUCF in index form, between submission 2018 and 2019, due to recalculations (1990 = 100%)

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 0.1% through the whole time period.

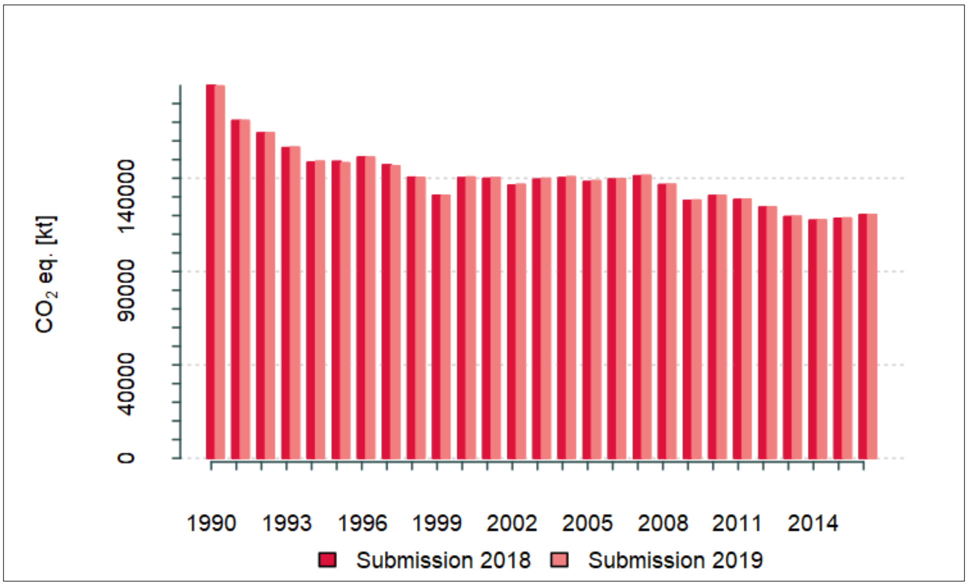


Fig. 10-8 Difference in trends of total emissions excluding LULUCF in index form, between submission 2018 and 2019, due to recalculations (1990 = 100%)

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 2019 (2017) submissions in comparison with previous submissions.

For changes in methodological descriptions please see Tab. 10-6.

Tab. 10-5 Table of implemented improvements in the 2019 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.3.	Introducing of COPERT 5	Improvement suggested by Party, UNFCCC recommendation	**NIR, chapter 3.**
Sector: Industrial processes and Other Product Use			
2.D	Update of activity data due to use of COPERT 5 model in 1.A.3	Improvement suggested by Party	**NIR, chapter 4.5**
2.F.1.e	New methodology for emission estimates of HFC 134a	Change of the methodology after UNFCCC review	**NIR, chapter 4.7.1**
2.H	Newly introduced HFO 1234yf emission estimates	Improvement suggested by Party	**NIR, chapter 4.9**
Sector: Agriculture			
3.A	Revision of emission factors, updated computational approach	Change of the methodology after UNFCCC review	**NIR, chapter 5.2**
Sector: LULUCF			
4.A.1	Revision of carbon stock change estimates	Change of the methodology after UNFCCC review	**NIR, chapter 6.4**
4.E	Introducing of soil carbon pool estimates	Change of the methodology after UNFCCC review	**NIR, chapter 6.8**
Sector: Waste			

Tab. 10-6 Methodological descriptions in submission 2019

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
Total (Net Emissions)	√	√	More detailed information for each recalculation is provided in Table 10-1 and in relevant Chapters of NIR
1. Energy	√	**√**	
A. Fuel Combustion (Sectoral Approach)		√	
1. Energy Industries		√	
2. Manufacturing Industries and Construction		√	
3. Transport	√	√	
4. Other Sectors		√	
5. Other		√	
B. Fugitive Emissions from Fuels			
1. Solid Fuels			
2. Oil and Natural Gas and Other emissions from Energy Production			
C. CO_2 transport and storage			
2. Industrial Processes	√	**√**	
A. Mineral Industry		√	
B. Chemical Industry			
C. Metal Industry		√	
D. Non-energy Products from Fuels and Solvent Use			
E. Electronics Industry			
F. Product Uses as Substitutes for ODS	√	√	
G. Other Product Manufacture and Use			
3. Agriculture		**√**	
A. Enteric Fermentation		√	
B. Manure Management		√	
C. Rice Cultivation	NO	NO	
D. Agricultural Soils		√	
E. Prescribed Burning of Savannas	NO	NO	
F. Field Burning of Agricultural Residues	NO	NO	
G. Liming			
H. Urea Application			
I. Other Carbon-containing Fertilizers	NO	NO	
J. Other	NO	NO	
4. Land Use, Land-Use Change and Forestry		**√**	
A. Forest Land		√	
B. Cropland		√	
C. Grassland		√	
D. Wetlands		√	
E. Settlements		√	
F. Other Land			
G. Harvested Wood Products		√	
H. Other			
5. Waste		**√**	
A. Solid Waste Disposal			
B. Biological treatment of solid waste			
C. Incineration and open burning of waste		√	
D. Wastewater treatment and discharge			
E. Other			

6. Other (as specified in Summary 1.A)	**NO**	**NO**	
KP LULUCF	Not reported in this submission	Not reported in this submission	
Article 3.3 activities			
Afforestation/reforestation			
Deforestation			
Article 3.4 activities			
Forest management			
Cropland management (if elected)			
Grazing land management (if elected)			
Revegetation (if elected)			
Wetland drainage and rewetting (if elected)			
HWP			
Memo Items:			
International Bunkers			
Aviation		√	
Marine			
Multilateral Operations			
CO_2 Emissions from Biomass		√	
CO_2 Captured			
Long-term storage of C in waste disposal sites			
Indirect N_2O		√	
Indirect CO_2		√	
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. 10-7 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	2019-2020
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	2020
1.A.3.b	Transport - Road Transportation	CO_2	LA,TA	Currently introduced COPERT 5	No planned improvement	
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	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	2020
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	2020
1.B.1.a	Coal Mining and Handling	CH_4	LA, TA	Tier 1 Abandoment mines	Tier 2 Abandoment mines	2020, 2021
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	2020
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	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	2020
2.C.1	Iron and Steel Production	CO_2	LA	Tier 2	Tier 3	2020
2.F.1	2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFCs and PFCs	LA, TA	Emission factors established by an expert judgement and Table 7.9, 2006 IPCC Gl., Vol. 3-2	Improvement of country-specific emission factors	2020, 2021
3	3.B Manure management	CH_4	LA	Tier 2	Swine, tier 2 method implementation	2021
3	3.B Manure management	N_2O	LA,TA	Tier 2	Swine, tier 2 method implementation	2021
3	3.B Manure management	N_2O	LA,TA	Country specific	Update of AWMS distribution scheme	2020
3	3.B Manure management	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	N_2O	LA, TA	Tier 2	Harmonization with reporting iunder UNECE	2021

	Soils, Indirect Emissions					
5	5.A Solid Waste Disposal	CO_2 CH_4	LA, TA	Tier 1	Review of factor F	2020
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	2020
5	5.D Wastewater Treatment and Discharge	N_2O CH_4	LA, TA	Tier 1, CS, D	Review of biogas composition	2020

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 2019.

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 2017.

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 29.5 kha as of 2017 (MAF 2018). 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 2019 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 2017, the areas of AR and D were estimated at the level of 13 084 cadastral units. The mean area of these units that enter the analysis of land-use changes within each of them is 603 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.

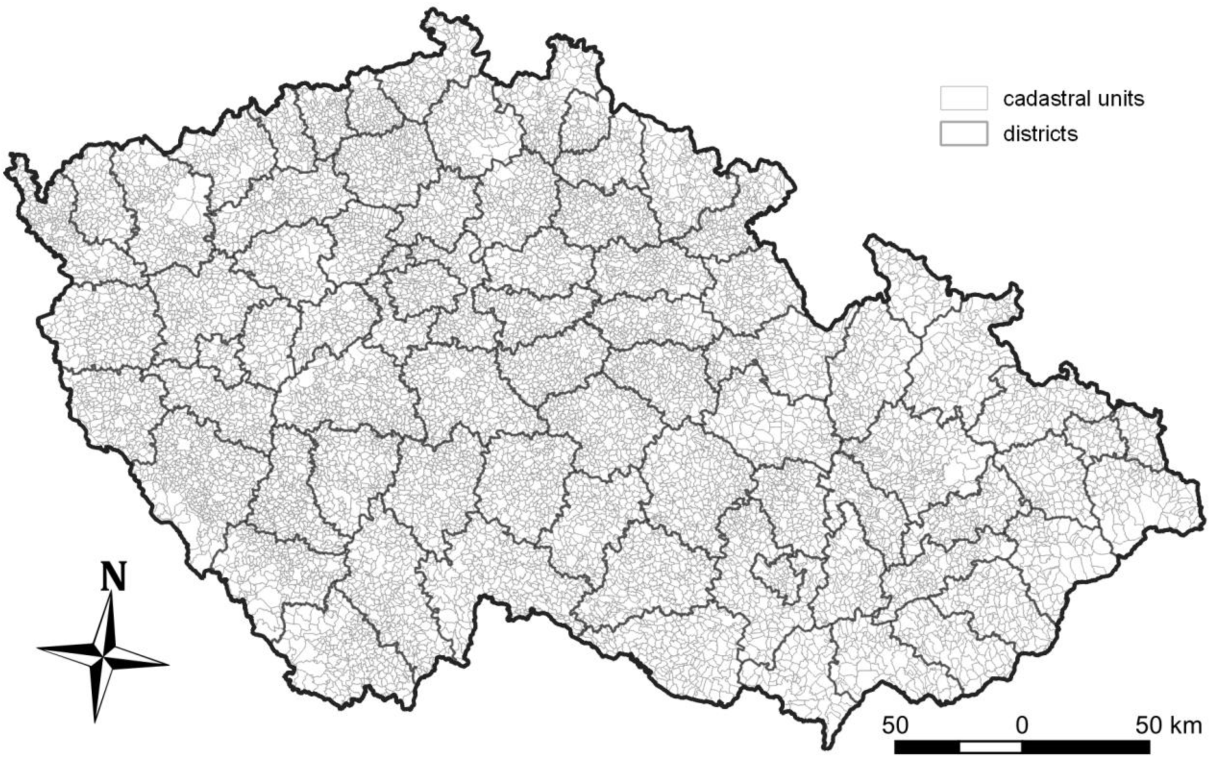


Fig. 11.1: The spatial detail of the land use representation and land-use change identification system used for detecting land use change associated with AR and D activities. In 2017, the areas of AR and D were estimated at the level of 13 084 individual cadastral units.

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
2017	0.59	0.43	0.04	1.42	0.00	2.48	0.06	0.06	0.03	0.44	0.00	0.59

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 2017 period, corresponding to a cumulative area of 62.6 kha. For the same period, the mean area of D reached 0.7 kha per year, which amounts to 18.5 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 4.A.1 of the Convention reporting. Although not explicitly labelled in this table, until 2009 4.A.1 was identical with the category of Forest Land remaining Forest Land (FLRFL) used in the KP reporting of FM. 4.A.2 represents Land converted to Forest land, remaining in conversion status for a period of 20 years. 4.A.1 and 4.A.2 form the entire category 4.A 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	4.A.2	4.A	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	39.9	38.3	2629.5	2591.2	34.0	2625.2
1995	397.2	159.2	461.6	1537.7	39.0	35.4	2630.1	2594.7	29.9	2624.6
1996	399.9	160.9	460.8	1536.4	38.3	34.7	2631.0	2596.2	27.5	2623.7
1997	403.3	160.9	460.3	1537.2	36.2	33.8	2631.8	2598.0	24.8	2622.8
1998	409.9	161.3	462.9	1532.5	34.0	33.3	2633.8	2600.5	20.8	2621.3
1999	412.7	163.3	458.9	1537.6	32.5	29.5	2634.5	2605.0	15.4	2620.4
2000	417.0	165.3	457.5	1536.6	31.3	29.6	2637.3	2607.7	12.0	2619.7
2001	422.2	166.5	456.2	1535.7	30.0	28.5	2639.2	2610.7	8.7	2619.4
2002	428.1	168.0	454.1	1531.5	28.6	32.7	2643.1	2610.3	8.3	2618.6
2003	435.5	169.6	452.7	1525.2	27.2	33.9	2644.2	2610.3	7.4	2617.6
2004	441.1	170.4	450.3	1521.5	27.0	35.5	2645.7	2610.3	6.6	2616.9
2005	447.2	171.1	448.7	1517.5	26.5	36.3	2647.4	2611.1	5.0	2616.2
2006	451.7	173.0	446.8	1514.1	26.1	37.4	2649.1	2611.7	3.9	2615.6
2007	457.6	174.2	444.8	1509.9	26.2	38.6	2651.2	2612.7	2.5	2615.2
2008	464.6	176.6	442.9	1502.3	27.2	39.5	2653.0	2613.6	1.1	2614.7
2009	471.0	177.8	440.9	1496.7	27.8	41.1	2655.2	2614.1	0.0	2614.1
2010	475.3	179.8	439.5	1491.2	28.3	43.2	2657.4	2613.3	0.0	2613.3
2011	480.2	181.9	437.4	1486.0	29.3	45.0	2659.8	2612.7	0.0	2612.7
2012	486.1	183.5	435.8	1478.9	30.1	47.4	2661.9	2612.2	0.0	2612.2
2013	492.7	185.2	434.2	1471.4	30.7	49.5	2663.7	2611.5	0.0	2611.5
2014	501.2	185.3	431.7	1463.6	33.3	51.2	2666.4	2610.9	0.0	2610.9
2015	506.0	186.2	430.7	1461.4	31.5	52.5	2668.4	2610.4	0.0	2610.4
2016	511.5	187.9	428.3	1458.2	31.1	52.8	2669.9	2609.8	0.0	2609.8
2017	516.7	189.1	426.7	1454.3	31.2	53.5	2671.7	2609.1	0.0	2609.1

The Czech inventory system adopts the 20-year default period for preserving lands under conversion status as recommended by IPCC 2006 Gl. (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 4.A.1 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 4.A.1 under the Convention reporting (4.A.1 is not explicitly shown in Tab. 11-2, but it is equal to 4.A - 4.A.2) 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.

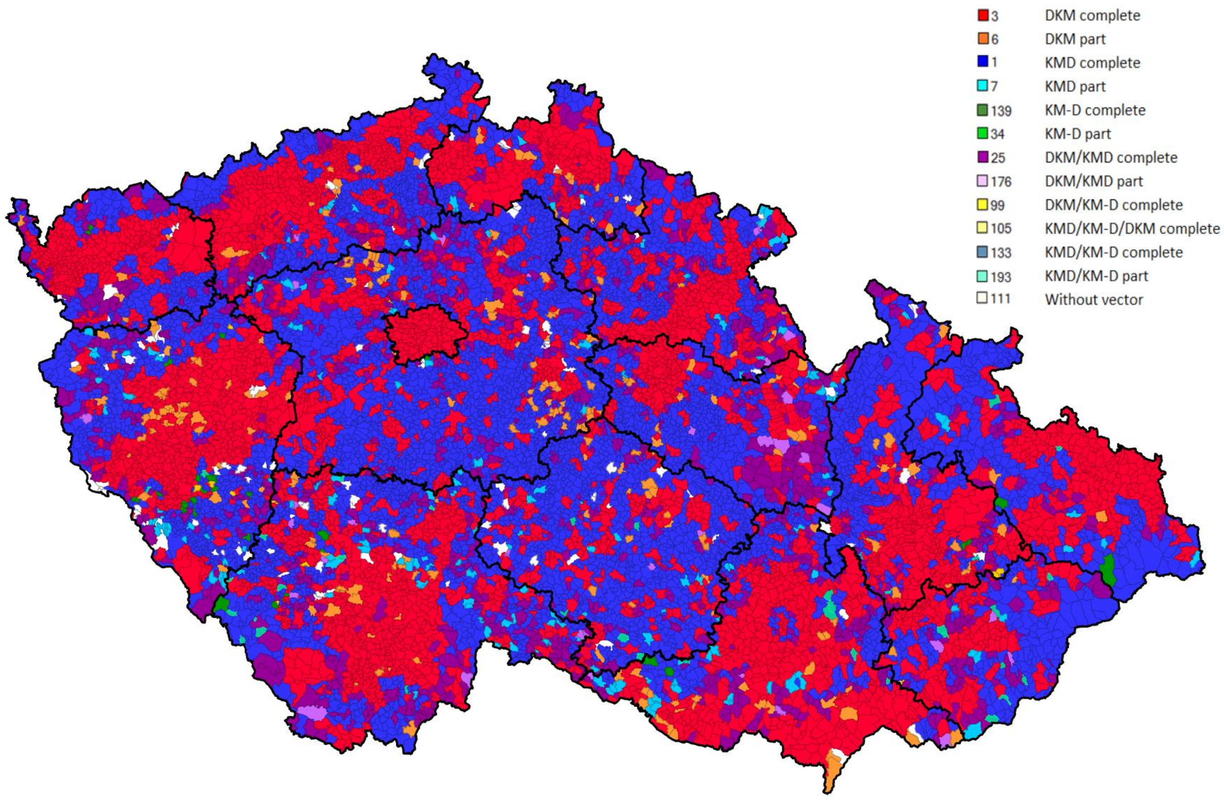


Fig. 11.2: The ongoing digitalization of the Czech cadastral land use information with units identified by categories of source map origin, coordination system and scale (DKM, KMD, KM-D and their combination) and completeness labelled by individual colours. Based on the information of COSMC as of January 2019.

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=13 084 as of 2017). 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 2017. 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 2017.

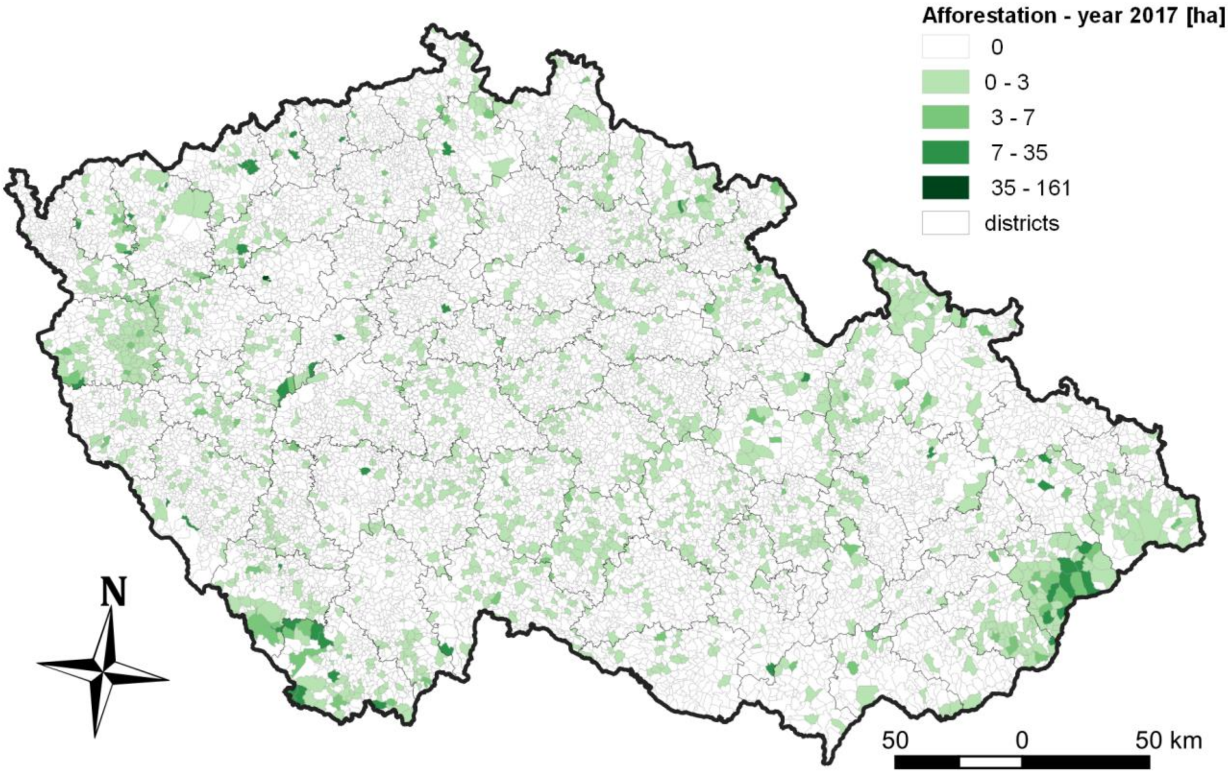


Fig. 11-3: The cadastral units with identified afforestation (AR) activities in 2017.

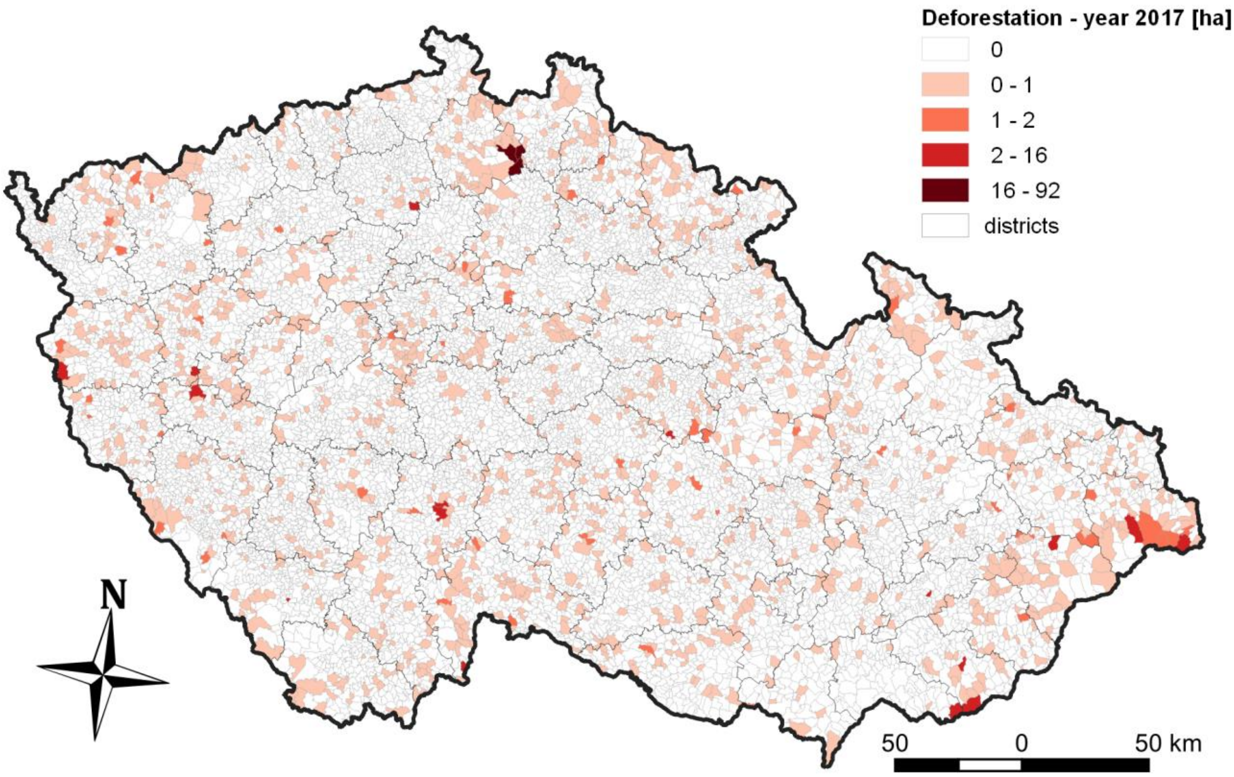


Fig. 11. 4: The cadastral units with identified deforestation (D) activities in 2017.

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 2019 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 Gl. (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 Gl. (IPCC 2006) 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 2019 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 2019 – this report).

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.

Apart from adopting age-specific increment data as described in Section 6.4.2, there is nomethodological discrepancy for estimating biomass carbon stock changes in new (afforested, young) mature forest stands.

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 Grassland and (newly) Settlements, based on the interpreted soil carbon stock maps (Sections 6.4.2.2, and 6.8.2 of the NIR text). Complementarily, for sub-categories involving Wetlands, “NA” was entered in association with the soil carbon pool, as no adopted applicable methodology is listed for this pool in IPCC 2006 Gl. (IPCC 2006) for the symmetric types of land-use conversion events.

For the FM activity, which resembles category 4.A.1 Forest Land remaining Forest Land, a newly implemented estimate of the net carbon stock change in dead organic matter (deadwood) was introduced in previous inventory submission (NIR 2018) based on the Tier 2 stock-difference method according to Eq. 2.8 of IPCC 2006 Gl. (IPCC 2006), in response to the review issue KL.5. The methodological details are presented in Section 6.4.2.1 of the NIR 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 4.A.1 Forest Land remaining Forest Land. These emissions are estimated identically as described in Section 6.4.2.1 of the NIR 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, 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).

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)

- Carbon stock change in biomass

  a. Partly in response to issues L.4 of the last review, the estimates of carbon stock change in biomass was revised, including the newly acquired data on mortality of the Czech National Forest Inventory. Such data were not available earlier and the calculation assumed no mortality in the conditions of intensive forest management in the country. The updated estimates marginally reduced the emission removal estimates in this emission category. This item concerns estimates of FM activity.

  b. Partly in response to issue L.16, newly introduced in the previous inventory submission (NIR 2018) was the species-specific 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. In this inventory submission, R-factor was also implemented for the associated conversions from Forest land. The biomass estimates changed accordingly for the entire time series and concern both FM and AR activities.

  c. By initiative of the inventory team, new EFs for carbon content in woody biomass following the new scientific literature (Thomas, S.C., Martin, A.R., 2012. Carbon content of tree tissues: A synthesis. Forests 3, 332–352. doi:10.3390/f3020332) that was not available for IPCC 2006 Gl. The new EFs for coniferous and broadleaved species affected the estimates of biomass for the entire time series of FM, AR and D activities.

- Carbon stock change estimates for DOM and litter

   a. In response to issue KL13 of the last review, new AD for dead organic matter (DOM) were introduced in the previous (NIR 2018) submission. 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). These AD and related estimates were slightly revised following the stock difference method (Eq. 2.19 of IPCC 2006) for FM and also used as a reference carbon stock for associated conversions related to forest land, i.e., activities AR and D.

- Soil carbon stock change

   a. In response to issue L. 19 of the last review, the estimates for soil carbon pools on Settlements are newly introduced. They are based on the data from Landscape inventory CzechTerra, which in its remote sensing component identified proportions of land cover that constitute the land use category Settlements. These proportions (area with tree cover, arable land, grass cover and the build-up, paved surfaces) were used to construct the reference carbon stock value applicable for Settlements (see Section 6.8.2). This allowed estimation of the associated emissions for land-use conversion involving Settlements to Forest land, hence also complementing emission the estimates for AR and D activities.

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 2017, the estimated overall uncertainty for AR activities was 33%. The overall uncertainty for D was 62%. For FM the overall uncertainty equalled 19%.

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 2017, such areas represented 2.4% 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 2017, it represented 1.2 % 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 2017, 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 2017, the estimated removals from AR activities reached 852 kt CO_2 eq. The estimated emissions from D equalled 301 kt 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 29.5 kha as of 2017 (MAF 2018), 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 NIR 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 excludes 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 2017, the proportion of domestically consumed HWP (Eq. 2.8.1 of IPCC 2014) reached 0.80 and 0.52 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. The data on annual domestic production of the major HPW items, i.e., paper and paperboard, wood-based panels and sawnwood, as used to estimate HWP pool changes are listed in Tab. 11-3. Emissions and removals resulting from changes in HPW pools do not include any imported HWP products.

- 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.

Tab. 11-3 Annual domestic production of paper and paperboard, wood-based panels and sawnwood in the country for 1990 to 2017as used for estimation of HWP changes to assess HWP emission contributon.

Year	HWP item		
	Paper and paperboard (t)	Wood-based panels (m^3)	Sawnwood (m^3)
1990	850 961	0.00	3 971 349
1991	711 534	1 008 014	3 018 525
1992	450 355	695 158	2 209 084
1993	643 000	524 769	3 025 000
1994	700 000	678 000	3 155 000
1995	738 000	715 000	3 490 000
1996	714 000	785 000	3 405 000
1997	772 000	842 000	3 393 000
1998	768 000	960 000	3 427 000
1999	770 000	865 000	3 584 000
2000	804 000	892 000	4 106 000
2001	864 000	921 000	3 889 000
2002	870 000	1 060 000	3 800 000
2003	950 000	1 109 000	3 805 000
2004	934 000	1 345 000	3 940 000
2005	969 000	1 390 000	4 003 000
2006	1 042 000	1 492 000	5 080 000
2007	1 023 000	1 566 000	5 454 000
2008	932 000	1 716 000	4 636 000
2009	804 786	1 681 000	4 048 000
2010	769 000	1 179 000	4 744 000
2011	775 200	1 372 000	4 454 000
2012	781 000	1 305 000	4 259 000
2013	610 900	1 282 000	4 037 000
2014	686 100	1 281 000	3 861 000
2015	740 320	1 288 000	4 150 000
2016	795 000	1 292 000	4 295 000
2017	907 999	1 380 000	4 317 000

11.5.4 Information on estimated emissions and removals of Forest Management activity under Art. 3.4

For inventory 2017, the estimated removals from *FM* with (without) HWP contribution reached -1725 (-946.6) kt 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 2017, the estimated emission contribution from HWP reached -779 kt 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 2018 to 31st of December 2018 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 2018 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 2018.

No invalid units exist as at 31 December 2018.

No discrepant transactions occurred in 2018.

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 2017 submission as the most recently reviewed inventory, multiplied by 8 results in:

8 x 129,383,524.791 = 1 035,068,198 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 2019 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 hasn't undergone any staffing since last submission, 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

According to document FCCC/ARR/2017/CZE no issues have been identified related to the National Registry and all previous review reccomendations have been resolved. Also the document SIAR/2018/CZ/1/1 confirms that that previous recommendations have been implemented and included in the annual report.

14.2 Changes to National Registry

The following changes to the national registry of the Czech Republic have therefore occurred in 2018:

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The current contact persons are: Martin Štandera mstandera@ote-cr.cz +420 296 579 329 Zuzana Stašková zstaskova@ote-cr.cz +420 296 579 209 Beáta Ondrušáková bondrusakova@ote-cr.cz +420 296 579 332
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 versions of the EUCR released after 8.0.8 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 8.0.8 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	The registry internet address changed during the reported period. The new URL is https://unionregistry.ec.europa.eu/euregistry/CZ/index.xhtml
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 8.0.8 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 1990–2015 and inventory report 2017 and will be updated in the European Union submission for the year 2018. The table below summarizes how the Party gives priority to selected actions, identified in paragraph 24 of the Annex to Decision 15/CMP.1.

In this inventory report the are minor updates in the following table regarding actions (a) and (f) and information about new biomass CCS project was included in action (d).

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. The submission of the analysis was postponed to the first quarter of 2019.
(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. New major project „Research center for low-carbon energy technologies“ was launched in 2018. It is focused on oxyfuel combustion of various sorts of biomass in a fluidized bed, oxy-gasification of biomass and utilization of the captured CO_2 to produce liquid fuels. The project should be finalized by 2022.
(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	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,

downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities.	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

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 and 2 including and excluding LULUCF. Tables A1-1 till A1-6 followed the approach in Tables 4.2 and 4.3 of the IPCC 2006 Gl., tables A1-7 till A1-10 are following methodological approach based on equation 4.4 and 4.5 of the IPCC 2006 Gls.

Tab. A1- 1 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2017 – 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	47860.54	47860.54	36.25	36.25
1.A.3.b Transport - Road transportation	CO_2	18081.80	18081.80	13.69	49.94
1.A.4 Other sectors - Gaseous Fuels	CO_2	7594.25	7594.25	5.75	55.69
2.C.1 Iron and Steel Production	CO_2	6453.12	6453.12	4.89	60.58
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5657.86	5657.86	4.28	64.86
1.A.4 Other sectors - Solid Fuels	CO_2	4122.69	4122.69	3.12	67.99
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	3995.73	3995.73	3.03	71.01
5.A Solid Waste Disposal on Land	CH_4	3720.28	3720.28	2.82	73.83
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3601.07	3601.07	2.73	76.56
3.A Enteric Fermentation	CH_4	2939.47	2939.47	2.23	78.78
1.A.1 Energy industries - Gaseous Fuels	CO_2	2906.43	2906.43	2.20	80.98
1.B.1.a Coal Mining and Handling	CH_4	2896.07	2896.07	2.19	83.18
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	2800.18	2800.18	2.12	85.30
2.A.1 Cement Production	CO_2	1728.27	1728.27	1.31	86.61
1.A.4 Other sectors - Liquid Fuels	CO_2	1221.37	1221.37	0.92	87.53
4.A.1 Forest Land remaining Forest Land	CO_2	-1010.83	1010.83	0.77	88.30
2.B.8 Petrochemical and Carbon Black Production	CO_2	1007.50	1007.50	0.76	89.06
5.D Wastewater treatment and discharge	CH_4	881.13	881.13	0.67	89.73
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	847.75	847.75	0.64	90.37
3.B Manure Management	N_2O	828.68	828.68	0.63	91.00
4.G Harvested wood products	CO_2	-778.50	778.50	0.59	91.59
2.B.1 Ammonia Production	CO_2	743.75	743.75	0.56	92.15
3.B Manure Management	CH_4	733.59	733.59	0.56	92.71
2.A.2 Lime Production	CO_2	673.53	673.53	0.51	93.22
4.A.2 Land converted to Forest Land	CO_2	-671.34	671.34	0.51	93.72
5.B Biological treatment of solid waste	CH_4	649.67	649.67	0.49	94.22
4.E.2 Land converted to Settlements	CO_2	583.80	583.80	0.44	94.66
1.A.4 Other sectors – Biomass	CH_4	577.91	577.91	0.44	95.10
1.B.2.b Natural Gas	CH_4	574.17	574.17	0.43	95.53
1.A.1 Energy industries - Liquid Fuels	CO_2	469.01	469.01	0.36	95.89
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	402.66	402.66	0.30	96.19
1.A.4 Other sectors - Solid Fuels	CH_4	317.60	317.60	0.24	96.43
2.A.4 Other process uses of carbonates	CO_2	298.74	298.74	0.23	96.66
1.A.5.b Other mobile - Liquid Fuels	CO_2	286.01	286.01	0.22	96.87
1.A.3.c Transport – Railways	CO_2	280.88	280.88	0.21	97.09
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	269.49	269.49	0.20	97.29
1.A.1 Energy industries - Other Fossil Fuels	CO_2	251.36	251.36	0.19	97.48
4.C.2 Land converted to Grassland	CO_2	-247.84	247.84	0.19	97.67
2.B.10 Other chemical industry	CO_2	229.49	229.49	0.17	97.84
2.G.3 N_2O from product uses	N_2O	223.50	223.50	0.17	98.01
1.A.1 Energy industries - Solid Fuels	N_2O	207.92	207.92	0.16	98.17
5.D Wastewater treatment and discharge	N_2O	197.90	197.90	0.15	98.32
1.A.3.b Transport - Road transportation	N_2O	183.17	183.17	0.14	98.46
3.G Liming	CO_2	159.04	159.04	0.12	98.58
2.A.3 Glass Production	CO_2	155.01	155.01	0.12	98.70
2.B.2 Nitric Acid Production	N_2O	134.32	134.32	0.10	98.80
5.C Incineration and open burning of waste	CO_2	133.39	133.39	0.10	98.90
4.C.1 Grassland remaining Grassland	CO_2	-130.95	130.95	0.10	99.00
3.H Urea application	CO_2	124.28	124.28	0.09	99.09
1.B.1.a Coal Mining and Handling	CO_2	122.45	122.45	0.09	99.19
2.D.1 Lubricant Use	CO_2	119.08	119.08	0.09	99.28
1.A.4 Other sectors – Biomass	N_2O	91.71	91.71	0.07	99.35
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	69.76	69.76	0.05	99.40

2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	66.48	66.48	0.05	99.45
5.B Biological treatment of solid waste	N_2O	64.25	64.25	0.05	99.50
2.B.8 Petrochemical and Carbon Black Production	CH_4	51.14	51.14	0.04	99.54
4.A.1 Forest Land remaining Forest Land	CH_4	38.08	38.08	0.03	99.56
1.A.3.e Transport - Other Transportation	CO_2	32.97	32.97	0.02	99.59
1.A.2 Manufacturing industries and construction - Biomass	N_2O	32.34	32.34	0.02	99.61
1.A.3.c Transport – Railways	N_2O	31.87	31.87	0.02	99.64
1.A.1 Energy industries – Biomass	N_2O	29.53	29.53	0.02	99.66
1.B.2.c Venting and Flaring	CH_4	27.01	27.01	0.02	99.68
4.A.1 Forest Land remaining Forest Land	N_2O	25.11	25.11	0.02	99.70
2.F.3 Fire Protection (CO_2 eq.)	HFC	24.86	24.86	0.02	99.72
1.A.3.b Transport - Road transportation	CH_4	24.66	24.66	0.02	99.74
1.A.4 Other sectors - Liquid Fuels	N_2O	21.40	21.40	0.02	99.75
4.D.2. Land converted to Wetlands	CO_2	20.89	20.89	0.02	99.77
1.A.2 Manufacturing industries and construction - Biomass	CH_4	20.46	20.46	0.02	99.79
1.A.4 Other sectors - Solid Fuels	N_2O	19.51	19.51	0.01	99.80
4.B.2 Land converted to Cropland	CO_2	19.00	19.00	0.01	99.81
1.A.1 Energy industries – Biomass	CH_4	18.59	18.59	0.01	99.83
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	17.16	17.16	0.01	99.84
2.D.3 Other non-energy products from fuels and solvent use	CO_2	17.13	17.13	0.01	99.85
1.A.4 Other sectors - Gaseous Fuels	CH_4	17.12	17.12	0.01	99.87
2.F.2 Foam Blowing (CO_2 eq.)	HFC	13.21	13.21	0.01	99.88
1.A.3.d Transport - Domestic navigation	CO_2	12.73	12.73	0.01	99.89
1.A.1 Energy industries - Solid Fuels	CH_4	12.28	12.28	0.01	99.90
4.B.1 Cropland remaining Cropland	CO_2	12.27	12.27	0.01	99.91
2.C.5 Lead Production	CO_2	11.18	11.18	0.01	99.91
1.A.3.a Transport - Civil Aviation	CO_2	9.84	9.84	0.01	99.92
2.C.1 Iron and Steel Production	CH_4	9.65	9.65	0.01	99.93
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	9.64	9.64	0.01	99.94
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	7.02	7.02	0.01	99.94
1.A.5.b Other mobile - Liquid Fuels	N_2O	7.00	7.00	0.01	99.95
1.B.2.a Oil	CH_4	6.63	6.63	0.01	99.95
2.D.2 Paraffin Wax Use	CO_2	6.48	6.48	0.00	99.96
1.B.1.b Solid Fuel Transformation	CH_4	4.50	4.50	0.00	99.96
1.B.2.c Venting and Flaring	CO_2	4.44	4.44	0.00	99.96
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	4.42	4.42	0.00	99.97
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	4.39	4.39	0.00	99.97
4.B.2. Land converted to Cropland	N_2O	4.38	4.38	0.00	99.97
2.C.2 Ferroalloys Production	CH_4	4.34	4.34	0.00	99.98
1.A.4 Other sectors - Gaseous Fuels	N_2O	4.08	4.08	0.00	99.98
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	3.44	3.44	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3.27	3.27	0.00	99.98
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.04	3.04	0.00	99.99
5.C Incineration and open burning of waste	N_2O	2.69	2.69	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.55	2.55	0.00	99.99
1.A.4 Other sectors - Liquid Fuels	CH_4	2.33	2.33	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2.06	2.06	0.00	99.99
2.F.5 Solvents (CO_2 eq.)	HFC	1.63	1.63	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	N_2O	1.56	1.56	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1.31	1.31	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.81	0.81	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.63	0.63	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.54	0.54	0.00	100.00
2.C.6 Zinc Production	CO_2	0.53	0.53	0.00	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	0.48	0.48	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0.40	0.40	0.00	100.00
1.A.3.c Transport – Railways	CH_4	0.39	0.39	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0.25	0.25	0.00	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0.22	0.22	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	0.08	0.08	0.00	100.00
1.B.2.a Oil	CO_2	0.04	0.04	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.03	0.03	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.03	0.03	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.02	0.02	0.00	100.00
1.A.3.e Transport - Other Transportation	CH_4	0.01	0.01	0.00	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00

Tab. A1- 2 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2017 – 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	3995.73	0.10	16.80	16.80
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	47860.54	0.07	12.29	29.09
1.A.3.b Transport - Road transportation	CO_2	10251.93	18081.80	0.06	10.39	39.48
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	4122.69	0.06	10.03	49.51
2.C.1 Iron and Steel Production	CO_2	9642.54	6453.12	0.05	8.67	58.18
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.90	7594.25	0.03	4.44	62.62
4.A.1 Forest Land remaining Forest Land	CO_2	-4281.55	-1010.83	0.03	4.34	66.96
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4281.81	2800.18	0.02	3.85	70.81
5.A Solid Waste Disposal on Land	CH_4	1979.27	3720.28	0.02	3.35	74.16
1.B.1.a Coal Mining and Handling	CH_4	10322.40	2896.07	0.02	3.30	77.46
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5502.33	269.49	0.02	2.91	80.37
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	2906.43	0.01	1.85	82.22
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.63	5657.86	0.01	1.83	84.05
2.A.1 Cement Production	CO_2	2489.18	1728.27	0.01	1.55	85.61
3.B Manure Management	N_2O	1619.88	828.68	0.01	1.46	87.06
1.A.4 Other sectors - Liquid Fuels	CO_2	3774.74	1221.37	0.01	1.06	88.12
1.B.2.b Natural Gas	CH_4	1044.93	574.17	0.01	0.94	89.06
5.D Wastewater treatment and discharge	CH_4	889.80	881.13	0.00	0.79	89.86
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	1007.50	0.00	0.71	90.57
4.G Harvested wood products	CO_2	-1712.98	-778.50	0.00	0.70	91.27
2.B.1 Ammonia Production	CO_2	990.80	743.75	0.00	0.67	91.94
2.A.2 Lime Production	CO_2	1336.65	673.53	0.00	0.61	92.54
4.A.2 Land converted to Forest Land	CO_2	-409.36	-671.34	0.00	0.60	93.15
5.B Biological treatment of solid waste	CH_4	0.00	649.67	0.00	0.58	93.73
3.A Enteric Fermentation	CH_4	5600.62	2939.47	0.00	0.56	94.29
3.G Liming	CO_2	1187.63	159.04	0.00	0.54	94.83
4.E.2 Land converted to Settlements	CO_2	1034.95	583.80	0.00	0.52	95.35
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	317.60	0.00	0.48	95.83
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	469.01	0.00	0.44	96.28
1.A.4 Other sectors – Biomass	CH_4	324.26	577.91	0.00	0.33	96.61
3.B Manure Management	CH_4	1695.73	733.59	0.00	0.31	96.92
2.A.4 Other process uses of carbonates	CO_2	113.86	298.74	0.00	0.27	97.19
1.A.3.c Transport – Railways	CO_2	768.15	280.88	0.00	0.25	97.44
4.C.2 Land converted to Grassland	CO_2	-188.41	-247.84	0.00	0.22	97.66
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	251.36	0.00	0.21	97.88
2.G.3 N_2O from product uses	N_2O	206.22	223.50	0.00	0.20	98.08
5.D Wastewater treatment and discharge	N_2O	234.18	197.90	0.00	0.18	98.26
1.A.3.b Transport - Road transportation	N_2O	99.97	183.17	0.00	0.16	98.42
1.B.1.a Coal Mining and Handling	CO_2	456.24	122.45	0.00	0.15	98.57
2.A.3 Glass Production	CO_2	142.75	155.01	0.00	0.13	98.70
2.B.2 Nitric Acid Production	N_2O	1050.29	134.32	0.00	0.12	98.82
5.C Incineration and open burning of waste	CO_2	20.83	133.39	0.00	0.12	98.94
4.C.1 Grassland remaining Grassland	CO_2	48.18	-130.95	0.00	0.12	99.06
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	17.16	0.00	0.07	99.13
1.A.3.a Transport - Civil Aviation	CO_2	139.44	9.84	0.00	0.07	99.20
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	69.76	0.00	0.06	99.26
5.B Biological treatment of solid waste	N_2O	0.00	64.25	0.00	0.06	99.32
3.H Urea application	CO_2	108.53	124.28	0.00	0.05	99.37
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	207.92	0.00	0.05	99.42
1.A.4 Other sectors – Biomass	N_2O	51.50	91.71	0.00	0.05	99.47
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	51.14	0.00	0.05	99.51
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	19.51	0.00	0.04	99.55
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	9.64	0.00	0.04	99.59
2.D.1 Lubricant Use	CO_2	116.13	119.08	0.00	0.04	99.64
1.A.3.c Transport – Railways	N_2O	88.35	31.87	0.00	0.03	99.66
1.A.1 Energy industries – Biomass	N_2O	0.48	29.53	0.00	0.03	99.69

1.A.3.e Transport - Other Transportation	CO_2	5.42	32.97	0.00	0.03	99.72
1.B.2.c Venting and Flaring	CH_4	12.28	27.01	0.00	0.02	99.74
4.A.1 Forest Land remaining Forest Land	N_2O	29.11	25.11	0.00	0.02	99.76
1.A.3.b Transport - Road transportation	CH_4	74.51	24.66	0.00	0.02	99.79
1.A.2 Manufacturing industries and construction – Biomass	N_2O	16.60	32.34	0.00	0.02	99.81
4.D.2. Land converted to Wetlands	CO_2	21.73	20.89	0.00	0.02	99.82
4.B.2 Land converted to Cropland	CO_2	87.19	19.00	0.00	0.02	99.84
1.A.1 Energy industries – Biomass	CH_4	0.30	18.59	0.00	0.02	99.86
1.A.2 Manufacturing industries and construction – Biomass	CH_4	10.45	20.46	0.00	0.01	99.87
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1345.38	847.75	0.00	0.01	99.88
1.A.3.d Transport - Domestic navigation	CO_2	53.52	12.73	0.00	0.01	99.89
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	66.48	0.00	0.01	99.90
4.B.1 Cropland remaining Cropland	CO_2	90.16	12.27	0.00	0.01	99.91
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	17.12	0.00	0.01	99.92
4.A.1 Forest Land remaining Forest Land	CH_4	44.15	38.08	0.00	0.01	99.93
2.C.5 Lead Production	CO_2	4.04	11.18	0.00	0.01	99.94
1.A.4 Other sectors - Liquid Fuels	N_2O	21.02	21.40	0.00	0.01	99.95
1.B.2.a Oil	CH_4	22.69	6.63	0.00	0.01	99.95
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	12.84	0.48	0.00	0.01	99.96
1.B.2.c Venting and Flaring	CO_2	2.02	4.44	0.00	0.00	99.96
4.B.2. Land converted to Cropland	N_2O	8.91	4.38	0.00	0.00	99.97
2.C.2 Ferroalloys Production	CH_4	0.18	4.34	0.00	0.00	99.97
1.A.4 Other sectors - Liquid Fuels	CH_4	9.96	2.33	0.00	0.00	99.98
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	12.28	0.00	0.00	99.98
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	5.38	0.22	0.00	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	3.27	0.00	0.00	99.98
5.C Incineration and open burning of waste	N_2O	0.42	2.69	0.00	0.00	99.99
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	4.08	0.00	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	2.06	0.00	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	3.31	0.40	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	1.56	0.00	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	3.04	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	1.31	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.55	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.3.a Transport - Civil Aviation	N_2O	1.19	0.08	0.00	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.42	0.25	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.63	0.00	0.00	100.00
2.D.2 Paraffin Wax Use	CO_2	9.43	6.48	0.00	0.00	100.00
1.A.3.c Transport – Railways	CH_4	1.08	0.39	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.43	0.10	0.00	0.00	100.00
2.C.1 Iron and Steel Production	CH_4	14.84	9.65	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.B.2.a Oil	CO_2	0.02	0.04	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.02	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
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.01	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	402.66	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.00	4.42	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.00	7.02	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	286.01	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.00	0.54	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.00	7.00	0.00	0.00	100.00
2.B.10 Other chemical industry	CO_2	0.00	229.49	0.00	0.00	100.00
2.C.6 Zinc Production	CO_2	0.00	0.53	0.00	0.00	100.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	17.13	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.00	3.44	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	3601.07	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.00	0.81	0.00	0.00	100.00
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.00	13.21	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.00	24.86	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	0.00	0.00	0.00	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	1.63	0.00	0.00	100.00
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	4.39	0.00	0.00	100.00

Tab. A1- 3 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2017 – 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	47860.54	47860.54	37.25	37.25
1.A.3.b Transport - Road transportation	CO_2	18081.80	18081.80	14.07	51.32
1.A.4 Other sectors - Gaseous Fuels	CO_2	7594.25	7594.25	5.91	57.23
2.C.1 Iron and Steel Production	CO_2	6453.12	6453.12	5.02	62.25
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5657.86	5657.86	4.40	66.65
1.A.4 Other sectors - Solid Fuels	CO_2	4122.69	4122.69	3.21	69.86
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	3995.73	3995.73	3.11	72.97
5.A Solid Waste Disposal on Land	CH_4	3720.28	3720.28	2.90	75.87
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3601.07	3601.07	2.80	78.67
3.A Enteric Fermentation	CH_4	2939.47	2939.47	2.29	80.96
1.A.1 Energy industries - Gaseous Fuels	CO_2	2906.43	2906.43	2.26	83.22
1.B.1.a Coal Mining and Handling	CH_4	2896.07	2896.07	2.25	85.47
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	2800.18	2800.18	2.18	87.65
2.A.1 Cement Production	CO_2	1728.27	1728.27	1.34	89.00
1.A.4 Other sectors - Liquid Fuels	CO_2	1221.37	1221.37	0.95	89.95
2.B.8 Petrochemical and Carbon Black Production	CO_2	1007.50	1007.50	0.78	90.73
5.D Wastewater treatment and discharge	CH_4	881.13	881.13	0.69	91.42
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	847.75	847.75	0.66	92.08
3.B Manure Management	N_2O	828.68	828.68	0.64	92.72
2.B.1 Ammonia Production	CO_2	743.75	743.75	0.58	93.30
3.B Manure Management	CH_4	733.59	733.59	0.57	93.87
2.A.2 Lime Production	CO_2	673.53	673.53	0.52	94.39
5.B Biological treatment of solid waste	CH_4	649.67	649.67	0.51	94.90
1.A.4 Other sectors – Biomass	CH_4	577.91	577.91	0.45	95.35
1.B.2.b Natural Gas	CH_4	574.17	574.17	0.45	95.80
1.A.1 Energy industries - Liquid Fuels	CO_2	469.01	469.01	0.36	96.16
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	402.66	402.66	0.31	96.47
1.A.4 Other sectors - Solid Fuels	CH_4	317.60	317.60	0.25	96.72
2.A.4 Other process uses of carbonates	CO_2	298.74	298.74	0.23	96.95
1.A.5.b Other mobile - Liquid Fuels	CO_2	286.01	286.01	0.22	97.18
1.A.3.c Transport – Railways	CO_2	280.88	280.88	0.22	97.40
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	269.49	269.49	0.21	97.61
1.A.1 Energy industries - Other Fossil Fuels	CO_2	251.36	251.36	0.20	97.80
2.B.10 Other chemical industry	CO_2	229.49	229.49	0.18	97.98
2.G.3 N_2O from product uses	N_2O	223.50	223.50	0.17	98.15
1.A.1 Energy industries - Solid Fuels	N_2O	207.92	207.92	0.16	98.32
5.D Wastewater treatment and discharge	N_2O	197.90	197.90	0.15	98.47
1.A.3.b Transport - Road transportation	N_2O	183.17	183.17	0.14	98.61
3.G Liming	CO_2	159.04	159.04	0.12	98.74
2.A.3 Glass Production	CO_2	155.01	155.01	0.12	98.86
2.B.2 Nitric Acid Production	N_2O	134.32	134.32	0.10	98.96
5.C Incineration and open burning of waste	CO_2	133.39	133.39	0.10	99.06
3.H Urea application	CO_2	124.28	124.28	0.10	99.16
1.B.1.a Coal Mining and Handling	CO_2	122.45	122.45	0.10	99.26
2.D.1 Lubricant Use	CO_2	119.08	119.08	0.09	99.35
1.A.4 Other sectors – Biomass	N_2O	91.71	91.71	0.07	99.42
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	69.76	69.76	0.05	99.47
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	66.48	66.48	0.05	99.53
5.B Biological treatment of solid waste	N_2O	64.25	64.25	0.05	99.58
2.B.8 Petrochemical and Carbon Black Production	CH_4	51.14	51.14	0.04	99.62
1.A.3.e Transport - Other Transportation	CO_2	32.97	32.97	0.03	99.64
1.A.2 Manufacturing industries and construction - Biomass	N_2O	32.34	32.34	0.03	99.67
1.A.3.c Transport – Railways	N_2O	31.87	31.87	0.02	99.69
1.A.1 Energy industries – Biomass	N_2O	29.53	29.53	0.02	99.72
1.B.2.c Venting and Flaring	CH_4	27.01	27.01	0.02	99.74
2.F.3 Fire Protection (CO_2 eq.)	HFC	24.86	24.86	0.02	99.76
1.A.3.b Transport - Road transportation	CH_4	24.66	24.66	0.02	99.77
1.A.4 Other sectors - Liquid Fuels	N_2O	21.40	21.40	0.02	99.79

1.A.2 Manufacturing industries and construction - Biomass	CH_4	20.46	20.46	0.02	99.81
1.A.4 Other sectors - Solid Fuels	N_2O	19.51	19.51	0.02	99.82
1.A.1 Energy industries – Biomass	CH_4	18.59	18.59	0.01	99.84
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	17.16	17.16	0.01	99.85
2.D.3 Other non-energy products from fuels and solvent use	CO_2	17.13	17.13	0.01	99.86
1.A.4 Other sectors - Gaseous Fuels	CH_4	17.12	17.12	0.01	99.88
2.F.2 Foam Blowing (CO_2 eq.)	HFC	13.21	13.21	0.01	99.89
1.A.3.d Transport - Domestic navigation	CO_2	12.73	12.73	0.01	99.90
1.A.1 Energy industries - Solid Fuels	CH_4	12.28	12.28	0.01	99.91
2.C.5 Lead Production	CO_2	11.18	11.18	0.01	99.92
1.A.3.a Transport - Civil Aviation	CO_2	9.84	9.84	0.01	99.92
2.C.1 Iron and Steel Production	CH_4	9.65	9.65	0.01	99.93
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	9.64	9.64	0.01	99.94
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	7.02	7.02	0.01	99.94
1.A.5.b Other mobile - Liquid Fuels	N_2O	7.00	7.00	0.01	99.95
1.B.2.a Oil	CH_4	6.63	6.63	0.01	99.95
2.D.2 Paraffin Wax Use	CO_2	6.48	6.48	0.01	99.96
1.B.1.b Solid Fuel Transformation	CH_4	4.50	4.50	0.00	99.96
1.B.2.c Venting and Flaring	CO_2	4.44	4.44	0.00	99.97
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	4.42	4.42	0.00	99.97
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	4.39	4.39	0.00	99.97
2.C.2 Ferroalloys Production	CH_4	4.34	4.34	0.00	99.98
1.A.4 Other sectors - Gaseous Fuels	N_2O	4.08	4.08	0.00	99.98
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	3.44	3.44	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3.27	3.27	0.00	99.98
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.04	3.04	0.00	99.99
5.C Incineration and open burning of waste	N_2O	2.69	2.69	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.55	2.55	0.00	99.99
1.A.4 Other sectors - Liquid Fuels	CH_4	2.33	2.33	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2.06	2.06	0.00	99.99
2.F.5 Solvents (CO_2 eq.)	HFC	1.63	1.63	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	N_2O	1.56	1.56	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1.31	1.31	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.81	0.81	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.63	0.63	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.54	0.54	0.00	100.00
2.C.6 Zinc Production	CO_2	0.53	0.53	0.00	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	0.48	0.48	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0.40	0.40	0.00	100.00
1.A.3.c Transport – Railways	CH_4	0.39	0.39	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0.25	0.25	0.00	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0.22	0.22	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	0.08	0.08	0.00	100.00
1.B.2.a Oil	CO_2	0.04	0.04	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.03	0.03	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.03	0.03	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.02	0.02	0.00	100.00
1.A.3.e Transport - Other Transportation	CH_4	0.01	0.01	0.00	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0.00	0.00	0.00	100.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	0.00	100.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0.00	0.00	0.00	100.00

Tab. A1- 4 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2017 – 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	3995.73	0.09	17.56	17.56
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	47860.54	0.07	13.46	31.02
1.A.3.b Transport - Road transportation	CO_2	10251.93	18081.80	0.06	11.11	42.13
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	4122.69	0.06	10.46	52.59
2.C.1 Iron and Steel Production	CO_2	9642.54	6453.12	0.05	9.20	61.79
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.90	7594.25	0.03	4.74	66.53
1.B.1.a Coal Mining and Handling	CH_4	10322.40	2896.07	0.02	3.43	69.96
5.A Solid Waste Disposal on Land	CH_4	1979.27	3720.28	0.02	3.55	73.51
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5502.33	269.49	0.02	3.04	76.55
3.A Enteric Fermentation	CH_4	5600.62	2939.47	0.01	2.81	79.36
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4281.81	2800.18	0.01	2.67	82.03
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	2906.43	0.01	1.97	84.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.63	5657.86	0.01	1.99	85.99
2.A.1 Cement Production	CO_2	2489.18	1728.27	0.01	1.65	87.64
1.A.4 Other sectors - Liquid Fuels	CO_2	3774.74	1221.37	0.01	1.10	88.74
1.B.2.b Natural Gas	CH_4	1044.93	574.17	0.01	1.00	89.73
5.D Wastewater treatment and discharge	CH_4	889.80	881.13	0.00	0.84	90.58
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1345.38	847.75	0.00	0.81	91.38
3.B Manure Management	N_2O	1619.88	828.68	0.00	0.79	92.18
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	1007.50	0.00	0.76	92.93
2.B.1 Ammonia Production	CO_2	990.80	743.75	0.00	0.71	93.64
3.B Manure Management	CH_4	1695.73	733.59	0.00	0.70	94.34
2.A.2 Lime Production	CO_2	1336.65	673.53	0.00	0.64	94.98
5.B Biological treatment of solid waste	CH_4	0.00	649.67	0.00	0.62	95.60
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	317.60	0.00	0.50	96.10
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	469.01	0.00	0.46	96.56
1.A.4 Other sectors – Biomass	CH_4	324.26	577.91	0.00	0.36	96.92
2.A.4 Other process uses of carbonates	CO_2	113.86	298.74	0.00	0.29	97.20
1.A.3.c Transport – Railways	CO_2	768.15	280.88	0.00	0.27	97.47
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	251.36	0.00	0.23	97.70
2.G.3 N_2O from product uses	N_2O	206.22	223.50	0.00	0.21	97.91
5.D Wastewater treatment and discharge	N_2O	234.18	197.90	0.00	0.19	98.10
1.A.3.b Transport - Road transportation	N_2O	99.97	183.17	0.00	0.17	98.27
1.B.1.a Coal Mining and Handling	CO_2	456.24	122.45	0.00	0.16	98.43
3.G Liming	CO_2	1187.63	159.04	0.00	0.15	98.58
2.A.3 Glass Production	CO_2	142.75	155.01	0.00	0.14	98.72
2.B.2 Nitric Acid Production	N_2O	1050.29	134.32	0.00	0.13	98.85
5.C Incineration and open burning of waste	CO_2	20.83	133.39	0.00	0.13	98.97
3.H Urea application	CO_2	108.53	124.28	0.00	0.12	99.09
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	17.16	0.00	0.08	99.17
1.A.3.a Transport - Civil Aviation	CO_2	139.44	9.84	0.00	0.07	99.24
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	69.76	0.00	0.07	99.31
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	66.48	0.00	0.06	99.37
5.B Biological treatment of solid waste	N_2O	0.00	64.25	0.00	0.06	99.43
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	207.92	0.00	0.05	99.49
1.A.4 Other sectors – Biomass	N_2O	51.50	91.71	0.00	0.05	99.54
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	51.14	0.00	0.05	99.59
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	19.51	0.00	0.04	99.63
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	9.64	0.00	0.04	99.67
2.D.1 Lubricant Use	CO_2	116.13	119.08	0.00	0.04	99.71
1.A.3.c Transport – Railways	N_2O	88.35	31.87	0.00	0.03	99.75
1.A.1 Energy industries – Biomass	N_2O	0.48	29.53	0.00	0.03	99.77
1.A.3.e Transport - Other Transportation	CO_2	5.42	32.97	0.00	0.03	99.80
1.B.2.c Venting and Flaring	CH_4	12.28	27.01	0.00	0.03	99.83
1.A.3.b Transport - Road transportation	CH_4	74.51	24.66	0.00	0.02	99.85
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	32.34	0.00	0.02	99.87
1.A.1 Energy industries – Biomass	CH_4	0.30	18.59	0.00	0.02	99.89
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	20.46	0.00	0.01	99.90
1.A.3.d Transport - Domestic navigation	CO_2	53.52	12.73	0.00	0.01	99.91

1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	17.12	0.00	0.01	99.93
2.C.5 Lead Production	CO_2	4.04	11.18	0.00	0.01	99.93
1.B.2.a Oil	CH_4	22.69	6.63	0.00	0.01	99.94
1.A.4 Other sectors - Liquid Fuels	N_2O	21.02	21.40	0.00	0.01	99.95
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	12.84	0.48	0.00	0.01	99.96
1.B.2.c Venting and Flaring	CO_2	2.02	4.44	0.00	0.00	99.96
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	4.39	0.00	0.00	99.96
2.C.2 Ferroalloys Production	CH_4	0.18	4.34	0.00	0.00	99.97
1.A.4 Other sectors - Liquid Fuels	CH_4	9.96	2.33	0.00	0.00	99.97
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	12.28	0.00	0.00	99.98
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	5.38	0.22	0.00	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	3.27	0.00	0.00	99.98
5.C Incineration and open burning of waste	N_2O	0.42	2.69	0.00	0.00	99.98
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	4.08	0.00	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	2.06	0.00	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	3.31	0.40	0.00	0.00	99.99
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	1.63	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	1.56	0.00	0.00	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	3.04	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	1.31	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.55	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.3.a Transport - Civil Aviation	N_2O	1.19	0.08	0.00	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.42	0.25	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.63	0.00	0.00	100.00
2.D.2 Paraffin Wax Use	CO_2	9.43	6.48	0.00	0.00	100.00
1.A.3.c Transport – Railways	CH_4	1.08	0.39	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.43	0.10	0.00	0.00	100.00
2.C.1 Iron and Steel Production	CH_4	14.84	9.65	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.B.2.a Oil	CO_2	0.02	0.04	0.00	0.00	100.00
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.02	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
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.01	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	402.66	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0	4.42	0.00	0.00	100.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0	7.02	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	286.01	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0	0.54	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	N_2O	0	7.00	0.00	0.00	100.00
2.B.10 Other chemical industry	CO_2	0	229.49	0.00	0.00	100.00
2.C.6 Zinc Production	CO_2	0	0.53	0.00	0.00	100.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0	17.13	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0	3.44	0.00	0.00	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0	3601.07	0.00	0.00	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0	0.81	0.00	0.00	100.00
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0	13.21	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	HFC	0	24.86	0.00	0.00	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0	0.03	0.00	0.00	100.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0	0.00	0.00	0.00	100.00

Tab. A1- 5 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 1990 – Level Assessment including LULUCF

IPCC Source Categories	GHG	Base Year Estimate	Base Year Estimate (Abs)	Level Assessment	Cumulative Total (LA)
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	53719.76	26.19	26.19
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	35635.57	17.37	17.37
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	24005.03	11.70	55.26
1.B.1.a Coal Mining and Handling	CH_4	10322.40	10322.40	5.03	60.29
1.A.3.b Transport - Road transportation	CO_2	10251.93	10251.93	5.00	65.29
2.C.1 Iron and Steel Production	CO_2	9642.54	9642.54	4.70	69.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.63	5685.63	2.77	72.76
3.A Enteric Fermentation	CH_4	5600.62	5600.62	2.73	75.49
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5502.33	5502.33	2.68	78.17
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4281.81	4281.81	2.09	80.26
4.A.1 Forest Land remaining Forest Land	CO_2	-4281.55	4281.55	2.09	82.35
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.90	4173.90	2.03	84.38
1.A.4 Other sectors - Liquid Fuels	CO_2	3774.74	3774.74	1.84	86.22
2.A.1 Cement Production	CO_2	2489.18	2489.18	1.21	87.43
5.A Solid Waste Disposal on Land	CH_4	1979.27	1979.27	0.96	88.40
4.G Harvested wood products	CO_2	-1712.98	1712.98	0.84	89.23
3.B Manure Management	CH_4	1695.73	1695.73	0.83	90.06
3.B Manure Management	N_2O	1619.88	1619.88	0.79	90.85
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	1514.04	0.74	91.59
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1345.38	1345.38	0.66	92.24
2.A.2 Lime Production	CO_2	1336.65	1336.65	0.65	92.90
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	1336.03	0.65	93.55
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	1331.86	0.65	94.20
3.G Liming	CO_2	1187.63	1187.63	0.58	94.77
2.B.2 Nitric Acid Production	N_2O	1050.29	1050.29	0.51	95.29
1.B.2.b Natural Gas	CH_4	1044.93	1044.93	0.51	95.80
4.E.2 Land converted to Settlements	CO_2	1034.95	1034.95	0.50	96.30
2.B.1 Ammonia Production	CO_2	990.80	990.80	0.48	96.78
5.D Wastewater treatment and discharge	CH_4	889.80	889.80	0.43	97.22
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	792.47	0.39	97.60
1.A.3.c Transport – Railways	CO_2	768.15	768.15	0.37	97.98
1.B.1.a Coal Mining and Handling	CO_2	456.24	456.24	0.22	98.20
4.A.2 Land converted to Forest Land	CO_2	-409.36	409.36	0.20	98.40
1.A.4 Other sectors – Biomass	CH_4	324.26	324.26	0.16	98.56
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	239.87	0.12	98.67
5.D Wastewater treatment and discharge	N_2O	234.18	234.18	0.11	98.79
2.G.3 N_2O from product uses	N_2O	206.22	206.22	0.10	98.89
4.C.2 Land converted to Grassland	CO_2	-188.41	188.41	0.09	98.98
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	152.87	0.07	99.06
2.A.3 Glass Production	CO_2	142.75	142.75	0.07	99.13
1.A.3.a Transport - Civil Aviation	CO_2	139.44	139.44	0.07	99.19
2.D.1 Lubricant Use	CO_2	116.13	116.13	0.06	99.25
2.A.4 Other process uses of carbonates	CO_2	113.86	113.86	0.06	99.31
3.H Urea application	CO_2	108.53	108.53	0.05	99.36
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	103.30	0.05	99.41
1.A.3.b Transport - Road transportation	N_2O	99.97	99.97	0.05	99.46
4.B.1 Cropland remaining Cropland	CO_2	90.16	90.16	0.04	99.50
1.A.3.c Transport – Railways	N_2O	88.35	88.35	0.04	99.54
4.B.2 Land converted to Cropland	CO_2	87.19	87.19	0.04	99.59
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	85.75	0.04	99.63
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	84.10	0.04	99.67
1.A.3.b Transport - Road transportation	CH_4	74.51	74.51	0.04	99.71
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	74.50	0.04	99.74
1.A.3.d Transport - Domestic navigation	CO_2	53.52	53.52	0.03	99.77
1.A.4 Other sectors – Biomass	N_2O	51.50	51.50	0.03	99.79
4.C.1 Grassland remaining Grassland	CO_2	48.18	48.18	0.02	99.82
4.A.1 Forest Land remaining Forest Land	CH_4	44.15	44.15	0.02	99.84
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	36.17	0.02	99.86
4.A.1 Forest Land remaining Forest Land	N_2O	29.11	29.11	0.01	99.87
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	24.04	0.01	99.88
1.B.2.a Oil	CH_4	22.69	22.69	0.01	99.89
4.D.2. Land converted to Wetlands	CO_2	21.73	21.73	0.01	99.90
1.A.4 Other sectors - Liquid Fuels	N_2O	21.02	21.02	0.01	99.91
5.C Incineration and open burning of waste	CO_2	20.83	20.83	0.01	99.92

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.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	12.84	12.84	0.01	99.95
1.B.2.c Venting and Flaring	CH_4	12.28	12.28	0.01	99.96
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	10.45	0.01	99.96
1.A.4 Other sectors - Liquid Fuels	CH_4	9.96	9.96	0.00	99.97
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	9.57	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	99.98
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	5.38	5.38	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	3.31	3.31	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	1.42	1.42	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	1.08	1.08	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	0.43	0.43	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- 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	27.24	27.24
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	35635.57	18.07	45.31
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	24005.03	12.17	57.49
1.B.1.a Coal Mining and Handling	CH_4	10322.40	10322.40	5.23	62.72
1.A.3.b Transport - Road transportation	CO_2	10251.93	10251.93	5.20	67.92
2.C.1 Iron and Steel Production	CO_2	9642.54	9642.54	4.89	72.81
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.63	5685.63	2.88	75.70
3.A Enteric Fermentation	CH_4	5600.62	5600.62	2.84	78.54
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5502.33	5502.33	2.79	81.33
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4281.81	4281.81	2.17	83.50
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.90	4173.90	2.12	85.61
1.A.4 Other sectors - Liquid Fuels	CO_2	3774.74	3774.74	1.91	87.53
2.A.1 Cement Production	CO_2	2489.18	2489.18	1.26	88.79
5.A Solid Waste Disposal on Land	CH_4	1979.27	1979.27	1.00	89.79
3.B Manure Management	CH_4	1695.73	1695.73	0.86	90.65
3.B Manure Management	N_2O	1619.88	1619.88	0.82	91.48
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	1514.04	0.77	92.24
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1345.38	1345.38	0.68	92.93
2.A.2 Lime Production	CO_2	1336.65	1336.65	0.68	93.60
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	1336.03	0.68	94.28
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	1331.86	0.68	94.96
3.G Liming	CO_2	1187.63	1187.63	0.60	95.56
2.B.2 Nitric Acid Production	N_2O	1050.29	1050.29	0.53	96.09
1.B.2.b Natural Gas	CH_4	1044.93	1044.93	0.53	96.62
2.B.1 Ammonia Production	CO_2	990.80	990.80	0.50	97.12
5.D Wastewater treatment and discharge	CH_4	889.80	889.80	0.45	97.58
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	792.47	0.40	97.98
1.A.3.c Transport – Railways	CO_2	768.15	768.15	0.39	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	98.76
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	239.87	0.12	98.88
5.D Wastewater treatment and discharge	N_2O	234.18	234.18	0.12	99.00
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	99.18
2.A.3 Glass Production	CO_2	142.75	142.75	0.07	99.26
1.A.3.a Transport - Civil Aviation	CO_2	139.44	139.44	0.07	99.33
2.D.1 Lubricant Use	CO_2	116.13	116.13	0.06	99.39
2.A.4 Other process uses of carbonates	CO_2	113.86	113.86	0.06	99.44
3.H Urea application	CO_2	108.53	108.53	0.06	99.50
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	103.30	0.05	99.55
1.A.3.b Transport - Road transportation	N_2O	99.97	99.97	0.05	99.60
1.A.3.c Transport – Railways	N_2O	88.35	88.35	0.04	99.65
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	85.75	0.04	99.69
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	84.10	0.04	99.73
1.A.3.b Transport - Road transportation	CH_4	74.51	74.51	0.04	99.77
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	74.50	0.04	99.81
1.A.3.d Transport - Domestic navigation	CO_2	53.52	53.52	0.03	99.84
1.A.4 Other sectors – Biomass	N_2O	51.50	51.50	0.03	99.86
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	36.17	0.02	99.88
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	24.04	0.01	99.89
1.B.2.a Oil	CH_4	22.69	22.69	0.01	99.90
1.A.4 Other sectors - Liquid Fuels	N_2O	21.02	21.02	0.01	99.92
5.C Incineration and open burning of waste	CO_2	20.83	20.83	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.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	12.84	12.84	0.01	99.96
1.B.2.c Venting and Flaring	CH_4	12.28	12.28	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 - Liquid Fuels	CH_4	9.96	9.96	0.01	99.97
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	9.57	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	99.98
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	5.38	5.38	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	3.31	3.31	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	1.42	1.42	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	1.08	1.08	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	0.43	0.43	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., 2017 – 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	47860.54	47860.54	5.00	36.25	2393.03	33.65	36.25	0.11	33.65
1.A.3.b Transport - Road transportation	CO_2	18081.80	18081.80	4.97	13.69	899.50	12.71	13.69	0.11	46.37
1.A.4 Other sectors - Gaseous Fuels	CO_2	7594.25	7594.25	3.91	5.75	296.56	5.28	5.75	0.08	51.65
2.C.1 Iron and Steel Production	CO_2	6453.12	6453.12	12.21	4.89	787.70	4.85	4.89	0.26	56.50
5.A Solid Waste Disposal on Land	CH_4	3720.28	3720.28	63.70	2.82	2369.79	4.08	2.82	1.38	60.58
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5657.86	5657.86	3.91	4.28	220.95	3.94	4.28	0.08	64.52
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3601.07	3601.07	43.57	2.73	1568.84	3.46	2.73	0.94	67.98
1.A.4 Other sectors - Solid Fuels	CO_2	4122.69	4122.69	5.00	3.12	206.13	2.90	3.12	0.11	70.88
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	3995.73	3995.73	5.00	3.03	199.79	2.81	3.03	0.11	73.69
3.A Enteric Fermentation	CH_4	2939.47	2939.47	15.81	2.23	464.77	2.28	2.23	0.34	75.97
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	2800.18	2800.18	20.62	2.12	577.27	2.26	2.12	0.45	78.23
1.B.1.a Coal Mining and Handling	CH_4	2896.07	2896.07	13.60	2.19	393.91	2.20	2.19	0.29	80.43
1.A.1 Energy industries - Gaseous Fuels	CO_2	2906.43	2906.43	3.91	2.20	113.50	2.02	2.20	0.08	82.45
2.A.1 Cement Production	CO_2	1728.27	1728.27	2.83	1.31	48.88	1.19	1.31	0.06	83.64
4.A.1 Forest Land remaining Forest Land	CO_2	-1010.83	1010.83	41.63	0.77	420.81	0.96	0.77	0.90	84.60
2.B.8 Petrochemical and Carbon Black Production	CO_2	1007	1007	40	1	406	0.95	0.76	0.87	85.55
5.D Wastewater treatment and discharge	CH_4	881	881	58	1	514	0.93	0.67	1.26	86.48
1.A.4 Other sectors - Liquid Fuels	CO_2	1221	1221	6	1	71	0.87	0.93	0.13	87.35
4.G Harvested wood products	CO_2	-779	779	62	1	483	0.84	0.59	1.34	88.19
5.B Biological treatment of solid waste	CH_4	650	650	91	0	593	0.83	0.49	1.97	89.03
4.E.2 Land converted to Settlements	CO_2	584	584	102	0	597	0.79	0.44	2.21	89.82
3.B Manure Management	N_2O	829	829	40	1	334	0.78	0.63	0.87	90.60
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	848	848	30	1	258	0.74	0.64	0.66	91.34
1.B.2.b Natural Gas	CH_4	574	574	75	0	432	0.67	0.43	1.63	92.01
3.B Manure Management	CH_4	734	734	22	1	164	0.60	0.56	0.48	92.61
4.A.2 Land converted to Forest Land	CO_2	-671	671	32	1	217	0.60	0.51	0.70	93.21
1.A.4 Other sectors - Biomass	CH_4	578	578	51	0	293	0.58	0.44	1.09	93.79
2.B.1 Ammonia Production	CO_2	744	744	9	1	64	0.54	0.56	0.19	94.33
2.A.2 Lime Production	CO_2	674	674	3	1	19	0.46	0.51	0.06	94.80
1.A.1 Energy industries - Liquid Fuels	CO_2	469	469	6	0	27	0.33	0.36	0.13	95.13

1.A.4 Other sectors - Solid Fuels	CH_4	318	318	50	0	159	0.32	0.24	1.08	95.45
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	403	403	18	0	73	0.32	0.30	0.39	95.77
1.A.3.b Transport - Road transportation	N_2O	183	183	134	0	245	0.29	0.14	2.89	96.05
1.A.1 Energy industries - Solid Fuels	N_2O	208	208	60	0	125	0.22	0.16	1.30	96.28
2.A.4 Other process uses of carbonates	CO_2	299	299	11	0	33	0.22	0.23	0.24	96.50
4.C.2 Land converted to Grassland	CO_2	-248	248	31	0	78	0.22	0.19	0.68	96.72
1.A.1 Energy industries - Other Fossil Fuels	CO_2	251	251	28	0	71	0.22	0.19	0.61	96.93
2.G.3 N_2O from product uses	N_2O	224	224	44	0	97	0.21	0.17	0.94	97.15
5.D Wastewater treatment and discharge	N_2O	198	198	56	0	112	0.21	0.15	1.22	97.35
1.A.5.b Other mobile - Liquid Fuels	CO_2	286	286	6	0	17	0.20	0.22	0.13	97.56
1.A.3.c Transport - Railways	CO_2	281	281	5	0	15	0.20	0.21	0.11	97.75
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	269	269	6	0	16	0.19	0.20	0.13	97.95
2.B.10 Other chemical industry	CO_2	229	229	4	0	9	0.16	0.17	0.08	98.10
3.G Liming	CO_2	159	159	30	0	48	0.14	0.12	0.66	98.24
4.C.1 Grassland remaining Grassland	CO_2	-131	131	45	0	59	0.13	0.10	0.98	98.37
3.H Urea application	CO_2	124	124	52	0	65	0.13	0.09	1.13	98.50
2.D.1 Lubricant Use	CO_2	119	119	50	0	60	0.12	0.09	1.09	98.62
2.A.3 Glass Production	CO_2	155	155	5	0	8	0.11	0.12	0.12	98.73
2.B.2 Nitric Acid Production	N_2O	134	134	16	0	21	0.10	0.10	0.34	98.83
5.C Incineration and open burning of waste	CO_2	133	133	16	0	21	0.10	0.10	0.34	98.93
1.B.1.a Coal Mining and Handling	CO_2	122	122	25	0	31	0.10	0.09	0.55	99.04
1.A.4 Other sectors - Biomass	N_2O	92	92	61	0	56	0.10	0.07	1.31	99.14
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	70	70	40	0	28	0.07	0.05	0.87	99.20
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	66	66	44	0	29	0.06	0.05	0.94	99.27
1.A.3.c Transport - Railways	N_2O	32	32	137	0	44	0.05	0.02	2.97	99.32
2.B.8 Petrochemical and Carbon Black Production	CH_4	51	51	40	0	21	0.05	0.04	0.87	99.36
5.B Biological treatment of solid waste	N_2O	64	64	5	0	3	0.05	0.05	0.11	99.41
1.A.3.b Transport - Road transportation	CH_4	25	25	157	0	39	0.04	0.02	3.41	99.45
4.A.1 Forest Land remaining Forest Land	CH_4	38	38	46	0	18	0.04	0.03	1.00	99.49
1.A.2 Manufacturing industries and construction - Biomass	N_2O	32	32	61	0	20	0.03	0.02	1.31	99.52
1.A.1 Energy industries - Biomass	N_2O	30	30	61	0	18	0.03	0.02	1.31	99.56
1.B.2.c Venting and Flaring	CH_4	27	27	50	0	14	0.03	0.02	1.09	99.58
4.A.1 Forest Land remaining Forest Land	N_2O	25	25	46	0	12	0.02	0.02	1.00	99.61
4.D.2. Land converted to Wetlands	CO_2	21	21	69	0	14	0.02	0.02	1.50	99.63
2.F.3 Fire Protection (CO_2 eq.)	HFC	25	25	42	0	10	0.02	0.02	0.91	99.65
1.A.3.e Transport - Other Transportation	CO_2	33	33	5	0	2	0.02	0.02	0.11	99.68

1.A.4 Other sectors - Liquid Fuels	N_2O	21	21	60	0	13	0.02	0.02	1.30	99.70
1.A.4 Other sectors - Solid Fuels	N_2O	20	20	60	0	12	0.02	0.01	1.30	99.72
1.A.2 Manufacturing industries and construction - Biomass	CH_4	20	20	51	0	10	0.02	0.02	1.09	99.74
1.A.1 Energy industries - Biomass	CH_4	19	19	51	0	9	0.02	0.01	1.09	99.76
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	17	17	60	0	10	0.02	0.01	1.30	99.78
4.B.2 Land converted to Cropland	CO_2	19	19	37	0	7	0.02	0.01	0.79	99.80
1.A.4 Other sectors - Gaseous Fuels	CH_4	17	17	50	0	9	0.02	0.01	1.08	99.81
2.F.2 Foam Blowing (CO_2 eq.)	HFC	13	13	42	0	6	0.01	0.01	0.91	99.83
1.A.1 Energy industries - Solid Fuels	CH_4	12	12	50	0	6	0.01	0.01	1.08	99.84
2.D.3 Other non-energy products from fuels and solvent use	CO_2	17	17	7	0	1	0.01	0.01	0.15	99.85
2.C.5 Lead Production	CO_2	11	11	51	0	6	0.01	0.01	1.10	99.86
4.B.2. Land converted to Cropland	N_2O	4	4	282	0	12	0.01	0.00	6.11	99.87
4.B.1 Cropland remaining Cropland	CO_2	12	12	29	0	4	0.01	0.01	0.64	99.88
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	10	10	50	0	5	0.01	0.01	1.08	99.89
1.A.3.d Transport - Domestic navigation	CO_2	13	13	5	0	1	0.01	0.01	0.11	99.90
2.C.1 Iron and Steel Production	CH_4	10	10	31	0	3	0.01	0.01	0.67	99.91
1.B.2.a Oil	CH_4	7	7	75	0	5	0.01	0.01	1.63	99.92
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	7	7	61	0	4	0.01	0.01	1.32	99.93
1.A.5.b Other mobile - Liquid Fuels	N_2O	7	7	60	0	4	0.01	0.01	1.30	99.93
1.A.3.a Transport - Civil Aviation	CO_2	10	10	6	0	1	0.01	0.01	0.12	99.94
2.D.2 Paraffin Wax Use	CO_2	6	6	50	0	3	0.01	0.00	1.09	99.95
1.B.1.b Solid Fuel Transformation	CH_4	5	5	64	0	3	0.00	0.00	1.38	99.95
1.B.2.c Venting and Flaring	CO_2	4	4	50	0	2	0.00	0.00	1.09	99.96
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	4	4	51	0	2	0.00	0.00	1.10	99.96
1.A.4 Other sectors - Gaseous Fuels	N_2O	4	4	60	0	2	0.00	0.00	1.30	99.97
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	0.94	99.97
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3	3	73	0	2	0.00	0.00	1.57	99.97
2.C.2 Ferroalloys Production	CH_4	4	4	25	0	1	0.00	0.00	0.55	99.98
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3	3	60	0	2	0.00	0.00	1.30	99.98
5.C Incineration and open burning of waste	N_2O	3	3	73	0	2	0.00	0.00	1.57	99.98
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	3	3	15	0	1	0.00	0.00	0.33	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	3	3	50	0	1	0.00	0.00	1.08	99.99
1.A.4 Other sectors - Liquid	CH_4	2	2	50	0	1	0.00	0.00	1.09	99.99

Fuels										
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2	2	54	0	1	0.00	0.00	1.16	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	2	2	60	0	1	0.00	0.00	1.30	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	2	2	42	0	1	0.00	0.00	0.91	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1	1	50	0	1	0.00	0.00	1.08	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	1	1	44	0	0	0.00	0.00	0.94	100.00
1.A.3.c Transport - Railways	CH_4	0	0	158	0	1	0.00	0.00	3.41	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	1	1	50	0	0	0.00	0.00	1.09	100.00
2.C.6 Zinc Production	CO_2	1	1	51	0	0	0.00	0.00	1.10	100.00
2.C.2 Ferroalloys Production	CO_2	1	1	25	0	0	0.00	0.00	0.55	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	0	0	60	0	0	0.00	0.00	1.30	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0	0	60	0	0	0.00	0.00	1.30	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0	0	50	0	0	0.00	0.00	1.09	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0	0	50	0	0	0.00	0.00	1.09	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0	0	137	0	0	0.00	0.00	2.97	100.00
1.A.3.a Transport - Civil Aviation	N_2O	0	0	110	0	0	0.00	0.00	2.38	100.00
1.B.2.b Natural Gas	CO_2	0	0	75	0	0	0.00	0.00	1.63	100.00
1.B.2.a Oil	CO_2	0	0	75	0	0	0.00	0.00	1.63	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0	0	42	0	0	0.00	0.00	0.91	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0	0	5	0	0	0.00	0.00	0.11	100.00
1.A.3.e Transport - Other Transportation	N_2O	0	0	60	0	0	0.00	0.00	1.30	100.00
1.A.3.e Transport - Other Transportation	CH_4	0	0	50	0	0	0.00	0.00	1.08	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0	0	79	0	0	0.00	0.00	1.70	100.00
5.C Incineration and open burning of waste	CH_4	0	0	82	0	0	0.00	0.00	1.78	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0	0	15	0	0	0.00	0.00	0.33	100.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0	0	42	0	0	0.00	0.00	0.91	100.00

Tab. A1- 8 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2017 – 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	47861	47861	5	36	2393	35	37.25	0.13	34.93
1.A.3.b Transport - Road transportation	CO_2	18082	18082	5	14	900	13	14.07	0.13	48.13
1.A.4 Other sectors - Gaseous Fuels	CO_2	7594	7594	4	6	297	5	5.91	0.10	53.61
2.C.1 Iron and Steel Production	CO_2	6453	6453	12	5	788	5	5.02	0.32	58.65
5.A Solid Waste Disposal on Land	CH_4	3720	3720	64	3	2370	4	2.90	1.68	62.88
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5658	5658	4	4	221	4	4.40	0.10	66.97
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	3601	3601	44	3	1569	4	2.80	1.15	70.56
1.A.4 Other sectors - Solid Fuels	CO_2	4123	4123	5	3	206	3	3.21	0.13	73.57
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	3996	3996	5	3	200	3	3.11	0.13	76.49
3.A Enteric Fermentation	CH_4	2939	2939	16	2	465	2	2.29	0.42	78.85
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	2800	2800	21	2	577	2	2.18	0.54	81.20
1.B.1.a Coal Mining and Handling	CH_4	2896	2896	14	2	394	2	2.25	0.36	83.49
1.A.1 Energy industries - Gaseous Fuels	CO_2	2906	2906	4	2	113	2	2.26	0.10	85.59
2.A.1 Cement Production	CO_2	1728	1728	3	1	49	1	1.34	0.07	86.82
2.B.8 Petrochemical and Carbon Black Production	CO_2	1007	1007	40	1	406	1	0.78	1.06	87.80
5.D Wastewater treatment and discharge	CH_4	881	881	58	1	514	1	0.69	1.54	88.77
1.A.4 Other sectors - Liquid Fuels	CO_2	1221	1221	6	1	71	1	0.95	0.15	89.67
5.B Biological treatment of solid waste	CH_4	650	650	91	0	593	1	0.51	2.40	90.54
3.B Manure Management	N_2O	829	829	40	1	334	1	0.64	1.06	91.35
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	848	848	30	1	258	1	0.66	0.80	92.11
1.B.2.b Natural Gas	CH_4	574	574	75	0	432	1	0.45	1.98	92.81
3.B Manure Management	CH_4	734	734	22	1	164	1	0.57	0.59	93.44
1.A.4 Other sectors - Biomass	CH_4	578	578	51	0	293	1	0.45	1.33	94.04
2.B.1 Ammonia Production	CO_2	744	744	9	1	64	1	0.58	0.23	94.60
2.A.2 Lime Production	CO_2	674	674	3	1	19	0	0.52	0.07	95.09
1.A.1 Energy industries - Liquid Fuels	CO_2	469	469	6	0	27	0	0.36	0.15	95.43
1.A.4 Other sectors - Solid Fuels	CH_4	318	318	50	0	159	0	0.25	1.32	95.76
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	403	403	18	0	73	0	0.31	0.47	96.09
1.A.3.b Transport - Road transportation	N_2O	183	183	134	0	245	0	0.14	3.52	96.39
1.A.1 Energy industries - Solid Fuels	N_2O	208	208	60	0	125	0	0.16	1.58	96.62
2.A.4 Other process uses of carbonates	CO_2	299	299	11	0	33	0	0.23	0.29	96.85
1.A.1 Energy industries - Other Fossil Fuels	CO_2	251	251	28	0	71	0	0.20	0.74	97.08
2.G.3 N_2O from product uses	N_2O	224	224	44	0	97	0	0.17	1.15	97.30
5.D Wastewater treatment and discharge	N_2O	198	198	56	0	112	0	0.15	1.48	97.51
1.A.5.b Other mobile - Liquid Fuels	CO_2	286	286	6	0	17	0	0.22	0.15	97.73
1.A.3.c Transport - Railways	CO_2	281	281	5	0	15	0	0.22	0.14	97.93
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	269	269	6	0	16	0	0.21	0.15	98.13
2.B.10 Other chemical industry	CO_2	229	229	4	0	9	0	0.18	0.10	98.29
3.G Liming	CO_2	159	159	30	0	48	0	0.12	0.80	98.44
3.H Urea application	CO_2	124	124	52	0	65	0	0.10	1.37	98.57
2.D.1 Lubricant Use	CO_2	119	119	50	0	60	0	0.09	1.32	98.69
2.A.3 Glass Production	CO_2	155	155	5	0	8	0	0.12	0.14	98.81
2.B.2 Nitric Acid Production	N_2O	134	134	16	0	21	0	0.10	0.41	98.92
5.C Incineration and open burning of waste	CO_2	133	133	16	0	21	0	0.10	0.42	99.02
1.B.1.a Coal Mining and Handling	CO_2	122	122	25	0	31	0	0.10	0.67	99.13
1.A.4 Other sectors - Biomass	N_2O	92	92	61	0	56	0	0.07	1.59	99.23
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	70	70	40	0	28	0	0.05	1.06	99.30

2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	66	66	44	0	29	0	0.05	1.15	99.37
1.A.3.c Transport - Railways	N_2O	32	32	137	0	44	0	0.02	3.61	99.42
2.B.8 Petrochemical and Carbon Black Production	CH_4	51	51	40	0	21	0	0.04	1.06	99.47
5.B Biological treatment of solid waste	N_2O	64	64	5	0	3	0	0.05	0.13	99.52
1.A.3.b Transport - Road transportation	CH_4	25	25	157	0	39	0	0.02	4.14	99.56
1.A.2 Manufacturing industries and construction - Biomass	N_2O	32	32	61	0	20	0	0.03	1.59	99.60
1.A.1 Energy industries - Biomass	N_2O	30	30	61	0	18	0	0.02	1.59	99.63
1.B.2.c Venting and Flaring	CH_4	27	27	50	0	14	0	0.02	1.33	99.66
2.F.3 Fire Protection (CO_2 eq.)	HFC	25	25	42	0	10	0	0.02	1.10	99.68
1.A.3.e Transport - Other Transportation	CO_2	33	33	5	0	2	0	0.03	0.13	99.71
1.A.4 Other sectors - Liquid Fuels	N_2O	21	21	60	0	13	0	0.02	1.58	99.73
1.A.4 Other sectors - Solid Fuels	N_2O	20	20	60	0	12	0	0.02	1.58	99.75
1.A.2 Manufacturing industries and construction - Biomass	CH_4	20	20	51	0	10	0	0.02	1.33	99.77
1.A.1 Energy industries - Biomass	CH_4	19	19	51	0	9	0	0.01	1.33	99.79
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	17	17	60	0	10	0	0.01	1.58	99.81
1.A.4 Other sectors - Gaseous Fuels	CH_4	17	17	50	0	9	0	0.01	1.32	99.83
2.F.2 Foam Blowing (CO_2 eq.)	HFC	13	13	42	0	6	0	0.01	1.10	99.84
1.A.1 Energy industries - Solid Fuels	CH_4	12	12	50	0	6	0	0.01	1.32	99.86
2.D.3 Other non-energy products from fuels and solvent use	CO_2	17	17	7	0	1	0	0.01	0.19	99.87
2.C.5 Lead Production	CO_2	11	11	51	0	6	0	0.01	1.34	99.88
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	10	10	50	0	5	0	0.01	1.32	99.89
1.A.3.d Transport - Domestic navigation	CO_2	13	13	5	0	1	0	0.01	0.14	99.90
2.C.1 Iron and Steel Production	CH_4	10	10	31	0	3	0	0.01	0.81	99.91
1.B.2.a Oil	CH_4	7	7	75	0	5	0	0.01	1.98	99.92
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	7	7	61	0	4	0	0.01	1.60	99.92
1.A.5.b Other mobile - Liquid Fuels	N_2O	7	7	60	0	4	0	0.01	1.58	99.93
1.A.3.a Transport - Civil Aviation	CO_2	10	10	6	0	1	0	0.01	0.15	99.94
2.D.2 Paraffin Wax Use	CO_2	6	6	50	0	3	0	0.01	1.32	99.95
1.B.1.b Solid Fuel Transformation	CH_4	5	5	64	0	3	0	0.00	1.69	99.95
1.B.2.c Venting and Flaring	CO_2	4	4	50	0	2	0	0.00	1.33	99.96
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	4	4	51	0	2	0	0.00	1.34	99.96
1.A.4 Other sectors - Gaseous Fuels	N_2O	4	4	60	0	2	0	0.00	1.58	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	1.15	99.97
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3	3	73	0	2	0	0.00	1.92	99.97
2.C.2 Ferroalloys Production	CH_4	4	4	25	0	1	0	0.00	0.67	99.98
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3	3	60	0	2	0	0.00	1.58	99.98
5.C Incineration and open burning of waste	N_2O	3	3	73	0	2	0	0.00	1.92	99.98
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	3	3	15	0	1	0	0.00	0.40	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	3	3	50	0	1	0	0.00	1.32	99.99
1.A.4 Other sectors - Liquid Fuels	CH_4	2	2	50	0	1	0	0.00	1.32	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2	2	54	0	1	0	0.00	1.42	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	2	2	60	0	1	0	0.00	1.58	100.00
2.F.5 Solvents (CO_2 eq.)	HFC	2	2	42	0	1	0	0.00	1.10	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	1	1	50	0	1	0	0.00	1.32	100.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	1	1	44	0	0	0	0.00	1.15	100.00
1.A.3.c Transport - Railways	CH_4	0	0	158	0	1	0	0.00	4.15	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	1	1	50	0	0	0	0.00	1.32	100.00
2.C.6 Zinc Production	CO_2	1	1	51	0	0	0	0.00	1.34	100.00
2.C.2 Ferroalloys Production	CO_2	1	1	25	0	0	0	0.00	0.67	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	0	0	60	0	0	0	0.00	1.58	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0	0	60	0	0	0	0.00	1.58	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0	0	50	0	0	0	0.00	1.32	100.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0	0	50	0	0	0	0.00	1.32	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0	0	137	0	0	0	0.00	3.61	100.00
1.A.3.a Transport - Civil Aviation	N_2O	0	0	110	0	0	0	0.00	2.90	100.00

1.B.2.b Natural Gas	CO_2	0	0	75	0	0	0	0.00	1.98	100.00
1.B.2.a Oil	CO_2	0	0	75	0	0	0	0.00	1.98	100.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0	0	42	0	0	0	0.00	1.10	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0	0	5	0	0	0	0.00	0.14	100.00
1.A.3.e Transport - Other Transportation	N_2O	0	0	60	0	0	0	0.00	1.58	100.00
1.A.3.e Transport - Other Transportation	CH_4	0	0	50	0	0	0	0.00	1.32	100.00
1.A.3.a Transport - Civil Aviation	CH_4	0	0	79	0	0	0	0.00	2.07	100.00
5.C Incineration and open burning of waste	CH_4	0	0	82	0	0	0	0.00	2.17	100.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0	0	15	0	0	0	0.00	0.40	0.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0	0	42	0	0	0	0.00	1.10	0.00

Tab. A1- 9 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2017 – Trend Assessment including LULUCF

IPCC Source Categories	GHG	Base Year Estimate (Abs)	Current Year Estimate (Abs)	Combined Uncertainty	TA_A1	Uncerta in ammount BY	Uncerta in ammount CY	BY uncerta in total	CY uncerta in 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	3996	5	17	1782	200	37417	4196	3	22	20	1.35	20.02
1.A.1 Energy industries - Solid Fuels	CO_2	53720	47861	5	12	2686	2393	56406	50254	36	14	13	17.57	32.88
1.A.3.b Transport - Road transportation	CO_2	10252	18082	5	10	510	900	10762	18981	13	13	12	23.66	44.53
1.A.4 Other sectors - Solid Fuels	CO_2	24005	4123	5	10	1200	206	25205	4329	3	13	12	25.06	56.55
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0	3601	44	0	0	1569	0	5170	4	6	5	35.69	61.61
1.A.4 Other sectors - Gaseous Fuels	CO_2	4174	7594	4	4	163	297	4337	7891	6	5	5	37.70	66.55
1.B.1.a Coal Mining and Handling	CH_4	10322	2896	14	3	1404	394	11726	3290	2	5	4	40.37	70.89
5.A Solid Waste Disposal on Land	CH_4	1979	3720	64	3	1261	2370	3240	6090	4	4	4	56.43	74.76
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5502	269	6	3	321	16	5823	285	0	4	3	56.53	78.24
4.A.1 Forest Land remaining Forest Land	CO_2	-4282	-1011	42	4	-1782	-421	-6064	-1432	-1	3	3	53.68	80.75
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336	2906	4	2	52	113	1388	3020	2	2	2	54.45	82.81
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5686	5658	4	2	222	221	5908	5879	4	2	2	55.95	84.76
1.A.4 Other sectors - Liquid Fuels	CO_2	3775	1221	6	1	220	71	3995	1293	1	1	1	56.43	86.07
5.B Biological treatment of solid waste	CH_4	0	650	91	1	0	593	0	1243	1	1	1	60.45	87.29
1.A.4 Other sectors - Solid Fuels	CH_4	1332	318	50	0	668	159	2000	477	0	1	1	61.53	88.11
3.G Liming	CO_2	1188	159	30	1	361	48	1549	207	0	1	1	61.86	88.91
3.A Enteric Fermentation	CH_4	5601	2939	16	1	886	465	6486	3404	2	1	1	65.00	89.76
2.B.8 Petrochemical and Carbon Black Production	CO_2	792	1007	40	1	319	406	1112	1414	1	1	1	67.76	90.42
2.B.2 Nitric	N_2O	1050	134	16	0	163	21	1213	155	0	1	1	67.90	91.05

Acid Production														
1.A.4 Other sectors - Biomass	CH_4	324	578	51	0	164	293	488	871	1	1	1	69.88	91.59
4.A.2 Land converted to Forest Land	CO_2	-409	-671	32	1	-133	-217	-542	-889	-1	1	1	68.41	92.11
1.A.1 Energy industries - Liquid Fuels	CO_2	1514	469	6	0	88	27	1602	496	0	1	1	68.59	92.66
4.G Harvested wood products	CO_2	-1713	-779	62	1	-1062	-483	-2775	-1261	-1	1	1	65.32	93.21
5.D Wastewater treatment and discharge	CH_4	890	881	58	1	519	514	1409	1396	1	1	0	68.81	93.67
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0	403	18	0	0	73	0	475	0	1	0	69.30	94.14
3.B Manure Management	CH_4	1696	734	22	0	379	164	2075	898	1	1	0	70.41	94.60
1.A.5.b Other mobile - Liquid Fuels	CO_2	0	286	6	0	0	17	0	303	0	0	0	70.52	94.89
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24	251	28	0	7	71	31	322	0	0	0	71.01	95.19
3.B Manure Management	N_2O	1620	829	40	1	653	334	2273	1163	1	0	0	73.27	95.52
2.C.1 Iron and Steel Production	CO_2	9643	6453	12	9	1177	788	10820	7241	5	0	0	78.61	95.63
1.A.3.b Transport - Road transportation	N_2O	100	183	134	0	134	245	234	428	0	0	0	80.27	95.90
2.A.4 Other process uses of carbonates	CO_2	114	299	11	0	13	33	127	332	0	0	0	80.49	96.15
2.B.10 Other chemical industry	CO_2	0	229	4	0	0	9	0	238	0	0	0	80.55	96.38
4.C.1 Grassland remaining Grassland	CO_2	48	-131	45	0	22	-59	70	-190	0	0	0	80.15	96.61
1.A.3.c Transport - Railways	CO_2	768	281	5	0	40	15	808	296	0	0	0	80.25	96.84
1.B.1.a Coal Mining and Handling	CO_2	456	122	25	0	116	31	572	153	0	0	0	80.46	97.06
2.A.2 Lime Production	CO_2	1337	674	3	1	38	19	1374	693	0	0	0	80.59	97.27
1.B.2.b Natural Gas	CH_4	1045	574	75	1	787	432	1832	1007	1	0	0	83.52	97.46
4.C.2 Land converted to Grassland	CO_2	-188	-248	31	0	-59	-78	-247	-325	0	0	0	82.99	97.62
4.E.2 Land converted to Settlements	CO_2	1035	584	102	1	1059	597	2094	1181	1	0	0	87.04	97.82
5.C Incineration and open burning of waste	CO_2	21	133	16	0	3	21	24	154	0	0	0	87.18	97.95
2.A.1 Cement Production	CO_2	2489	1728	3	2	70	49	2560	1777	1	0	0	87.52	98.04
2.G.3 N_2O from product uses	N_2O	206	224	44	0	90	97	296	321	0	0	0	88.18	98.17
1.A.2 Manufacturing industries	N_2O	153	17	60	0	92	10	245	27	0	0	0	88.25	98.30

and construction - Solid Fuels														
2.B.1 Ammonia Production	CO_2	991	744	9	1	85	64	1076	808	1	0	0	88.68	98.39
1.A.4 Other sectors - Biomass	N_2O	51	92	61	0	31	56	83	147	0	0	0	89.06	98.49
1.A.1 Energy industries - Solid Fuels	N_2O	240	208	60	0	144	125	384	333	0	0	0	89.90	98.56
1.A.3.a Transport - Civil Aviation	CO_2	139	10	6	0	8	1	147	10	0	0	0	89.91	98.65
3.H Urea application	CO_2	109	124	52	0	57	65	165	189	0	0	0	90.35	98.73
1.A.4 Other sectors - Solid Fuels	N_2O	103	20	60	0	62	12	165	31	0	0	0	90.43	98.80
5.D Wastewater treatment and discharge	N_2O	234	198	56	0	132	112	366	309	0	0	0	91.18	98.87
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	86	10	50	0	43	5	129	14	0	0	0	91.21	98.94
5.B Biological treatment of solid waste	N_2O	0	64	5	0	0	3	0	67	0	0	0	91.24	99.01
2.D.1 Lubricant Use	CO_2	116	119	50	0	58	60	174	179	0	0	0	91.64	99.07
2.A.3 Glass Production	CO_2	143	155	5	0	8	8	150	163	0	0	0	91.70	99.13
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4282	2800	21	4	883	577	5165	3377	2	0	0	95.61	99.15
1.A.3.b Transport - Road transportation	CH_4	75	25	157	0	117	39	192	63	0	0	0	95.87	99.21
4.B.1 Cropland remaining Cropland	CO_2	90	12	29	0	27	4	117	16	0	0	0	95.90	99.27
1.A.3.c Transport - Railways	N_2O	88	32	137	0	121	44	210	76	0	0	0	96.19	99.34
4.B.2 Land converted to Cropland	CO_2	87	19	37	0	32	7	119	26	0	0	0	96.24	99.39
1.A.1 Energy industries - Biomass	N_2O	0	30	61	0	0	18	1	47	0	0	0	96.36	99.43
2.B.8 Petrochemical and Carbon Black Production	CH_4	36	51	40	0	15	21	51	72	0	0	0	96.50	99.47
2.F.3 Fire Protection (CO_2 eq.)	HFC	0	25	42	0	0	10	0	35	0	0	0	96.57	99.50
1.A.2 Manufacturing industries and construction - Biomass	N_2O	17	32	61	0	10	20	27	52	0	0	0	96.70	99.54
1.A.3.e Transport - Other Transportation	CO_2	5	33	5	0	0	2	6	35	0	0	0	96.72	99.57
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	75	70	40	0	30	28	105	98	0	0	0	96.91	99.60
1.B.2.c	CH_4	12	27	50	0	6	14	18	41	0	0	0	97.00	99.63

Venting and Flaring														
1.A.1 Energy industries - Biomass	CH_4	0	19	51	0	0	9	0	28	0	0	0	97.06	99.65
1.A.3.d Transport - Domestic navigation	CO_2	54	13	5	0	3	1	56	13	0	0	0	97.07	99.68
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1345	848	30	0	409	258	1755	1106	1	0	0	98.81	99.72
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10	20	51	0	5	10	16	31	0	0	0	98.88	99.74
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0	13	42	0	0	6	0	19	0	0	0	98.92	99.76
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0	17	7	0	0	1	0	18	0	0	0	98.93	99.78
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84	66	44	0	37	29	121	95	0	0	0	99.13	99.80
1.A.4 Other sectors - Gaseous Fuels	CH_4	10	17	50	0	5	9	14	26	0	0	0	99.18	99.81
4.A.1 Forest Land remaining Forest Land	CH_4	44	38	46	0	20	18	65	56	0	0	0	99.30	99.82
1.B.2.a Oil	CH_4	23	7	75	0	17	5	40	12	0	0	0	99.34	99.84
2.C.5 Lead Production	CO_2	4	11	51	0	2	6	6	17	0	0	0	99.38	99.85
1.A.4 Other sectors - Liquid Fuels	N_2O	21	21	60	0	13	13	34	34	0	0	0	99.46	99.86
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	13	0	60	0	8	0	21	1	0	0	0	99.47	99.88
4.D.2. Land converted to Wetlands	CO_2	22	21	69	0	15	14	37	35	0	0	0	99.56	99.89
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0	7	61	0	0	4	0	11	0	0	0	99.59	99.90
1.A.5.b Other mobile - Liquid Fuels	N_2O	0	7	60	0	0	4	0	11	0	0	0	99.62	99.91
4.A.1 Forest Land remaining Forest Land	N_2O	29	25	46	0	13	12	43	37	0	0	0	99.70	99.92
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0	4	51	0	0	2	0	7	0	0	0	99.71	99.92
1.B.1.b Solid Fuel Transformation	CH_4	1	5	64	0	0	3	1	7	0	0	0	99.73	99.93
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0	4	44	0	0	2	0	6	0	0	0	99.75	99.94

1.A.4 Other sectors - Liquid Fuels	CH_4	10	2	50	0	5	1	15	4	0	0	0	99.76	99.94
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0	3	73	0	0	2	1	6	0	0	0	99.77	99.95
2.C.2 Ferroalloys Production	CH_4	0	4	25	0	0	1	0	5	0	0	0	99.78	99.95
4.B.2. Land converted to Cropland	N_2O	9	4	282	0	25	12	34	17	0	0	0	99.86	99.96
1.A.1 Energy industries - Solid Fuels	CH_4	14	12	50	0	7	6	21	18	0	0	0	99.90	99.96
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	5	0	50	0	3	0	8	0	0	0	0	99.91	99.97
1.B.2.c Venting and Flaring	CO_2	2	4	50	0	1	2	3	7	0	0	0	99.92	99.97
1.A.4 Other sectors - Gaseous Fuels	N_2O	2	4	60	0	1	2	4	7	0	0	0	99.94	99.98
5.C Incineration and open burning of waste	N_2O	0	3	73	0	0	2	1	5	0	0	0	99.95	99.98
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0	3	15	0	0	1	0	4	0	0	0	99.95	99.98
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0	2	54	0	0	1	0	3	0	0	0	99.96	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	3	0	60	0	2	0	5	1	0	0	0	99.96	99.99
2.F.5 Solvents (CO_2 eq.)	HFC	0	2	42	0	0	1	0	2	0	0	0	99.97	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	1	2	60	0	0	1	1	2	0	0	0	99.97	99.99
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3	3	60	0	2	2	5	5	0	0	0	99.99	100.00
1.A.3.a Transport - Civil Aviation	N_2O	1	0	110	0	1	0	2	0	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.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	3	3	50	0	1	1	4	4	0	0	0	100	100
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0	1	44	0	0	0	0	1	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
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.6 Zinc Production	CO_2	0	1	51	0	0	0	0	1	0	0	0	100	100

1.A.3.c Transport - Railways	CH_4	1	0	158	0	2	1	3	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
2.D.2 Paraffin Wax Use	CO_2	9	6	50	0	5	3	14	10	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.C.1 Iron and Steel Production	CH_4	15	10	31	0	5	3	19	13	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.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.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
1.A.3.e Transport - Other Transportation	N_2O	0	0	60	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
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
2.F.4 Aerosols (CO_2 eq.)	HFC	0	0	42	0	0	0	0	0	0	0	0	100	100

Tab. A1- 10 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2017 – 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	3995.7	5.0	16.8	1781.8	199.8	37417.3	4195.5	2.9	21.5	20.7	1.3	20.7
1.A.1 Energy industries - Solid Fuels	CO_2	53719.8	47860.5	5.0	12.3	2686.0	2393.0	56405.7	50253.6	34.9	14.4	13.9	16.9	34.6
1.A.4 Other sectors - Solid Fuels	CO_2	24005.0	4122.7	5.0	10.0	1200.3	206.1	25205.3	4328.8	3.0	12.9	12.4	18.2	47.0
1.A.3.b Transport - Road transportation	CO_2	10251.9	18081.8	5.0	10.4	510.0	899.5	10761.9	18981.3	13.2	12.8	12.3	24.1	59.3
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.0	3601.1	43.6	0.0	0.0	1568.8	0.0	5169.9	3.6	5.5	5.3	34.3	64.6
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.9	7594.3	3.9	4.4	163.0	296.6	4336.9	7890.8	5.5	5.4	5.2	36.2	69.8
1.B.1.a Coal Mining and Handling	CH_4	10322.4	2896.1	13.6	3.3	1404.0	393.9	11726.4	3290.0	2.3	4.6	4.5	38.8	74.3
5.A Solid Waste Disposal on Land	CH_4	1979.3	3720.3	63.7	3.3	1260.8	2369.8	3240.1	6090.1	4.2	4.2	4.1	54.2	78.4
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5502.3	269.5	5.8	2.9	320.8	15.7	5823.2	285.2	0.2	3.7	3.6	54.3	82.0
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.0	2906.4	3.9	1.8	52.2	113.5	1388.2	3019.9	2.1	2.3	2.2	55.1	84.2
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.6	5657.9	3.9	1.8	222.0	220.9	5907.7	5878.8	4.1	2.2	2.1	56.5	86.2
1.A.4 Other sectors - Liquid Fuels	CO_2	3774.7	1221.4	5.8	1.1	220.1	71.2	3994.8	1292.6	0.9	1.4	1.3	57.0	87.6
5.B Biological treatment	CH_4	0.0	649.7	91.3	0.6	0.0	593.1	0.0	1242.7	0.9	1.3	1.3	60.8	88.9

of solid waste														
1.A.4 Other sectors - Solid Fuels	CH_4	1331.9	317.6	50.2	0.5	668.1	159.3	1999.9	476.9	0.3	0.9	0.8	61.9	89.7
3.A Enteric Fermentation	CH_4	5600.6	2939.5	15.8	0.6	885.5	464.8	6486.2	3404.2	2.4	0.9	0.8	64.9	90.6
3.G Liming	CO_2	1187.6	159.0	30.4	0.5	361.2	48.4	1548.8	207.4	0.1	0.9	0.8	65.2	91.4
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.5	1007.5	40.3	0.7	319.5	406.1	1111.9	1413.6	1.0	0.7	0.7	67.8	92.1
2.B.2 Nitric Acid Production	N_2O	1050.3	134.3	15.5	0.1	163.0	20.9	1213.3	155.2	0.1	0.7	0.7	68.0	92.7
1.A.4 Other sectors - Biomass	CH_4	324.3	577.9	50.6	0.3	164.2	292.6	488.4	870.5	0.6	0.6	0.6	69.9	93.3
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.0	469.0	5.8	0.4	88.3	27.3	1602.3	496.4	0.3	0.6	0.6	70.1	93.9
5.D Wastewater treatment and discharge	CH_4	889.8	881.1	58.4	0.8	519.5	514.4	1409.3	1395.6	1.0	0.5	0.5	73.4	94.4
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.0	402.7	18.0	0.0	0.0	72.6	0.0	475.3	0.3	0.5	0.5	73.9	94.8
3.B Manure Management	CH_4	1695.7	733.6	22.4	0.3	379.2	164.0	2074.9	897.6	0.6	0.5	0.5	74.9	95.3
3.B Manure Management	N_2O	1619.9	828.7	40.3	1.5	653.0	334.1	2272.9	1162.7	0.8	0.3	0.3	77.1	95.6
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.0	286.0	5.8	0.0	0.0	16.7	0.0	302.7	0.2	0.3	0.3	77.2	96.0
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.0	251.4	28.3	0.2	6.8	71.1	30.8	322.5	0.2	0.3	0.3	77.7	96.3
1.A.3.b Transport - Road transportation	N_2O	100.0	183.2	133.8	0.2	133.7	245.1	233.7	428.2	0.3	0.3	0.3	79.3	96.5
2.A.4 Other process uses of carbonates	CO_2	113.9	298.7	11.2	0.3	12.7	33.4	126.6	332.1	0.2	0.3	0.3	79.5	96.8
2.B.10 Other chemical industry	CO_2	0.0	229.5	3.9	0.0	0.0	9.0	0.0	238.5	0.2	0.3	0.2	79.6	97.0
1.A.3.c Transport - Railways	CO_2	768.1	280.9	5.2	0.3	40.1	14.6	808.2	295.5	0.2	0.2	0.2	79.7	97.3
1.B.1.a Coal Mining and Handling	CO_2	456.2	122.5	25.3	0.2	115.5	31.0	571.8	153.5	0.1	0.2	0.2	79.9	97.5
2.A.2 Lime Production	CO_2	1336.6	673.5	2.8	0.6	37.8	19.1	1374.5	692.6	0.5	0.2	0.2	80.0	97.7
2.C.1 Iron and Steel	CO_2	9642.5	6453.1	12.2	8.7	1177.0	787.7	10819.6	7240.8	5.0	0.2	0.2	85.1	97.9

Production														
1.B.2.b Natural Gas	CH_4	1044.9	574.2	75.3	0.9	787.1	432.5	1832.0	1006.7	0.7	0.2	0.2	87.9	98.1
5.C Incineration and open burning of waste	CO_2	20.8	133.4	15.8	0.1	3.3	21.1	24.1	154.5	0.1	0.1	0.1	88.1	98.2
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.9	17.2	60.1	0.1	91.9	10.3	244.8	27.5	0.0	0.1	0.1	88.1	98.4
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	88.8	98.5
1.A.4 Other sectors - Biomass	N_2O	51.5	91.7	60.5	0.0	31.2	55.5	82.7	147.2	0.1	0.1	0.1	89.1	98.6
1.A.3.a Transport - Civil Aviation	CO_2	139.4	9.8	5.6	0.1	7.8	0.6	147.3	10.4	0.0	0.1	0.1	89.1	98.7
1.A.1 Energy industries - Solid Fuels	N_2O	239.9	207.9	60.1	0.0	144.2	125.0	384.1	333.0	0.2	0.1	0.1	89.9	98.8
3.H Urea application	CO_2	108.5	124.3	52.2	0.0	56.7	64.9	165.2	189.2	0.1	0.1	0.1	90.4	98.9
1.A.4 Other sectors - Solid Fuels	N_2O	103.3	19.5	60.1	0.0	62.1	11.7	165.4	31.2	0.0	0.1	0.1	90.4	98.9
5.D Wastewater treatment and discharge	N_2O	234.2	197.9	56.4	0.2	132.0	111.5	366.2	309.4	0.2	0.1	0.1	91.2	99.0
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.7	9.6	50.2	0.0	43.0	4.8	128.8	14.5	0.0	0.1	0.1	91.2	99.1
5.B Biological treatment of solid waste	N_2O	0.0	64.3	5.0	0.1	0.0	3.2	0.0	67.5	0.0	0.1	0.1	91.2	99.2
2.A.3 Glass Production	CO_2	142.8	155.0	5.4	0.1	7.7	8.3	150.4	163.4	0.1	0.1	0.1	91.3	99.2
2.D.1 Lubricant Use	CO_2	116.1	119.1	50.2	0.0	58.4	59.8	174.5	178.9	0.1	0.1	0.1	91.7	99.3
1.A.3.b Transport - Road transportation	CH_4	74.5	24.7	157.5	0.0	117.3	38.8	191.8	63.5	0.0	0.1	0.1	91.9	99.4
1.A.3.c Transport - Railways	N_2O	88.4	31.9	137.3	0.0	121.3	43.7	209.6	75.6	0.1	0.1	0.1	92.2	99.4
1.A.1 Energy industries - Biomass	N_2O	0.5	29.5	60.5	0.0	0.3	17.9	0.8	47.4	0.0	0.1	0.0	92.3	99.5
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.2	51.1	40.3	0.0	14.6	20.6	50.7	71.8	0.0	0.0	0.0	92.5	99.5
3.D.2 Agricultural Soils,	N_2O	1345.4	847.8	30.4	0.0	409.2	257.8	1754.6	1105.6	0.8	0.0	0.0	94.1	99.5

Indirect N_2O emissions														
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.0	24.9	41.9	0.0	0.0	10.4	0.0	35.3	0.0	0.0	0.0	94.2	99.6
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.6	32.3	60.5	0.0	10.1	19.6	26.7	51.9	0.0	0.0	0.0	94.3	99.6
1.A.3.e Transport - Other Transportation	CO_2	5.4	33.0	5.0	0.0	0.3	1.6	5.7	34.6	0.0	0.0	0.0	94.3	99.6
1.B.2.c Venting and Flaring	CH_4	12.3	27.0	50.5	0.0	6.2	13.6	18.5	40.7	0.0	0.0	0.0	94.4	99.7
1.A.1 Energy industries - Biomass	CH_4	0.3	18.6	50.6	0.0	0.2	9.4	0.5	28.0	0.0	0.0	0.0	94.5	99.7
1.A.3.d Transport - Domestic navigation	CO_2	53.5	12.7	5.2	0.0	2.8	0.7	56.3	13.4	0.0	0.0	0.0	94.5	99.7
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.4	20.5	50.6	0.0	5.3	10.4	15.7	30.8	0.0	0.0	0.0	94.6	99.8
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.0	13.2	41.9	0.0	0.0	5.5	0.0	18.7	0.0	0.0	0.0	94.6	99.8
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.0	17.1	7.1	0.0	0.0	1.2	0.0	18.3	0.0	0.0	0.0	94.6	99.8
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.1	66.5	43.6	0.0	36.6	29.0	120.7	95.4	0.1	0.0	0.0	94.8	99.8
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.6	17.1	50.1	0.0	4.8	8.6	14.4	25.7	0.0	0.0	0.0	94.9	99.8
1.B.2.a Oil	CH_4	22.7	6.6	75.3	0.0	17.1	5.0	39.8	11.6	0.0	0.0	0.0	94.9	99.8
2.C.5 Lead Production	CO_2	4.0	11.2	51.0	0.0	2.1	5.7	6.1	16.9	0.0	0.0	0.0	94.9	99.9
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	12.8	0.5	60.2	0.0	7.7	0.3	20.6	0.8	0.0	0.0	0.0	94.9	99.9
1.A.4 Other sectors - Liquid Fuels	N_2O	21.0	21.4	60.2	0.0	12.7	12.9	33.7	34.3	0.0	0.0	0.0	95.0	99.9
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4281.8	2800.2	20.6	3.8	882.7	577.3	5164.5	3377.5	2.3	0.0	0.0	98.8	99.9
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.0	7.0	60.8	0.0	0.0	4.3	0.0	11.3	0.0	0.0	0.0	98.8	99.9

1.A.5.b Other mobile - Liquid Fuels	N_2O	0.0	7.0	60.2	0.0	0.0	4.2	0.0	11.2	0.0	0.0	0.0	98.8	99.9
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.0	4.4	51.0	0.0	0.0	2.3	0.0	6.7	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	98.9	99.9
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.0	4.4	43.6	0.0	0.0	1.9	0.0	6.3	0.0	0.0	0.0	98.9	99.9
1.A.4 Other sectors - Liquid Fuels	CH_4	10.0	2.3	50.2	0.0	5.0	1.2	15.0	3.5	0.0	0.0	0.0	98.9	99.9
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.3	3.3	72.8	0.0	0.2	2.4	0.5	5.6	0.0	0.0	0.0	98.9	99.9
2.C.2 Ferroalloys Production	CH_4	0.2	4.3	25.5	0.0	0.0	1.1	0.2	5.4	0.0	0.0	0.0	98.9	99.9
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	5.4	0.2	50.2	0.0	2.7	0.1	8.1	0.3	0.0	0.0	0.0	98.9	100.0
1.A.1 Energy industries - Solid Fuels	CH_4	14.0	12.3	50.2	0.0	7.0	6.2	21.1	18.4	0.0	0.0	0.0	98.9	100.0
1.B.2.c Venting and Flaring	CO_2	2.0	4.4	50.5	0.0	1.0	2.2	3.0	6.7	0.0	0.0	0.0	99.0	100.0
5.C Incineration and open burning of waste	N_2O	0.4	2.7	72.8	0.0	0.3	2.0	0.7	4.6	0.0	0.0	0.0	99.0	100.0
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.3	4.1	60.1	0.0	1.4	2.5	3.7	6.5	0.0	0.0	0.0	99.0	100.0
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.0	3.4	15.3	0.0	0.0	0.5	0.0	4.0	0.0	0.0	0.0	99.0	100.0
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.2	2.1	53.9	0.0	0.1	1.1	0.3	3.2	0.0	0.0	0.0	99.0	100.0
1.A.1 Energy industries - Liquid Fuels	N_2O	3.3	0.4	60.2	0.0	2.0	0.2	5.3	0.6	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	N_2O	0.7	1.6	60.1	0.0	0.4	0.9	1.2	2.5	0.0	0.0	0.0	99.0	100.0

Fuels														
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.1	3.0	60.1	0.0	1.9	1.8	5.0	4.9	0.0	0.0	0.0	99.0	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	99.0	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	99.0	100.0
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.6	2.6	50.1	0.0	1.3	1.3	3.9	3.8	0.0	0.0	0.0	99.0	100.0
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.0	0.8	43.6	0.0	0.0	0.4	0.0	1.2	0.0	0.0	0.0	99.0	100.0
1.A.1 Energy industries - Liquid Fuels	CH_4	1.4	0.3	50.2	0.0	0.7	0.1	2.1	0.4	0.0	0.0	0.0	99.0	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	99.0	100.0
1.A.3.c Transport - Railways	CH_4	1.1	0.4	157.5	0.0	1.7	0.6	2.8	1.0	0.0	0.0	0.0	99.0	100.0
2.C.6 Zinc Production	CO_2	0.0	0.5	51.0	0.0	0.0	0.3	0.0	0.8	0.0	0.0	0.0	99.0	100.0
2.C.2 Ferroalloys Production	CO_2	0.0	0.6	25.5	0.0	0.0	0.2	0.0	0.8	0.0	0.0	0.0	99.0	100.0
2.D.2 Paraffin Wax Use	CO_2	9.4	6.5	50.2	0.0	4.7	3.3	14.2	9.7	0.0	0.0	0.0	99.1	100.0
1.A.3.d Transport - Domestic navigation	N_2O	0.4	0.1	137.3	0.0	0.6	0.1	1.0	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.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.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
2.C.1 Iron and Steel Production	CH_4	14.8	9.7	30.8	0.0	4.6	3.0	19.4	12.6	0.0	0.0	0.0	99.1	100.0
1.A.3.e Transport - Other Transporta	N_2O	0.0	0.0	60.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.1	100.0

tion														
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
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	1728.3	2.8	1.6	70.4	48.9	2559.6	1777.1	1.2	0.0	0.0	99.4	100.0
2.B.1 Ammonia Production	CO_2	990.8	743.7	8.6	0.7	85.2	64.0	1076.0	807.7	0.6	0.0	0.0	99.8	100.0
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.5	69.8	40.3	0.1	30.0	28.1	104.5	97.9	0.1	0.0	0.0	100.0	100.0
2.F.4 Aerosols (CO_2 eq.)	HFC	0.0	0.0	41.9	0.0	0.0	0.0	0.0	0.0	0.0	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 (2017) abs**	**Activity data uncertainty**	**Emission factor uncertainty**
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	47860.54	4.00	3.00
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	12.28	4.00	50.00
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	207.92	4.00	60.00
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	469.01	5.00	3.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.42	0.25	5.00	50.00
1.A.1 Energy industries - Liquid Fuels	N_2O	3.31	0.40	5.00	60.00
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	2906.43	3.00	2.50
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	1.31	3.00	50.00
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	1.56	3.00	60.00
1.A.1 Energy industries - Biomass	CH_4	0.30	18.59	8.00	50.00
1.A.1 Energy industries - Biomass	N_2O	0.48	29.53	8.00	60.00
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	251.36	20.00	20.00
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	2.06	20.00	50.00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	3.27	20.00	70.00
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	3995.73	4.00	3.00
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	9.64	4.00	50.00
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	17.16	4.00	60.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5502.33	269.49	5.00	3.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	5.38	0.22	5.00	50.00
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	12.84	0.48	5.00	60.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.63	5657.86	3.00	2.50
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.55	3.00	50.00
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	3.04	3.00	60.00
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	20.46	8.00	50.00
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	32.34	8.00	60.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.00	402.66	10.00	15.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.00	4.42	10.00	50.00
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.00	7.02	10.00	60.00
1.A.3.a Transport - Civil Aviation	CO_2	139.44	9.84	4.00	3.57
1.A.3.a Transport - Civil Aviation	CH_4	0.02	0.00	4.00	78.50
1.A.3.a Transport - Civil Aviation	N_2O	1.19	0.08	4.00	110.00
1.A.3.b Transport - Road transportation	CO_2	10251.93	18081.80	3.00	2.74
1.A.3.b Transport - Road transportation	CH_4	74.51	24.66	4.00	283.32
1.A.3.b Transport - Road transportation	N_2O	99.97	183.17	3.00	397.18
1.A.3.c Transport - Railways	CO_2	768.15	280.88	5.00	7.82
1.A.3.c Transport - Railways	CH_4	1.08	0.39	5.00	146.00
1.A.3.c Transport - Railways	N_2O	88.35	31.87	5.00	143.59
1.A.3.d Transport - Domestic navigation	CO_2	53.52	12.73	5.00	1.48
1.A.3.d Transport - Domestic navigation	CH_4	0.13	0.03	5.00	157.00

1.A.3.d Transport - Domestic navigation	N_2O	0.43	0.10	5.00	137.18
1.A.3.e Transport - Other Transportation	CO_2	5.42	32.97	4.00	3.00
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.01	4.00	50.00
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.02	4.00	60.00
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	4122.69	4.00	3.00
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	317.60	4.00	50.00
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	19.51	4.00	60.00
1.A.4 Other sectors - Liquid Fuels	CO_2	3774.74	1221.37	5.00	3.00
1.A.4 Other sectors - Liquid Fuels	CH_4	9.96	2.33	5.00	50.00
1.A.4 Other sectors - Liquid Fuels	N_2O	21.02	21.40	5.00	60.00
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.90	7594.25	3.00	2.50
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	17.12	3.00	50.00
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	4.08	3.00	60.00
1.A.4 Other sectors - Biomass	CH_4	324.26	577.91	8.00	50.00
1.A.4 Other sectors - Biomass	N_2O	51.50	91.71	8.00	60.00
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	286.01	5.00	3.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.00	0.54	5.00	50.00
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.00	7.00	5.00	60.00
1.B.1.a Coal Mining and Handling	CO_2	456.24	122.45	4.00	25.00
1.B.1.a Coal Mining and Handling	CH_4	10322.40	2896.07	4.00	13.00
1.B.1.b Solid Fuel Transformation	CH_4	0.75	4.50	40.00	50.00
1.B.2.a Oil	CO_2	0.02	0.04	7.00	75.00
1.B.2.a Oil	CH_4	22.69	6.63	7.00	75.00
1.B.2.b Natural Gas	CO_2	0.17	0.09	7.00	75.00
1.B.2.b Natural Gas	CH_4	1044.93	574.17	7.00	75.00
1.B.2.c Venting and Flaring	CO_2	2.02	4.44	7.00	50.00
1.B.2.c Venting and Flaring	CH_4	12.28	27.01	7.00	50.00
2.A.1 Cement Production	CO_2	2489.18	1728.27	2.00	2.00
2.A.2 Lime Production	CO_2	1336.65	673.53	2.00	2.00
2.A.3 Glass Production	CO_2	142.75	155.01	5.00	2.00
2.A.4 Other process uses of carbonates	CO_2	113.86	298.74	5.00	10.00
2.B.1 Ammonia Production	CO_2	990.80	743.75	5.00	7.00
2.B.2 Nitric Acid Production	N_2O	1050.29	134.32	4.00	15.00
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	69.76	5.00	40.00
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	1007.50	5.00	40.00
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	51.14	5.00	40.00
2.B.10 Other chemical industry	CO_2	0.00	229.49	3.00	2.50
2.C.1 Iron and Steel Production	CO_2	9642.54	6453.12	7.00	10.00
2.C.1 Iron and Steel Production	CH_4	14.84	9.65	7.00	30.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.63	5.00	25.00
2.C.2 Ferroalloys Production	CH_4	0.18	4.34	5.00	25.00
2.C.5 Lead Production	CO_2	4.04	11.18	10.00	50.00
2.C.6 Zinc Production	CO_2	0.00	0.53	10.00	50.00
2.D.1 Lubricant Use	CO_2	116.13	119.08	5.00	50.00
2.D.2 Paraffin Wax Use	CO_2	9.43	6.48	5.00	50.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	17.13	5.00	5.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.00	3.44	3.00	15.00
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	NF_3	0.00	0.00	3.00	15.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	HFC	0.00	3601.07	37.00	23.00
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.00	0.81	37.00	23.00
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.00	13.21	35.00	23.00
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.00	24.86	35.00	23.00
2.F.3 Fire Protection (CO_2 eq.)	PFC	0.00	0.03	35.00	23.00
2.F.4 Aerosols (CO_2 eq.)	HFC	0.00	0.00	35.00	23.00
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	1.63	35.00	23.00
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	66.48	37.00	23.00
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	4.39	37.00	23.00
2.G.3 N_2O from product uses	N_2O	206.22	223.50	37.00	23.00
3.A Enteric Fermentation	CH_4	5600.62	2939.47	5.00	15.00
3.B Manure Management	CH_4	1695.73	733.59	10.00	20.00
3.B Manure Management	N_2O	1619.88	828.68	5.00	40.00
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4281.81	2800.18	5.00	20.00
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1345.38	847.75	5.00	30.00
3.G Liming	CO_2	1187.63	159.04	5.00	30.00
3.H Urea application	CO_2	108.53	124.28	15.00	50.00
4.A.1 Forest Land remaining Forest Land	CO_2	-4281.55	-1010.83	20.00	235.59

4.A.1 Forest Land remaining Forest Land	CH_4	44.15	38.08	20.00	41.05
4.A.1 Forest Land remaining Forest Land	N_2O	29.11	25.11	20.00	41.05
4.A.2 Land converted to Forest Land	CO_2	-409.36	-671.34	0.00	25.72
4.B.1 Cropland remaining Cropland	CO_2	90.16	12.27	0.00	29.47
4.B.2 Land converted to Cropland	CO_2	87.19	19.00	0.00	36.66
4.B.2. Land converted to Cropland	N_2O	8.91	4.38	0.00	283.64
4.C.1 Grassland remaining Grassland	CO_2	48.18	-130.95	0.00	45.40
4.C.2 Land converted to Grassland	CO_2	-188.41	-247.84	0.00	31.28
4.D.2. Land converted to Wetlands	CO_2	21.73	20.89	0.00	69.28
4.E.2 Land converted to Settlements	CO_2	1034.95	583.80	0.00	102.32
4.G Harvested wood products	CO_2	-1712.98	-778.50	0.00	62.00
5.A Solid Waste Disposal on Land	CH_4	1979.27	3720.28	0.00	63.70
5.B Biological treatment of solid waste	CH_4	0.00	649.67	5.00	91.15
5.B Biological treatment of solid waste	N_2O	0.00	64.25	5.00	0.60
5.C Incineration and open burning of waste	CO_2	20.83	133.39	15.00	5.00
5.C Incineration and open burning of waste	CH_4	0.00	0.00	20.00	80.00
5.C Incineration and open burning of waste	N_2O	0.42	2.69	20.00	70.00
5.D Wastewater treatment and discharge	CH_4	889.80	881.13	30.14	50.00
5.D Wastewater treatment and discharge	N_2O	234.18	197.90	26.00	50.00

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	2393.03	1.9635
1.A.1 Energy industries - Solid Fuels	CH_4	50.16	6.16	0.0051
1.A.1 Energy industries - Solid Fuels	N_2O	60.13	125.03	0.1026
1.A.1 Energy industries - Liquid Fuels	CO_2	5.83	27.35	0.0224
1.A.1 Energy industries - Liquid Fuels	CH_4	50.25	0.13	0.0001
1.A.1 Energy industries - Liquid Fuels	N_2O	60.21	0.24	0.0002
1.A.1 Energy industries - Gaseous Fuels	CO_2	3.91	113.50	0.0931
1.A.1 Energy industries - Gaseous Fuels	CH_4	50.09	0.66	0.0005
1.A.1 Energy industries - Gaseous Fuels	N_2O	60.07	0.94	0.0008
1.A.1 Energy industries - Biomass	CH_4	50.64	9.41	0.0077
1.A.1 Energy industries - Biomass	N_2O	60.53	17.87	0.0147
1.A.1 Energy industries - Other Fossil Fuels	CO_2	28.28	71.10	0.0583
1.A.1 Energy industries - Other Fossil Fuels	CH_4	53.85	1.11	0.0009
1.A.1 Energy industries - Other Fossil Fuels	N_2O	72.80	2.38	0.0020
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	5.00	199.79	0.1639
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	50.16	4.83	0.0040
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	60.13	10.32	0.0085
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5.83	15.71	0.0129
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	50.25	0.11	0.0001
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	60.21	0.29	0.0002
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	3.91	220.95	0.1813
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	50.09	1.28	0.0010
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	60.07	1.83	0.0015
1.A.2 Manufacturing industries and construction - Biomass	CH_4	50.64	10.36	0.0085
1.A.2 Manufacturing industries and construction - Biomass	N_2O	60.53	19.58	0.0161
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	18.03	72.59	0.0596
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	50.99	2.25	0.0018
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	60.83	4.27	0.0035
1.A.3.a Transport - Civil Aviation	CO_2	5.36	0.53	0.0004
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	4.06	734.55	0.6027
1.A.3.b Transport - Road transportation	CH_4	283.35	69.87	0.0573
1.A.3.b Transport - Road transportation	N_2O	397.19	727.54	0.5969
1.A.3.c Transport - Railways	CO_2	9.28	26.07	0.0214
1.A.3.c Transport - Railways	CH_4	146.09	0.57	0.0005

1.A.3.c Transport - Railways	N_2O	143.68	45.79	0.0376
1.A.3.d Transport - Domestic navigation	CO_2	5.22	0.66	0.0005
1.A.3.d Transport - Domestic navigation	CH_4	157.08	0.05	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	1.65	0.0014
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	0.01	0.0000
1.A.4 Other sectors - Solid Fuels	CO_2	5.00	206.13	0.1691
1.A.4 Other sectors - Solid Fuels	CH_4	50.16	159.31	0.1307
1.A.4 Other sectors - Solid Fuels	N_2O	60.13	11.73	0.0096
1.A.4 Other sectors - Liquid Fuels	CO_2	5.83	71.22	0.0584
1.A.4 Other sectors - Liquid Fuels	CH_4	50.25	1.17	0.0010
1.A.4 Other sectors - Liquid Fuels	N_2O	60.21	12.89	0.0106
1.A.4 Other sectors - Gaseous Fuels	CO_2	3.91	296.56	0.2433
1.A.4 Other sectors - Gaseous Fuels	CH_4	50.09	8.57	0.0070
1.A.4 Other sectors - Gaseous Fuels	N_2O	60.07	2.45	0.0020
1.A.4 Other sectors - Biomass	CH_4	50.64	292.63	0.2401
1.A.4 Other sectors - Biomass	N_2O	60.53	55.52	0.0456
1.A.5.b Other mobile - Liquid Fuels	CO_2	5.83	16.68	0.0137
1.A.5.b Other mobile - Liquid Fuels	CH_4	50.25	0.27	0.0002
1.A.5.b Other mobile - Liquid Fuels	N_2O	60.21	4.21	0.0035
1.B.1.a Coal Mining and Handling	CO_2	25.32	31.00	0.0254
1.B.1.a Coal Mining and Handling	CH_4	13.60	393.91	0.3232
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	5.00	0.0041
1.B.2.b Natural Gas	CO_2	75.33	0.07	0.0001
1.B.2.b Natural Gas	CH_4	75.33	432.50	0.3549
1.B.2.c Venting and Flaring	CO_2	50.49	2.24	0.0018
1.B.2.c Venting and Flaring	CH_4	50.49	13.64	0.0112
2.A.1 Cement Production	CO_2	2.83	48.88	0.0401
2.A.2 Lime Production	CO_2	2.83	19.05	0.0156
2.A.3 Glass Production	CO_2	5.39	8.35	0.0068
2.A.4 Other process uses of carbonates	CO_2	11.18	33.40	0.0274
2.B.1 Ammonia Production	CO_2	8.60	63.98	0.0525
2.B.2 Nitric Acid Production	N_2O	15.52	20.85	0.0171
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	40.31	28.12	0.0231
2.B.8 Petrochemical and Carbon Black Production	CO_2	40.31	406.14	0.3332
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.31	20.61	0.0169
2.B.10 Other chemical industry	CO_2	3.91	8.96	0.0074
2.C.1 Iron and Steel Production	CO_2	12.21	787.70	0.6463
2.C.1 Iron and Steel Production	CH_4	30.81	2.97	0.0024
2.C.2 Ferroalloys Production	CO_2	25.50	0.16	0.0001
2.C.2 Ferroalloys Production	CH_4	25.50	1.11	0.0009
2.C.5 Lead Production	CO_2	50.99	5.70	0.0047
2.C.6 Zinc Production	CO_2	50.99	0.27	0.0002
2.D.1 Lubricant Use	CO_2	50.25	59.84	0.0491
2.D.2 Paraffin Wax Use	CO_2	50.25	3.26	0.0027
2.D.3 Other non-energy products from fuels and solvent use	CO_2	7.07	1.21	0.0010
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	15.30	0.53	0.0004
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	1568.84	1.2872
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	43.57	0.35	0.0003
2.F.2 Foam Blowing (CO_2 eq.)	HFC	41.88	5.53	0.0045
2.F.3 Fire Protection (CO_2 eq.)	HFC	41.88	10.41	0.0085
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	0.00	0.0000
2.F.5 Solvents (CO_2 eq.)	HFC	41.88	0.68	0.0006
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	43.57	28.96	0.0238
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	43.57	1.91	0.0016
2.G.3 N_2O from product uses	N_2O	43.57	97.37	0.0799
3.A Enteric Fermentation	CH_4	15.81	464.77	0.3813
3.B Manure Management	CH_4	22.36	164.03	0.1346
3.B Manure Management	N_2O	40.31	334.05	0.2741
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	20.62	577.27	0.4736
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	30.41	257.83	0.2115
3.G Liming	CO_2	30.41	48.37	0.0397
3.H Urea application	CO_2	52.20	64.88	0.0532
4.A.1 Forest Land remaining Forest Land	CO_2	236.44	-2389.96	-1.9609

4.A.1 Forest Land remaining Forest Land	CH_4	45.66	17.39	0.0143
4.A.1 Forest Land remaining Forest Land	N_2O	45.66	11.47	0.0094
4.A.2 Land converted to Forest Land	CO_2	25.72	-172.69	-0.1417
4.B.1 Cropland remaining Cropland	CO_2	29.4662	3.6164	0.0030
4.B.2 Land converted to Cropland	CO_2	36.66	6.97	0.01
4.B.2. Land converted to Cropland	N_2O	283.64	12.43	0.01
4.C.1 Grassland remaining Grassland	CO_2	45.40	-59.45	-0.05
4.C.2 Land converted to Grassland	CO_2	31.28	-77.53	-0.06
4.D.2. Land converted to Wetlands	CO_2	69.28	14.47	0.01
4.E.2 Land converted to Settlements	CO_2	102.32	597.36	0.49
4.G Harvested wood products	CO_2	62.00	-482.67	-0.40
5.A Solid Waste Disposal on Land	CH_4	63.70	2369.79	1.94
5.B Biological treatment of solid waste	CH_4	91.29	593.07	0.49
5.B Biological treatment of solid waste	N_2O	5.04	3.24	0.00
5.C Incineration and open burning of waste	CO_2	15.81	21.09	0.02
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	1.96	0.00
5.D Wastewater treatment and discharge	CH_4	58.38	514.44	0.42
5.D Wastewater treatment and discharge	N_2O	56.36	111.53	0.0915
		Level uncertainty =	**9734.97**	**4.03**

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	0.0702	0.2521	0.21	1.4262	1.4417
1.A.1 Energy industries - Solid Fuels	CH_4	0.0000	0.0001	0.00	0.0004	0.0009
1.A.1 Energy industries - Solid Fuels	N_2O	0.0003	0.0011	0.02	0.0062	0.0181
1.A.1 Energy industries - Liquid Fuels	CO_2	-0.0026	0.0025	-0.01	0.0175	0.0192
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	0.0005
1.A.1 Energy industries - Gaseous Fuels	CO_2	0.0108	0.0153	0.03	0.0650	0.0703
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.0000	0.0000	0.00	0.0000	0.0002
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.0000	0.0000	0.00	0.0000	0.0003
1.A.1 Energy industries - Biomass	CH_4	0.0001	0.0001	0.00	0.0011	0.0050
1.A.1 Energy industries - Biomass	N_2O	0.0002	0.0002	0.01	0.0018	0.0094
1.A.1 Energy industries - Other Fossil Fuels	CO_2	0.0012	0.0013	0.02	0.0375	0.0450
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	-0.0993	0.0210	-0.30	0.1191	0.3208
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	-0.0002	0.0001	-0.01	0.0003	0.0120
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	-0.0004	0.0001	-0.03	0.0005	0.0256
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	-0.0172	0.0014	-0.05	0.0100	0.0525
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0.0000	0.0000	0.00	0.0000	0.0009
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	0.0000	0.0000	0.00	0.0000	0.0025
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	0.0106	0.0298	0.03	0.1265	0.1292
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	0.0012	0.0038
1.A.2 Manufacturing industries and construction - Biomass	N_2O	0.0001	0.0002	0.01	0.0019	0.0071
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.0021	0.0021	0.03	0.0300	0.0437
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.0000	0.0000	0.00	0.0003	0.0012
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.0000	0.0000	0.00	0.0005	0.0023
1.A.3.a Transport - Civil Aviation	CO_2	-0.0004	0.0001	0.00	0.0003	0.0015
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	0.0605	0.0953	0.17	0.4041	0.4368
1.A.3.b Transport - Road transportation	CH_4	-0.0001	0.0001	-0.03	0.0007	0.0346
1.A.3.b Transport - Road transportation	N_2O	0.0006	0.0010	0.25	0.0041	0.2490
1.A.3.c Transport - Railways	CO_2	-0.0011	0.0015	-0.01	0.0105	0.0136
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	-0.02	0.0012	0.0188
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	0.0002	0.0002	0.00	0.0010	0.0011
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	-0.0594	0.0217	-0.18	0.1229	0.2164
1.A.4 Other sectors - Solid Fuels	CH_4	-0.0028	0.0017	-0.14	0.0095	0.1419
1.A.4 Other sectors - Solid Fuels	N_2O	-0.0002	0.0001	-0.01	0.0006	0.0148
1.A.4 Other sectors - Liquid Fuels	CO_2	-0.0063	0.0064	-0.02	0.0455	0.0493

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	0.0026
1.A.4 Other sectors - Gaseous Fuels	CO_2	0.0259	0.0400	0.06	0.1697	0.1816
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	0.0344	0.1033
1.A.4 Other sectors - Biomass	N_2O	0.0003	0.0005	0.02	0.0055	0.0193
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.0015	0.0015	0.00	0.0107	0.0116
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	-0.0009	0.0006	-0.02	0.0036	0.0227
1.B.1.a Coal Mining and Handling	CH_4	-0.0196	0.0153	-0.26	0.0863	0.2696
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	0.0000	0.0000	0.00	0.0003	0.0032
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	0.0299	0.0485
1.B.2.c Venting and Flaring	CO_2	0.0000	0.0000	0.00	0.0002	0.0009
1.B.2.c Venting and Flaring	CH_4	0.0001	0.0001	0.01	0.0014	0.0052
2.A.1 Cement Production	CO_2	0.0007	0.0091	0.00	0.0258	0.0258
2.A.2 Lime Production	CO_2	-0.0010	0.0035	0.00	0.0100	0.0102
2.A.3 Glass Production	CO_2	0.0003	0.0008	0.00	0.0058	0.0058
2.A.4 Other process uses of carbonates	CO_2	0.0012	0.0016	0.01	0.0111	0.0163
2.B.1 Ammonia Production	CO_2	0.0006	0.0039	0.00	0.0277	0.0280
2.B.2 Nitric Acid Production	N_2O	-0.0028	0.0007	-0.04	0.0040	0.0429
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	0.0001	0.0004	0.00	0.0026	0.0053
2.B.8 Petrochemical and Carbon Black Production	CO_2	0.0026	0.0053	0.11	0.0375	0.1116
2.B.8 Petrochemical and Carbon Black Production	CH_4	0.0001	0.0003	0.01	0.0019	0.0062
2.B.10 Other chemical industry	CO_2	0.0012	0.0012	0.00	0.0051	0.0060
2.C.1 Iron and Steel Production	CO_2	0.0014	0.0340	0.01	0.3365	0.3368
2.C.1 Iron and Steel Production	CH_4	0.0000	0.0001	0.00	0.0005	0.0005
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	0.0002	0.0006
2.C.5 Lead Production	CO_2	0.0000	0.0001	0.00	0.0008	0.0024
2.C.6 Zinc Production	CO_2	0.0000	0.0000	0.00	0.0000	0.0001
2.D.1 Lubricant Use	CO_2	0.0002	0.0006	0.01	0.0044	0.0125
2.D.2 Paraffin Wax Use	CO_2	0.0000	0.0000	0.00	0.0002	0.0003
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.0001	0.0001	0.00	0.0006	0.0008
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	0.0190	0.0190	0.44	0.9926	1.0843
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.0000	0.0000	0.00	0.0002	0.0002
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.0001	0.0001	0.00	0.0034	0.0038
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.0001	0.0001	0.00	0.0065	0.0071
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	0.0000	0.0000
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	0.0183	0.0184
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	0.0616	0.0626
3.A Enteric Fermentation	CH_4	-0.0035	0.0155	-0.05	0.1095	0.1212
3.B Manure Management	CH_4	-0.0019	0.0039	-0.04	0.0547	0.0662
3.B Manure Management	N_2O	-0.0011	0.0044	-0.04	0.0309	0.0542
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	0.0003	0.0148	0.01	0.1043	0.1044
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	-0.0001	0.0045	0.00	0.0316	0.0317
3.G Liming	CO_2	-0.0032	0.0008	-0.10	0.0059	0.0956
3.H Urea application	CO_2	0.0003	0.0007	0.01	0.0139	0.0200
4.A.1 Forest Land remaining Forest Land	CO_2	0.0092	-0.0053	2.16	-0.1506	2.1629
4.A.1 Forest Land remaining Forest Land	CH_4	0.0001	0.0002	0.00	0.0057	0.0061
4.A.1 Forest Land remaining Forest Land	N_2O	0.0000	0.0001	0.00	0.0037	0.0040
4.A.2 Land converted to Forest Land	CO_2	-0.0022	-0.0035	-0.06	0.0000	0.0554

4.B.1 Cropland remaining Cropland	CO_2	-0.0002	0.0001	-0.01	0.0000	0.0071
4.B.2 Land converted to Cropland	CO_2	-0.0002	0.0001	-0.01	0.00	0.01
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	-0.04	0.00	0.04
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	0.10	0.00	0.10
5.A Solid Waste Disposal on Land	CH_4	0.01	0.02	0.82	0.00	0.82
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	0.02
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	0.20	0.21
5.D Wastewater treatment and discharge	N_2O	0.00	0.00	0.01	0.04	0.04
					Trend uncertainty =	**3.09**

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 (2017) abs**	**Activity data uncertainty**	**Emission factor uncertainty**
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	47860.54	4	3
1.A.1 Energy industries - Solid Fuels	CH_4	14.03	12.28	4	50
1.A.1 Energy industries - Solid Fuels	N_2O	239.87	207.92	4	60
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	469.01	5	3
1.A.1 Energy industries - Liquid Fuels	CH_4	1.42	0.25	5	50
1.A.1 Energy industries - Liquid Fuels	N_2O	3.31	0.40	5	60
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	2906.43	3	3
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.61	1.31	3	50
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.73	1.56	3	60
1.A.1 Energy industries - Biomass	CH_4	0.30	18.59	8	50
1.A.1 Energy industries - Biomass	N_2O	0.48	29.53	8	60
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	251.36	20	20
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.20	2.06	20	50
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.31	3.27	20	70
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	35635.57	3995.73	4	3
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	85.75	9.64	4	50
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	152.87	17.16	4	60
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5502.33	269.49	5	3
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	5.38	0.22	5	50
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	12.84	0.48	5	60
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	5685.63	5657.86	3	3
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	2.61	2.55	3	50
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	3.11	3.04	3	60
1.A.2 Manufacturing industries and construction - Biomass	CH_4	10.45	20.46	8	50
1.A.2 Manufacturing industries and construction - Biomass	N_2O	16.60	32.34	8	60
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.00	402.66	10	15
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.00	4.42	10	50
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.00	7.02	10	60
1.A.3.a Transport - Civil Aviation	CO_2	139.44	9.84	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	0.08	4	110
1.A.3.b Transport - Road transportation	CO_2	10251.93	18081.80	3	3
1.A.3.b Transport - Road transportation	CH_4	74.51	24.66	4	283
1.A.3.b Transport - Road transportation	N_2O	99.97	183.17	3	397
1.A.3.c Transport - Railways	CO_2	768.15	280.88	5	8
1.A.3.c Transport - Railways	CH_4	1.08	0.39	5	146
1.A.3.c Transport - Railways	N_2O	88.35	31.87	5	144
1.A.3.d Transport - Domestic navigation	CO_2	53.52	12.73	5	1
1.A.3.d Transport - Domestic navigation	CH_4	0.13	0.03	5	157
1.A.3.d Transport - Domestic navigation	N_2O	0.43	0.10	5	137
1.A.3.e Transport - Other Transportation	CO_2	5.42	32.97	4	3
1.A.3.e Transport - Other Transportation	CH_4	0.00	0.01	4	50
1.A.3.e Transport - Other Transportation	N_2O	0.00	0.02	4	60
1.A.4 Other sectors - Solid Fuels	CO_2	24005.03	4122.69	4	3
1.A.4 Other sectors - Solid Fuels	CH_4	1331.86	317.60	4	50
1.A.4 Other sectors - Solid Fuels	N_2O	103.30	19.51	4	60
1.A.4 Other sectors - Liquid Fuels	CO_2	3774.74	1221.37	5	3
1.A.4 Other sectors - Liquid Fuels	CH_4	9.96	2.33	5	50
1.A.4 Other sectors - Liquid Fuels	N_2O	21.02	21.40	5	60
1.A.4 Other sectors - Gaseous Fuels	CO_2	4173.90	7594.25	3	3
1.A.4 Other sectors - Gaseous Fuels	CH_4	9.57	17.12	3	50
1.A.4 Other sectors - Gaseous Fuels	N_2O	2.28	4.08	3	60
1.A.4 Other sectors - Biomass	CH_4	324.26	577.91	8	50
1.A.4 Other sectors - Biomass	N_2O	51.50	91.71	8	60
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.00	286.01	5	3
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.00	0.54	5	50
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.00	7.00	5	60
1.B.1.a Coal Mining and Handling	CO_2	456.24	122.45	4	25
1.B.1.a Coal Mining and Handling	CH_4	10322.40	2896.07	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	6.63	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	574.17	7	75
1.B.2.c Venting and Flaring	CO_2	2.02	4.44	7	50
1.B.2.c Venting and Flaring	CH_4	12.28	27.01	7	50
2.A.1 Cement Production	CO_2	2489.18	1728.27	2	2
2.A.2 Lime Production	CO_2	1336.65	673.53	2	2
2.A.3 Glass Production	CO_2	142.75	155.01	5	2
2.A.4 Other process uses of carbonates	CO_2	113.86	298.74	5	10
2.B.1 Ammonia Production	CO_2	990.80	743.75	5	7
2.B.2 Nitric Acid Production	N_2O	1050.29	134.32	4	15
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	74.50	69.76	5	40
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	1007.50	5	40
2.B.8 Petrochemical and Carbon Black Production	CH_4	36.17	51.14	5	40
2.B.10 Other chemical industry	CO_2	0.00	229.49	3	3
2.C.1 Iron and Steel Production	CO_2	9642.54	6453.12	7	10
2.C.1 Iron and Steel Production	CH_4	14.84	9.65	7	30
2.C.2 Ferroalloys Production	CO_2	0.03	0.63	5	25
2.C.2 Ferroalloys Production	CH_4	0.18	4.34	5	25
2.C.5 Lead Production	CO_2	4.04	11.18	10	50
2.C.6 Zinc Production	CO_2	0.00	0.53	10	50
2.D.1 Lubricant Use	CO_2	116.13	119.08	5	50
2.D.2 Paraffin Wax Use	CO_2	9.43	6.48	5	50
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	17.13	5	5
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.00	3.44	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	3601.07	37	23
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.00	0.81	37	23
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.00	13.21	35	23
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.00	24.86	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	0.00	35	23
2.F.5 Solvents (CO_2 eq.)	HFC	0.00	1.63	35	23
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	84.10	66.48	37	23

2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	0.00	4.39	37	23
2.G.3 N_2O from product uses	N_2O	206.22	223.50	37	23
3.A Enteric Fermentation	CH_4	5600.62	2939.47	5	15
3.B Manure Management	CH_4	1695.73	733.59	10	20
3.B Manure Management	N_2O	1619.88	828.68	5	40
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	4281.81	2800.18	5	20
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	1345.38	847.75	5	30
3.G Liming	CO_2	1187.63	159.04	5	30
3.H Urea application	CO_2	108.53	124.28	15	50
5.A Solid Waste Disposal on Land	CH_4	1979.27	3720.28	0	64
5.B Biological treatment of solid waste	CH_4	0.00	649.67	5	91
5.B Biological treatment of solid waste	N_2O	0.00	64.25	5	1
5.C Incineration and open burning of waste	CO_2	20.83	133.39	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	2.69	20	70
5.D Wastewater treatment and discharge	CH_4	889.80	881.13	30	50
5.D Wastewater treatment and discharge	N_2O	234.18	197.90	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	2393.03	2.0969
1.A.1 Energy industries - Solid Fuels	CH_4	50.16	6.16	0.0054
1.A.1 Energy industries - Solid Fuels	N_2O	60.13	125.03	0.1096
1.A.1 Energy industries - Liquid Fuels	CO_2	5.83	27.35	0.0240
1.A.1 Energy industries - Liquid Fuels	CH_4	50.25	0.13	0.0001
1.A.1 Energy industries - Liquid Fuels	N_2O	60.21	0.24	0.0002
1.A.1 Energy industries - Gaseous Fuels	CO_2	3.91	113.50	0.0995
1.A.1 Energy industries - Gaseous Fuels	CH_4	50.09	0.66	0.0006
1.A.1 Energy industries - Gaseous Fuels	N_2O	60.07	0.94	0.0008
1.A.1 Energy industries - Biomass	CH_4	50.64	9.41	0.0082
1.A.1 Energy industries - Biomass	N_2O	60.53	17.87	0.0157
1.A.1 Energy industries - Other Fossil Fuels	CO_2	28.28	71.10	0.0623
1.A.1 Energy industries - Other Fossil Fuels	CH_4	53.85	1.11	0.0010
1.A.1 Energy industries - Other Fossil Fuels	N_2O	72.80	2.38	0.0021
1.A.2 Manufacturing industries and construction - Solid Fuels	CO_2	5.00	199.79	0.1751
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	50.16	4.83	0.0042
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	60.13	10.32	0.0090
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	5.83	15.71	0.0138
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	50.25	0.11	0.0001
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	60.21	0.29	0.0003
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	3.91	220.95	0.1936
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	50.09	1.28	0.0011
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	60.07	1.83	0.0016
1.A.2 Manufacturing industries and construction - Biomass	CH_4	50.64	10.36	0.0091
1.A.2 Manufacturing industries and construction - Biomass	N_2O	60.53	19.58	0.0172
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	18.03	72.59	0.0636
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	50.99	2.25	0.0020
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	60.83	4.27	0.0037
1.A.3.a Transport - Civil Aviation	CO_2	5.36	0.53	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	4.06	734.55	0.6437
1.A.3.b Transport - Road transportation	CH_4	283.35	69.87	0.0612
1.A.3.b Transport - Road transportation	N_2O	397.19	727.54	0.6375
1.A.3.c Transport - Railways	CO_2	9.28	26.07	0.0228
1.A.3.c Transport - Railways	CH_4	146.09	0.57	0.0005
1.A.3.c Transport - Railways	N_2O	143.68	45.79	0.0401
1.A.3.d Transport - Domestic navigation	CO_2	5.22	0.66	0.0006
1.A.3.d Transport - Domestic navigation	CH_4	157.08	0.05	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	1.65	0.0014
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	0.01	0.0000
1.A.4 Other sectors - Solid Fuels	CO_2	5.00	206.13	0.1806
1.A.4 Other sectors - Solid Fuels	CH_4	50.16	159.31	0.1396
1.A.4 Other sectors - Solid Fuels	N_2O	60.13	11.73	0.0103
1.A.4 Other sectors - Liquid Fuels	CO_2	5.83	71.22	0.0624
1.A.4 Other sectors - Liquid Fuels	CH_4	50.25	1.17	0.0010
1.A.4 Other sectors - Liquid Fuels	N_2O	60.21	12.89	0.0113
1.A.4 Other sectors - Gaseous Fuels	CO_2	3.91	296.56	0.2599
1.A.4 Other sectors - Gaseous Fuels	CH_4	50.09	8.57	0.0075
1.A.4 Other sectors - Gaseous Fuels	N_2O	60.07	2.45	0.0021
1.A.4 Other sectors - Biomass	CH_4	50.64	292.63	0.2564
1.A.4 Other sectors - Biomass	N_2O	60.53	55.52	0.0486
1.A.5.b Other mobile - Liquid Fuels	CO_2	5.83	16.68	0.0146
1.A.5.b Other mobile - Liquid Fuels	CH_4	50.25	0.27	0.0002
1.A.5.b Other mobile - Liquid Fuels	N_2O	60.21	4.21	0.0037
1.B.1.a Coal Mining and Handling	CO_2	25.32	31.00	0.0272
1.B.1.a Coal Mining and Handling	CH_4	13.60	393.91	0.3452
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	5.00	0.0044
1.B.2.b Natural Gas	CO_2	75.33	0.07	0.0001
1.B.2.b Natural Gas	CH_4	75.33	432.50	0.3790
1.B.2.c Venting and Flaring	CO_2	50.49	2.24	0.0020
1.B.2.c Venting and Flaring	CH_4	50.49	13.64	0.0120
2.A.1 Cement Production	CO_2	2.83	48.88	0.0428
2.A.2 Lime Production	CO_2	2.83	19.05	0.0167
2.A.3 Glass Production	CO_2	5.39	8.35	0.0073
2.A.4 Other process uses of carbonates	CO_2	11.18	33.40	0.0293
2.B.1 Ammonia Production	CO_2	8.60	63.98	0.0561
2.B.2 Nitric Acid Production	N_2O	15.52	20.85	0.0183
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	40.31	28.12	0.0246
2.B.8 Petrochemical and Carbon Black Production	CO_2	40.31	406.14	0.3559
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.31	20.61	0.0181
2.B.10 Other chemical industry	CO_2	3.91	8.96	0.0079
2.C.1 Iron and Steel Production	CO_2	12.21	787.70	0.6902
2.C.1 Iron and Steel Production	CH_4	30.81	2.97	0.0026
2.C.2 Ferroalloys Production	CO_2	25.50	0.16	0.0001
2.C.2 Ferroalloys Production	CH_4	25.50	1.11	0.0010
2.C.5 Lead Production	CO_2	50.99	5.70	0.0050
2.C.6 Zinc Production	CO_2	50.99	0.27	0.0002
2.D.1 Lubricant Use	CO_2	50.25	59.84	0.0524
2.D.2 Paraffin Wax Use	CO_2	50.25	3.26	0.0029
2.D.3 Other non-energy products from fuels and solvent use	CO_2	7.07	1.21	0.0011
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	15.30	0.53	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	1568.84	1.3747
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	43.57	0.35	0.0003
2.F.2 Foam Blowing (CO_2 eq.)	HFC	41.88	5.53	0.0048
2.F.3 Fire Protection (CO_2 eq.)	HFC	41.88	10.41	0.0091
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	0.00	0.0000
2.F.5 Solvents (CO_2 eq.)	HFC	41.88	0.68	0.0006
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	43.57	28.96	0.0254
2.G.2 SF_6 and PFC from other product use (CO_2 eq.)	SF_6	43.5660	1.9132	0.0017
2.G.3 N_2O from product uses	N_2O	43.5660	97.3701	0.0853
3.A Enteric Fermentation	CH_4	15.8114	464.7705	0.4073
3.B Manure Management	CH_4	22.3607	164.0347	0.1437
3.B Manure Management	N_2O	40.3113	334.0517	0.2927
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	20.6155	577.2726	0.5058
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	30.4138	257.8331	0.2259
3.G Liming	CO_2	30.4138	48.3691	0.0424
3.H Urea application	CO_2	52.2015	64.8783	0.0568
5.A Solid Waste Disposal on Land	CH_4	63.6993	2369.7921	2.0765
5.B Biological treatment of solid waste	CH_4	91.2874	593.0677	0.5197
5.B Biological treatment of solid waste	N_2O	5.0359	3.2358	0.0028
5.C Incineration and open burning of waste	CO_2	15.8114	21.0911	0.0185
5.C Incineration and open burning of waste	CH_4	82.4621	0.0010	0.0000
5.C Incineration and open burning of waste	N_2O	72.8011	1.9586	0.0017
5.D Wastewater treatment and discharge	CH_4	58.3835	514.4362	0.4508

5.D Wastewater treatment and discharge	N_2O	56.3560	111.5296	0.0977
				13.7770
		Level uncertainty =	**10067.4083**	**3.70**

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	0.0751	0.2690	0.2254	1.5216	1.5382
1.A.1 Energy industries - Solid Fuels	CH_4	0.0000	0.0001	0.0009	0.0004	0.0010
1.A.1 Energy industries - Solid Fuels	N_2O	0.0003	0.0012	0.0182	0.0066	0.0194
1.A.1 Energy industries - Liquid Fuels	CO_2	-0.0028	0.0026	-0.0085	0.0186	0.0205
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	0.0115	0.0163	0.0288	0.0693	0.0750
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	0.0052	0.0012	0.0053
1.A.1 Energy industries - Biomass	N_2O	0.0002	0.0002	0.0099	0.0019	0.0100
1.A.1 Energy industries - Other Fossil Fuels	CO_2	0.0013	0.0014	0.0265	0.0400	0.0480
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	-0.1058	0.0225	-0.3173	0.1270	0.3418
1.A.2 Manufacturing industries and construction - Solid Fuels	CH_4	-0.0003	0.0001	-0.0127	0.0003	0.0127
1.A.2 Manufacturing industries and construction - Solid Fuels	N_2O	-0.0005	0.0001	-0.0273	0.0005	0.0273
1.A.2 Manufacturing industries and construction - Liquid Fuels	CO_2	-0.0183	0.0015	-0.0549	0.0107	0.0560
1.A.2 Manufacturing industries and construction - Liquid Fuels	CH_4	0.0000	0.0000	-0.0009	0.0000	0.0009
1.A.2 Manufacturing industries and construction - Liquid Fuels	N_2O	0.0000	0.0000	-0.0026	0.0000	0.0026
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CO_2	0.0113	0.0318	0.0282	0.1349	0.1378
1.A.2 Manufacturing industries and construction - Gaseous Fuels	CH_4	0.0000	0.0000	0.0002	0.0001	0.0003
1.A.2 Manufacturing industries and construction - Gaseous Fuels	N_2O	0.0000	0.0000	0.0004	0.0001	0.0004
1.A.2 Manufacturing industries and construction - Biomass	CH_4	0.0001	0.0001	0.0039	0.0013	0.0041
1.A.2 Manufacturing industries and construction - Biomass	N_2O	0.0001	0.0002	0.0073	0.0021	0.0076
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CO_2	0.0023	0.0023	0.0339	0.0320	0.0467
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	CH_4	0.0000	0.0000	0.0012	0.0004	0.0013
1.A.2 Manufacturing industries and construction - Other Fossil Fuels	N_2O	0.0000	0.0000	0.0024	0.0006	0.0024
1.A.3.a Transport - Civil Aviation	CO_2	-0.0004	0.0001	-0.0016	0.0003	0.0016
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	0.0646	0.1016	0.1770	0.4311	0.4661
1.A.3.b Transport - Road transportation	CH_4	-0.0001	0.0001	-0.0368	0.0008	0.0368
1.A.3.b Transport - Road transportation	N_2O	0.0007	0.0010	0.2657	0.0044	0.2658
1.A.3.c Transport - Railways	CO_2	-0.0012	0.0016	-0.0093	0.0112	0.0145
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	-0.0200	0.0013	0.0200
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	0.0002	0.0002	0.0005	0.0010	0.0012
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	-0.0633	0.0232	-0.1898	0.1311	0.2307
1.A.4 Other sectors - Solid Fuels	CH_4	-0.0030	0.0018	-0.1508	0.0101	0.1511
1.A.4 Other sectors - Solid Fuels	N_2O	-0.0003	0.0001	-0.0158	0.0006	0.0158
1.A.4 Other sectors - Liquid Fuels	CO_2	-0.0067	0.0069	-0.0202	0.0485	0.0526
1.A.4 Other sectors - Liquid Fuels	CH_4	0.0000	0.0000	-0.0011	0.0001	0.0011
1.A.4 Other sectors - Liquid Fuels	N_2O	0.0000	0.0001	0.0027	0.0009	0.0028
1.A.4 Other sectors - Gaseous Fuels	CO_2	0.0276	0.0427	0.0691	0.1811	0.1938
1.A.4 Other sectors - Gaseous Fuels	CH_4	0.0001	0.0001	0.0031	0.0004	0.0031
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	0.0021	0.0032	0.1040	0.0367	0.1103
1.A.4 Other sectors - Biomass	N_2O	0.0003	0.0005	0.0198	0.0058	0.0206
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.0016	0.0016	0.0048	0.0114	0.0123
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.0000	0.0000	0.0002	0.0000	0.0002
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.0000	0.0000	0.0024	0.0003	0.0024
1.B.1.a Coal Mining and Handling	CO_2	-0.0010	0.0007	-0.0239	0.0039	0.0242
1.B.1.a Coal Mining and Handling	CH_4	-0.0209	0.0163	-0.2719	0.0921	0.2871
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	0.0000	0.0000	-0.0033	0.0004	0.0034
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	-0.0005	0.0032	-0.0405	0.0319	0.0516
1.B.2.c Venting and Flaring	CO_2	0.0000	0.0000	0.0009	0.0002	0.0009
1.B.2.c Venting and Flaring	CH_4	0.0001	0.0002	0.0054	0.0015	0.0056
2.A.1 Cement Production	CO_2	0.0007	0.0097	0.0015	0.0275	0.0275
2.A.2 Lime Production	CO_2	-0.0010	0.0038	-0.0021	0.0107	0.0109
2.A.3 Glass Production	CO_2	0.0004	0.0009	0.0007	0.0062	0.0062
2.A.4 Other process uses of carbonates	CO_2	0.0013	0.0017	0.0127	0.0119	0.0174
2.B.1 Ammonia Production	CO_2	0.0006	0.0042	0.0043	0.0296	0.0299
2.B.2 Nitric Acid Production	N_2O	-0.0030	0.0008	-0.0455	0.0043	0.0457
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	0.0001	0.0004	0.0049	0.0028	0.0057
2.B.8 Petrochemical and Carbon Black Production	CO_2	0.0028	0.0057	0.1122	0.0400	0.1192
2.B.8 Petrochemical and Carbon Black Production	CH_4	0.0002	0.0003	0.0063	0.0020	0.0066
2.B.10 Other chemical industry	CO_2	0.0013	0.0013	0.0032	0.0055	0.0064
2.C.1 Iron and Steel Production	CO_2	0.0015	0.0363	0.0151	0.3590	0.3593
2.C.1 Iron and Steel Production	CH_4	0.0000	0.0001	0.0000	0.0005	0.0005
2.C.2 Ferroalloys Production	CO_2	0.0000	0.0000	0.0001	0.0000	0.0001
2.C.2 Ferroalloys Production	CH_4	0.0000	0.0000	0.0006	0.0002	0.0006
2.C.5 Lead Production	CO_2	0.0000	0.0001	0.0024	0.0009	0.0026
2.C.6 Zinc Production	CO_2	0.0000	0.0000	0.0001	0.0000	0.0002
2.D.1 Lubricant Use	CO_2	0.0003	0.0007	0.0125	0.0047	0.0134
2.D.2 Paraffin Wax Use	CO_2	0.0000	0.0000	0.0001	0.0003	0.0003
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.0001	0.0001	0.0005	0.0007	0.0008
2.E.1 Integrated Circuit or Semiconductor (CO_2 eq.)	SF_6	0.0000	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	0.0202	0.0202	0.4655	1.0590	1.1568
2.F.1 Refrigeration and Air Conditioning Equipment (CO_2 eq.)	PFC	0.0000	0.0000	0.0001	0.0002	0.0003
2.F.2 Foam Blowing (CO_2 eq.)	HFC	0.0001	0.0001	0.0017	0.0037	0.0041
2.F.3 Fire Protection (CO_2 eq.)	HFC	0.0001	0.0001	0.0032	0.0069	0.0076
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	0.0000	0.0000	0.0000
2.F.5 Solvents (CO_2 eq.)	HFC	0.0000	0.0000	0.0002	0.0005	0.0005
2.G.1 Electrical Equipment (CO_2 eq.)	SF_6	0.0001	0.0004	0.0016	0.0196	0.0196
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	0.0118	0.0657	0.0668
3.A Enteric Fermentation	CH_4	-0.0037	0.0165	-0.0550	0.1168	0.1291
3.B Manure Management	CH_4	-0.0020	0.0041	-0.0398	0.0583	0.0706
3.B Manure Management	N_2O	-0.0012	0.0047	-0.0473	0.0329	0.0576
3.D.1 Agricultural Soils, Direct N_2O emissions	N_2O	0.0003	0.0157	0.0061	0.1113	0.1114
3.D.2 Agricultural Soils, Indirect N_2O emissions	N_2O	-0.0001	0.0048	-0.0026	0.0337	0.0338

3.G Liming	CO_2	-0.0034	0.0009	-0.1016	0.0063	0.1018
3.H Urea application	CO_2	0.0003	0.0007	0.0154	0.0148	0.0213
5.A Solid Waste Disposal on Land	CH_4	0.0138	0.0209	0.8773	0.0000	0.8773
5.B Biological treatment of solid waste	CH_4	0.0037	0.0037	0.3328	0.0258	0.3338
5.B Biological treatment of solid waste	N_2O	0.0004	0.0004	0.0002	0.0026	0.0026
5.C Incineration and open burning of waste	CO_2	0.0007	0.0007	0.0034	0.0159	0.0163
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	0.0010	0.0004	0.0010
5.D Wastewater treatment and discharge	CH_4	0.0017	0.0050	0.0872	0.2111	0.2284
5.D Wastewater treatment and discharge	N_2O	0.0003	0.0011	0.0134	0.0409	0.0430
					Trend uncertainty =	**2.34**

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

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

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:

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

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

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

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.

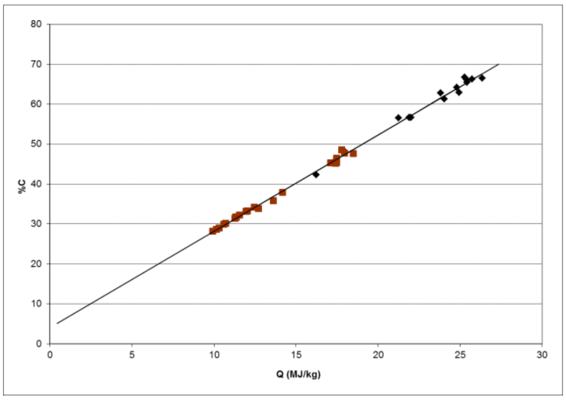


Fig. A3 1 Combined set of aggregated data “Comb”. Correlation between carbon content (%C) and net calorific value for lignite (brown coal) (indicated with brown squares) and bituminous coal (indicated with black squares)

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.

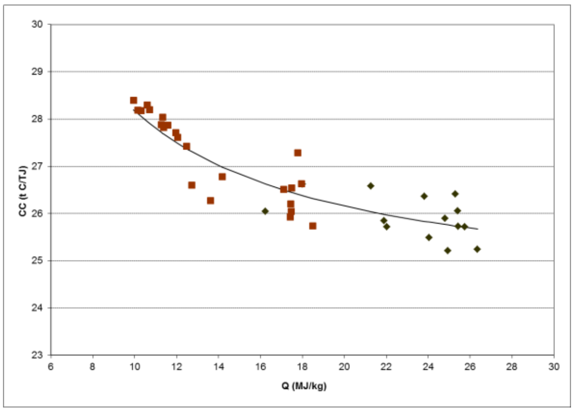


Fig. A3 2 Combined set of aggregated data "Comb". Correlation between the factor of carbon content CC and net calorific value for brown coal (indicated as brown squares) and black coal (indicated as black squares), found through the eq. A3-5.

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:

$$Qm = \sum wi \bullet Qmi \quad (A3\text{-}8)$$

$$Qv = Qm \bullet d \quad (A3\text{-}9)$$

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

$$CEFTJ = CEF_m/Q_m \quad (A3\text{-}10)$$

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

$$EF\ (CO_2) = CEFTJ \bullet M_{CO2}/M_C \quad (A3\text{-}11)$$

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

$$EF (CO_2) = 0.269 \bullet (Qv/3.6)^2 – 2.988 \bullet (Qv/3.6) + 59.212 \qquad (A3-12)$$

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.

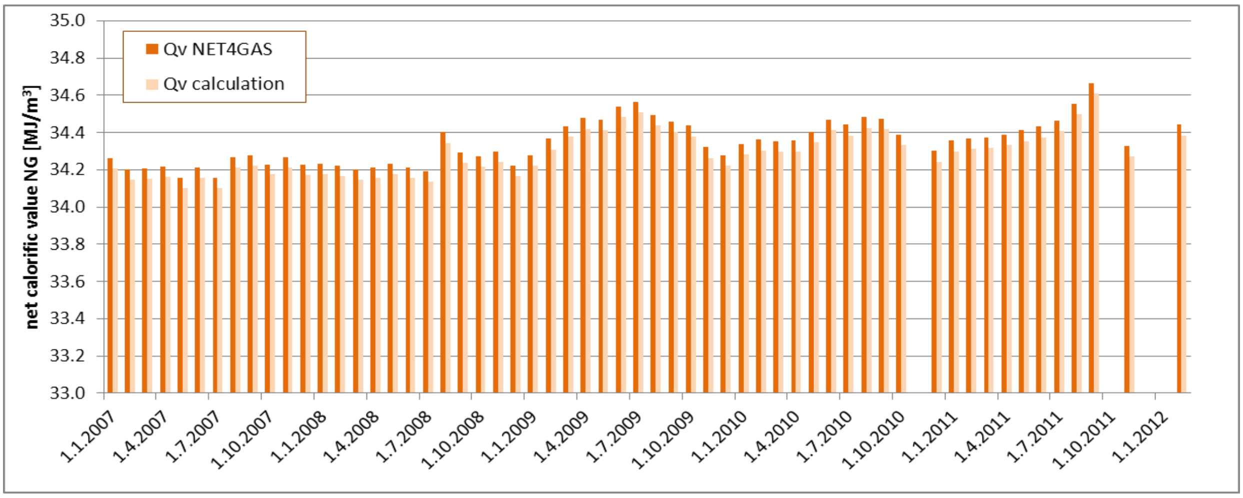


Fig. A3 3 Net calorific values given in NET4GAS Ltd. reports and net calorific values calculated on the basis of composition of Natural Gas in 1.1.2007 – 1.2.2012 (both values are given at 15°C)

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).

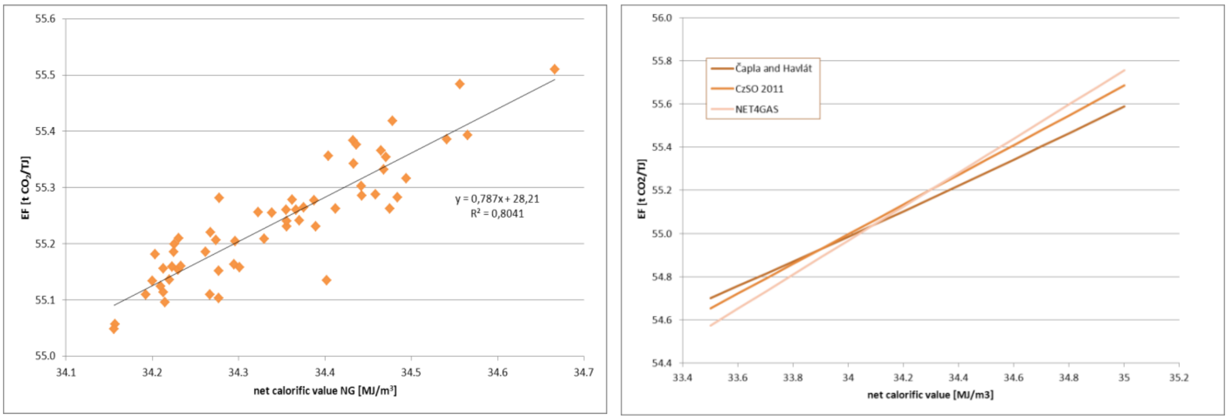


Fig. A3 4 Correlation of EF [t CO_2/TJ] and net calorific value of Natural Gas and Comparison of three approaches used for calculation

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.

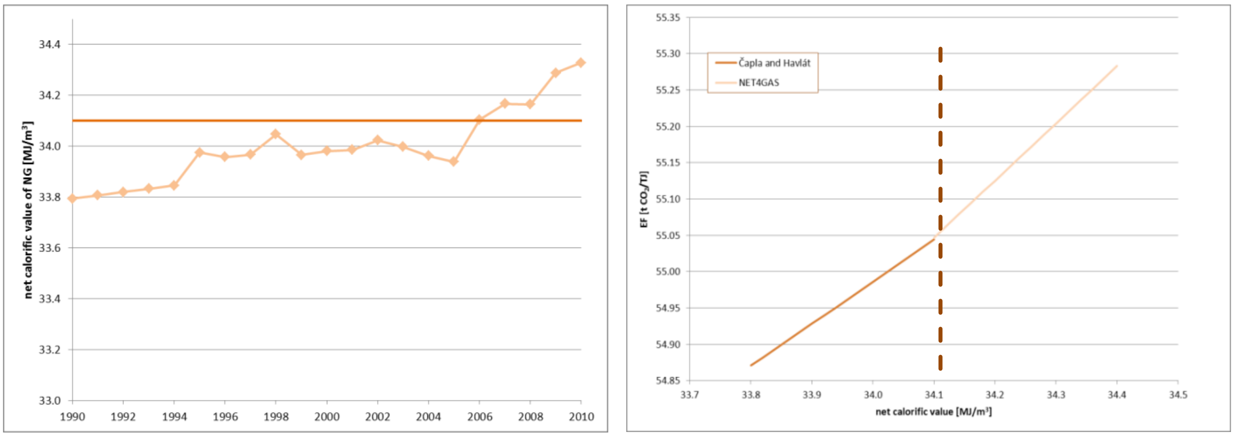


Fig. A3 5 Trend in Natural Gas NCV 1990 – 2010 and Correlation between NCV and EF combined from two approaches – Čapla and Havlát (NCV lower than 34.1 MJ/m^3) and computed correlation on the basis of NET4GAS dataset (NCV higher than 34.1 MJ/m^3)

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):

$$EF (CO_2) = 0.787 \bullet Qv + 28.21 \qquad (A3\text{-}15)$$

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.

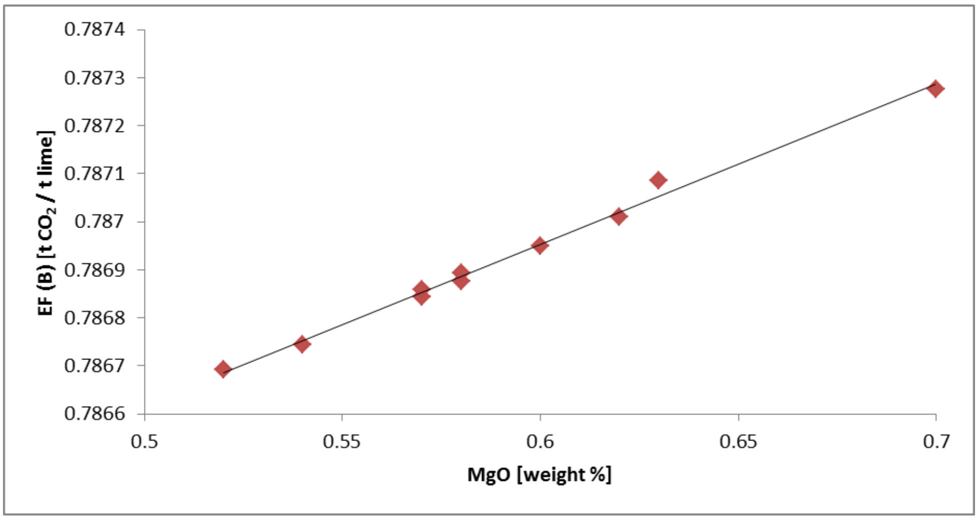


Fig. A3 6 Correlation between emission factor and mass representation of $MgCO_3$ in input material

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

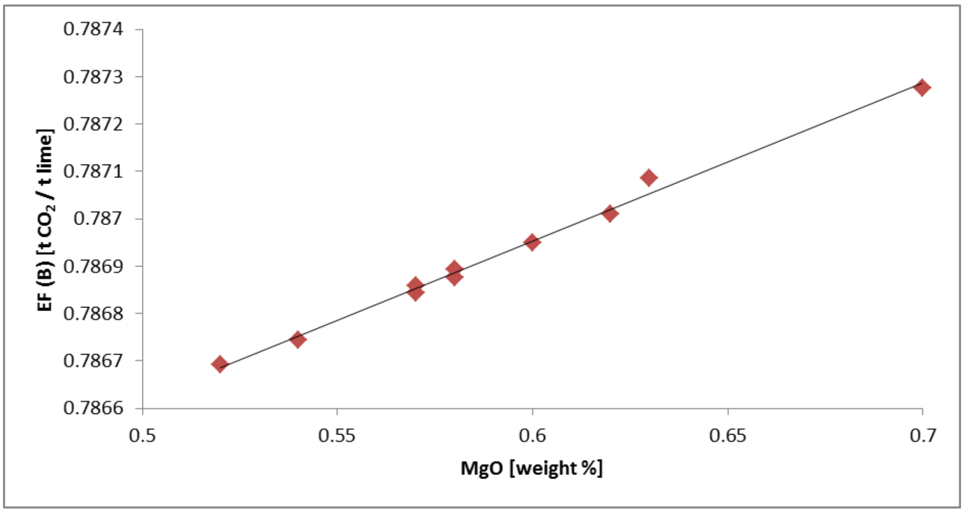


Fig. A3 7 Correlation of emission factor in mass representation of MgO in output material

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.

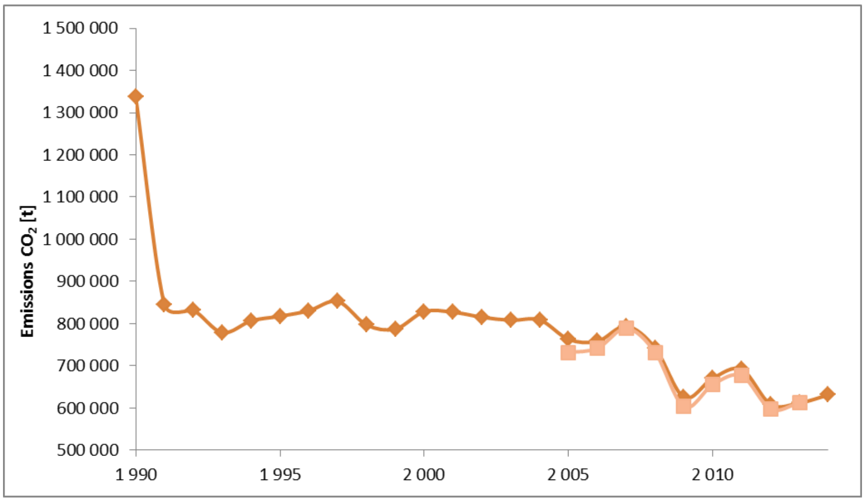


Fig. A3 8 Development of emissions of CO_2 from production of lime in CR for period 1990 – 2014

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.

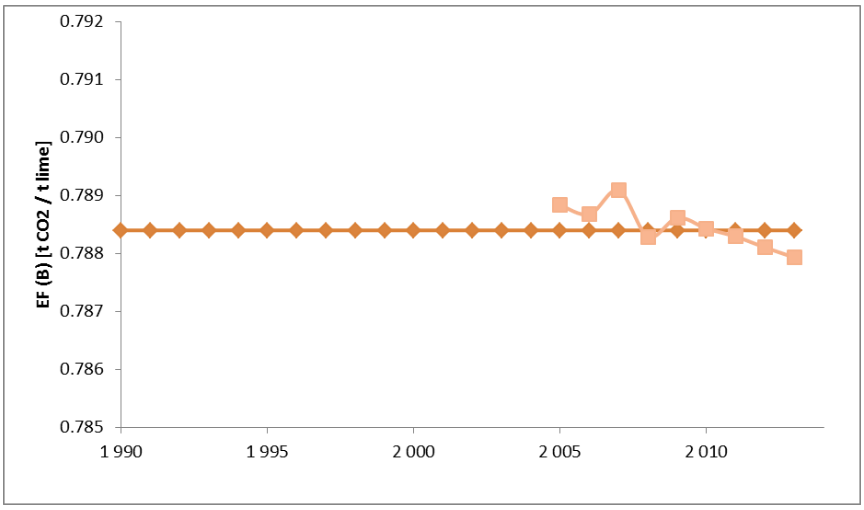


Fig. A3 9 Development of EF for production of lime in CR for period 1990 - 2014 (method B)

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 2017.

Tab. A4 - 1 Energy balance for solid fuels 2017

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	0	0	24 707	0	0
Total Imports (Balance)	0	0	105	0	2.917
Total Exports (Balance)	0	0	0	0	0
International Marine Bunkers	0	0	2 131	0	3.15
Stock Changes (National Territory)	0	0	28	0	0
Inland Consumption (Calculated)	0	0	0	0	0
Statistical Differences	3297.142	0	0	62	0
Transformation Sector	0	0	221	0	0
Main Activity Producer Electricity Plants	0	0	1 316	0	69.253
Main Activity Producer CHP Plants	0	0	0	1 605	0
Main Activity Producer Heat Plants	0	0	0	0	0
Autoproducer Electricity Plants	0	0	0	0	0
Autoproducer CHP Plants	0	0	807	0	0
Autoproducer Heat Plants	0	0	0	0	0
Patent Fuel Plants (Transformation)	0	0	807	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	0	0	0	0
Own Use in Electricity, CHP and Heat Plants	0	0	0	0	0
Coal Mines	0	0	28	0	0
Patent Fuel Plants (Energy)	0	0	2 653	472	398.687
Coke Ovens (Energy)	0	0	0	0	381.797
BKB Plants (Energy)	0	0	2 653	472	16.89
Gas Works (Energy)	0	0	1 065	437	16.89
Blast Furnaces (Energy)	0	0	17	374	0
Petroleum Refineries	0	0	804	0	3.537
Coal Liquefaction Plants (Energy)	0	0	0	5	0
Non-specified (Energy)	0	0	5	44	13.353
Distribution Losses	0	0	19	0	0
Total Final Consumption	0	0	13	7	0
Total Non-Energy Use	0	0	0	0	0
Final Energy Consumption	0	0	94	7	0
Industry Sector	0	0	93	0	0
Iron and Steel	0	0	3	0	0
Chemical (including Petrochemical)	0	0	3	0	0
Non-Ferrous Metals	0	0	7	0	0
Non-Metallic Minerals	0	0	7	0	0
Transport Equipment	0	0	1	0	0
Machinery	0	0	1 587	35	0
Mining and Quarrying	0	0	58	3	0
Food, Beverages and Tobacco	0	0	1 514	32	0
Paper, Pulp and Printing	0	0	16	0	0
Wood and Wood Products	0	0	0	0	0
Construction	0	0	0	0	0
Textiles and Leather	0	0	24 707	0	0
Non-specified (Industry)	0	0	105	0	2.917
Transport Sector	0	0	0	0	0
Other Sectors	0	0	2 131	0	3.15
Commercial and Public Services	0	0	28	0	0
Residential	0	0	0	0	0

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]
Agriculture/Forestry	3297.142	0	0	62	0
Fishing	0	0	221	0	0
Non-specified (Other)	0	0	1 316	0	69.253

Tab. A4 - 2 Energy balance for solid fuels 2017

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	128	15177	20320	18064	5442
Total Imports (Balance)	225	0	0	0	0
Total Exports (Balance)	105	0	0	0	0
International Marine Bunkers	0	0	0	0	0
Stock Changes (National Territory)	-2	0	0	0	0
Inland Consumption (Calculated)	246	15177	20320	18064	5442
Statistical Differences	30	15	29	177	45
Transformation Sector	0	14892	6613	6694	1127
Main Activity Producer Electricity Plants	0	0	0	0	0
Main Activity Producer CHP Plants	0	0	6613	6694	542
Main Activity Producer Heat Plants	0	0	0	0	0
Autoproducer Electricity Plants	0	0	0	0	0
Autoproducer CHP Plants	0	14892	0	0	584
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	270	7836	6111	1112
Own Use in Electricity, CHP and Heat Plants	0	0	0	1	1
Coal Mines	0	270	0	0	1111
Patent Fuel Plants (Energy)	0	0	0	0	0
Coke Ovens (Energy)	0	0	7829	2246	0
BKB Plants (Energy)	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	3865	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	441	596	79
Total Final Consumption	216	0	5401	4487	3080
Total Non-Energy Use	0	0	0		732
Final Energy Consumption	216	0	5401	4487	2348
Industry Sector	41	0	5401	4487	2348
Iron and Steel	0	0	5327	4487	1028
Chemical (including Petrochemical)	0	0	0	0	1273
Non-Ferrous Metals	0	0	0	0	0
Non-Metallic Minerals	38	0	74	0	47
Transport Equipment	0	0	0	0	0
Machinery	0	0	0	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	3	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	175	0	0	0	0
Commercial and Public Services	20	0	0	0	0
Residential	155	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 2017

LIQUID FUELS	Crude Oil [kt/year]	Refinery Feedstocks [kt/year]	Additives Oxygenates [kt/year]
Indigenous Production	108		105
From Other Sources			
From Other Sources - Solid fuels			
From Other Sources - Natural Gas			
From Other Sources - Renewables			411
Backflows		78	
Primary Product Receipts			
Refinery Gross Output			
Inputs of Recycled Products			
Refinery Fuel			
Total Imports (Balance)	7 814	21	13
Total Exports (Balance)	24		
International Marine Bunkers			
Interproduct Transfers			
Products Transferred		131	
Direct Use			393
Stock Changes (National Territory)	-34	5	3
Refinery Intake (Calculated)	7 864	235	139
Gross Inland Deliveries (Calculated)	7 216		
Statistical Differences	-13	0	1
Gross Inland Deliveries (Observed)	0		
Refinery Intake (Observed)	7 877	235	138

Tab. A4 - 4 Energy balance for liquid fuels 2017

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	145	358	840	1521	117	0
Refinery Fuel	127	0	0	0	0	0
Total Imports (Balance)	0	172	110	575	8	3
Total Exports (Balance)	0	90	21	590	34	0
International Marine Bunkers	0	0	0	0	0	0
Stock Changes (National Territory)	0	1	13	3	1	0
Gross Inland Deliveries (Calculated)	18	441	942	1509	92	3
Statistical Differences	0	0	0	0	0	0
Gross Inland Deliveries (Observed)	18	441	942	1509	92	3
Refinery Intake (Observed)	0	0	0	0	0	0
Non-energy use in Petrochemical industry	0	255	942	0	0	0

	Refinery Gas Energy Use	Refinery Gas Non Energy Use	LPG Energy Use	LPG Non Energy Use	Naphtha Energy Use	Naphtha Non Energy Use	Motor Gasoline Energy Use	Motor Gasoline Non Energy Use	Biogasoline Energy Use	Biogasoline Non Energy Use	Aviation Gasoline Energy Use	Aviation Gasoline Non Energy Use
Transformation Sector	18	0	10	0	0	0	0	0	0	0	0	0
Main Activity Producer Electricity Plants												
Autoproducer Electricity Plants												
Main Activity Producer CHP Plants	18		7									
Autoproducer CHP Plants												
Main Activity Producer Heat Plants												
Autoproducer Heat Plants			3									
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	173	258	0	942	1509	0	92	0	3	0
Transport Sector	0	0	96	0	0	0	1509	0	92	0	3	0
International Aviation												
Domestic Aviation											3	
Road			96				1509		92			
Rail												
Domestic Navigation												
Pipeline Transport												
Non-specified (Transport)												
Industry Sector	0	0	24	258	0	942	0	0	0	0	0	0
Iron and Steel												
Chemical (including Petrochemical)			7	258		942						
Non-Ferrous Metals												
Non-Metallic Minerals			2									
Transport Equipment			1									
Machinery			3									
Mining and Quarrying												
Food, Beverages and Tobacco			2									
Paper, Pulp and Printing												
Wood and Wood Products												
Construction			2									
Textiles and Leather			1									
Non-specified (Industry)			6									
Other Sectors	0	0	53	0	0	0	0	0	0	0	0	0
Commercial and Public Services			6									
Residential			43									
Agriculture/Forestry			4									
Fishing												
Non-specified (Other)												

Tab. A4 - 5 Energy balance for liquid fuels 2017

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	180		0		3273		0		130		169	
Refinery Fuel	0		0		0		0		0		0	
Total Imports (Balance)	207		2		2081		55		6		0	
Total Exports (Balance)	1		0		820		41		78		149	
International Marine Bunkers	0		0		0		0		0		0	
Stock Changes (National Territory)	10		0		45		-2		1		26	
Gross Inland Deliveries (Calculated)	396		2		4813		288		101		56	
Statistical Differences	-5		0		0		0		-2		0	
Gross Inland Deliveries (Observed)	391		2		4813		288		103		56	
Refinery Intake (Observed)	0		0		0		0		0		0	
Non-energy use in Petrochemical industry	0		0		0		0		2		0	
	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use
Transformation Sector	0	0	0	0	0	0	0	0	4	0	20	0
Main Activity Producer Electricity Plants											4	0
Autoproducer Electricity Plants									1		0	0
Main Activity Producer CHP Plants									1		11	0
Autoproducer CHP Plants									1		1	0
Main Activity Producer Heat Plants									1		3	0
Autoproducer Heat Plants											1	0
Gas Works (Transformation)											0	0
For Blended Natural Gas											0	0
Coke Ovens (Transformation)											0	0
Blast Furnaces (Transformation)											0	0
Petrochemical Industry											0	0
Patent Fuel Plants (Transformation)											0	0
Non-specified (Transformation)											0	0
Energy Sector	0	0	0	0	6	0	0	0	0	0	0	0
Coal Mines					6						0	0
Oil and Gas Extraction											0	0
Coke Ovens (Energy)											0	0
Blast Furnaces (Energy)											0	0
Gas Works (Energy)											0	0
Own Use in Electricity, CHP and Heat Plants											0	0
Non-specified (Energy)											0	0
Distribution Losses											0	0
Total Final Consumption	391	0	2	0	4807	0	288	0	97	2	36	6
Transport Sector	391	0	0	0	4425	0	288	0	87	0	0	0
International Aviation	343										0	0
Domestic Aviation	48										0	0
Road					4421		281				0	0
Rail							7		87		0	0
Domestic Navigation					4						0	0
Pipeline Transport											0	0
Non-specified (Transport)											0	0
Industry Sector	0	0	0	0	46	0	0	0	5	2	24	6
Iron and Steel											0	0
Chemical (including Petrochemical)										2	2	6
Non-Ferrous Metals											0	0
Non-Metallic Minerals											4	0
Transport Equipment									1		0	0
Machinery									1		1	0
Mining and Quarrying											2	0
Food, Beverages and Tobacco									1		2	0
Paper, Pulp and Printing											2	0
Wood and Wood Products									1		3	0
Construction					44				1		1	0
Textiles and Leather											0	0
Non-specified (Industry)					2						7	0
Other Sectors	0	0	2	0	336	0	0	0	5	0	12	0
Commercial and Public Services					9				2		9	0
Residential											0	0
Agriculture/Forestry					319				3		3	0
Fishing											0	0
Non-specified (Other)			2		8						0	0

Tab. A4 - 6 Energy balance for liquid fuels 2017

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		85		551		12		102		817	
Refinery Fuel	0		0		0		0		102		0	
Total Imports (Balance)	18		208		283		12		8		141	
Total Exports (Balance)	0		75		446		13		3		110	
International Marine Bunkers	0		0		0		0		0		0	
Stock Changes (National Territory)	1		-1		-1		0		0		-20	
Gross Inland Deliveries (Calculated)	19		202		387		11		5		724	
Statistical Differences	0		0		0		0		0		0	
Gross Inland Deliveries (Observed)	19		202		387		11		5		724	
Refinery Intake (Observed)	0		0		0		0		0		0	
Non-energy use in Petrochemical industry	0		0		0		0		0		489	
	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	78
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												78
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	19	0	202	1	386	0	11	0	5	30	616
Transport Sector	0	0	0	158	0	0	0	0	0	0	0	0
International Aviation												
Domestic Aviation												
Road				148								
Rail				10								
Domestic Navigation												
Pipeline Transport												
Non-specified (Transport)												
Industry Sector	0	19	0	44	0	386	0	11	0	5	30	616
Iron and Steel										1		
Chemical (including Petrochemical)		1									30	616
Non-Ferrous Metals										1		
Non-Metallic Minerals										1		
Transport Equipment												
Machinery										1		
Mining and Quarrying												
Food, Beverages and Tobacco												
Paper, Pulp and Printing												
Wood and Wood Products												
Construction						386						
Textiles and Leather												
Non-specified (Industry)		18		44				11		1		
Other Sectors	0	0	0	0	1	0	0	0	0	0	0	0
Commercial and Public Services												
Residential												
Agriculture/Forestry												
Fishing												
Non-specified (Other)					1							

Tab. A4 - 7 Energy balance for Natural Gas 2016 [TJ] in GCV

Indigenous Production	8768
Associated Gas	5092
Non-Associated Gas	0
Colliery Gas	3676
From Other Sources	0
Total Imports (Balance)	341211
Total Exports (Balance)	0
International Marine Bunkers	0
Stock Changes (National Territory)	-14989
Inland Consumption (Calculated)	334990
Statistical Differences	0
Inland Consumption (Observed)	334990
Recoverable Gas	0
Opening Stock Level (National Territory)	72046
Closing Stock Level (National Territory)	87035
Opening stock level (Held abroad)	11116
Closing stock level (Held abroad)	5125
Memo:	0
Gas Vented	0
Gas Flared	0
Memo: Cushion Gas	0
Cushion Gas Closing Stock Level	45173
Memo: From other sources	0
From Other Sources - Oil	0
From Other Sources - Coal	0
From Other Sources - Renewables	0

Transformation Sector	64937
Main Activity Producer Electricity Plants	12530
Autoproducer Electricity Plants	20
Main Activity Producer CHP Plants	21492
Autoproducer CHP Plants	2283
Main Activity Producer Heat Plants	19649
Autoproducer Heat Plants	8963
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	4413
Coal Mines	0
Oil and Gas Extraction	82
Petroleum Refineries	4331
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	4176
Transport Sector	3254
Road	2595
of which Biogas	0
Pipeline Transport	659
Non-specified (Transport)	0
Industry Sector	101831
Iron and Steel	11302
Chemical (including Petrochemical)	10715
Non-Ferrous Metals	2316
Non-Metallic Minerals	24977
Transport Equipment	7526
Machinery	11909
Mining and Quarrying	2309
Food, Beverages and Tobacco	14628
Paper, Pulp and Printing	4818
Wood and Wood Products	573
Construction	3809
Textiles and Leather	2494
Non-specified (Industry)	4455
Other Sectors	151792
Commercial and Public Services	53762
Residential	93248
Agriculture/Forestry	3039
Fishing	5
Non-specified (Other)	1738

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

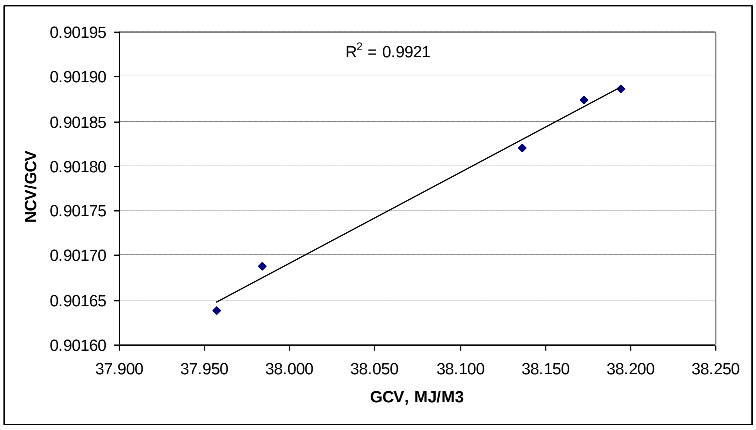


Fig. A5 1 Regression line corresponds with the data shown in Tab. A5-1.

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 - 2017. 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
Anthracite	NO	NO	NO	NO	NO	NO	NO
Bituminous Coal	19 559	19 372	21 420	21 633	21 704	21 888	22 025
Coking Coal	28 413	27 178	28 419	28 467	28 467	28 466	28 464
Lignite	12 083	12 068	12 050	12 082	12 213	12 494	12 610
Coke Oven Coke	27 167	27 177	27 426	27 375	27 215	27 216	27 218
Coal Tar	NE	NE	NE	NE	NE	NE	NE
BKB	22 868	23 058	21 854	22 922	23 136	22 941	22 918
Crude Oil	41 646	41 646	41 650	41 652	41 652	41 652	41 650
Refinery gas	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
Naphtha	43 300	43 300	43 300	43 300	43 300	43 352	43 416
Motor gasoline	43 340	43 332	43 342	43 340	43 308	43 320	43 320
Aviation gasoline	43 836	43 836	43 836	43 836	43 836	43 836	43 836
Biogasoline	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
Other kerosene	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
Heating and other gas oil	42 300	42 300	42 300	42 300	42 300	42 279	42 310
Biodiesel	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
Fuel Oil - high sulphur	40 700	40 700	40 700	40 700	40 700	40 863	40 804
Residential Fuel Oil	40 576	40 589	40 619	40 626	40 635	40 738	40 258
Petroleum coke	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

**) 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]	1997	1998	1999	2000	2001	2002	2003
Anthracite	NO	NO	NO	NO	NO	32 000	32 000
Bituminous Coal	22 332	23 812	24 065	21 719	22 210	23 121	23 432
Coking Coal	28 608	28 608	28 537	28 392	28 596	28 752	28 971
Lignite	12 115	12 115	12 824	12 484	12 444	12 442	12 420
Coke Oven Coke	28 225	28 230	28 688	28 013	28 502	28 542	28 562
Coal Tar	NE	NE	NE	NE	NE	36 979	36 979
BKB	22 924	24 080	24 620	24 912	24 243	23 803	25 505
Crude Oil	41 650	41 622	41 628	41 543	41 889	41 483	41 991
Refinery gas	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
Naphtha	43 391	43 709	43 686	43 669	42 837	42 858	42 940
Motor gasoline	43 300	43 300	43 300	43 300	43 300	43 300	43 300
Aviation gasoline	43 800	43 800	43 800	43 800	43 800	43 800	43 793
Biogasoline	27 000	27 000	27 000	27 000	27 000	27 000	27 000
Kerosene Jet Fuel	43 116	43 000	43 000	43 000	42 800	42 800	42 800
Other kerosene	42 800	42 800	42 800	42 800	42 800	42 800	42 800
Road diesel	42 552	42 555	42 686	42 691	41 920	41 940	41 929
Heating and other gas oil	42 300	42 300	42 412	42 461	41 764	41 748	41 711
Biodiesel	37 000	37 000	37 000	37 000	37 000	37 000	37 000
Fuel Oil - low sulphur	38 784	38 890	39 639	39 694	39 286	39 313	40 000
Fuel Oil - high sulphur	40 783	40 775	40 917	40 893	39 636	40 316	40 371
Residential Fuel Oil	40 595	40 538	40 544	40 659	39 511	39 670	40 182
Petroleum coke	37 500	37 500	37 500	37 500	37 500	37 500	37 500
Other products*)	39 392	38 387	39 290	39 398	40 754	40 711	40 660

**) 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]	2004	2005	2006	2007	2008	2009	2010
Anthracite	32 000	32 000	30 941	30 000	30 000	30 000	30 000
Bituminous Coal	23 294	22 332	22 388	23 445	23 413	22 659	23 578
Coking Coal	28 745	28 818	29 148	29 279	29 326	29 381	29 385
Lignite	12 607	12 687	12 797	12 455	12 616	12 482	12 649
Coke Oven Coke	28 024	27 870	28 622	28 312	28 344	28 590	27 888
Coal Tar	18 846	37 336	36 341	37 000	37 000	37 161	36 936
BKB	24 025	22 948	23 643	23 528	22 059	22 203	20 732
Crude Oil	41 980	41 980	41 986	42 259	42 357	42 353	42 400
Refinery gas	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
Naphtha	42 841	42 841	42 841	43 935	43 951	43 947	43 961
Motor gasoline	43 300	43 300	43 817	43 800	43 839	44 165	44 235
Aviation gasoline	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
Kerosene Jet Fuel	42 800	42 800	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
Road diesel	41 873	41 829	42 779	42 749	42 870	42 976	43 037
Heating and other gas oil	41 718	41 800	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
Fuel oil - low sulphur	39 584	39 538	39 599	41 484	39 718	39 700	39 696
Fuel oil - high sulphur	40 519	39 869	39 663	39 758	39 700	39 695	39 489
Residential Fuel Oil	39 997	39 686	39 628	40 594	39 710	39 698	39 603
Petroleum coke	37 500	37 500	37 500	37 500	37 500	37 500	37 500
Other products*)	40 820	40 894	39 300	39 300	40 000	40 074	39 821

**) 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 3d Net calorific values for fossil fuels

NCV [kJ/kg]	2011	2012	2013	2014	2015	2016	2017
Anthracite	29 809	28 170	28 944	28 756	28 476	27 976	28 393
Bituminous Coal	23 009	23 274	22 790	22 274	21 485	21 915	20 288
Coking Coal	29 207	29 373	29 244	29 468	29 536	29 509	29 580
Lignite	12 072	12 067	12 000	11 996	11 938	11 955	11 515
Coke Oven Coke	27 774	28 160	28 465	28 594	28 775	28 776	29 145
Coal Tar	36 995	38 000	37 750	36 738	36 801	35 124	36 474
BKB	19 500	19 500	19 500	19 500	19 793	20 005	20 008
Crude Oil	42 370	42 392	42 400	42 400	42 400	42 400	42 400
Refinery gas	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
Naphtha	43 971	43 993	43 600	43 600	43 600	43 600	43 600
Motor gasoline	44 308	44 302	44 315	44 433	44 487	44 203	44 400
Aviation gasoline	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
Kerosene Jet Fuel	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
Road diesel	42 985	42 958	42 962	42 991	42 943	42 957	42 940
Heating and other gas oil	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
Fuel oil - low sulphur	39 522	39 436	39 439	39 500	39 500	39 500	39 500
Fuel oil - high sulphur	39 427	39 581	39 500	39 500	39 500	39 500	39 500
Residential Fuel Oil	39 482	39 509	39 475	39 500	39 500	39 500	39 500
Petroleum coke	37 500	38 500	38 500	38 500	38 500	39 400	39 400
Other products*)	40 189	40 354	40 179	39 910	39 438	39 220	39 203

**) 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 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
NCV [MJ/m^3]	2017								
Natural Gas	34 547								

***) 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	2019
Reported year	2018
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	2019
Reported year	2018
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	2019
Reported year	2018
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												
1	CDM	NO	NO	NO	32 898	NO	NO	NO	NO	NO	NO	NO	NO
2	CH	NO	NO	NO	NO	NO	NO	NO	NO	NO	13 249	NO	NO
	Sub-total	NO	NO	NO	32 898	NO	NO	NO	NO	NO	13 249	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	32 898	NO	NO	NO	NO	NO	13 249	NO	NO

SEF Table 3

Party	Czech Republic
Submission year	2019
Reported year	2018
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	2019
Reported year	2018
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	19 649	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	19 649	NO	NO

SEF Table 5ABCDE

Party	Czech Republic
Submission year	2019
Reported year	2018
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	32 898	NO	NO	NO	NO	NO	13 249	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	32 898	NO	NO	NO	NO	NO	13 249	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	2019
Reported year	2018
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

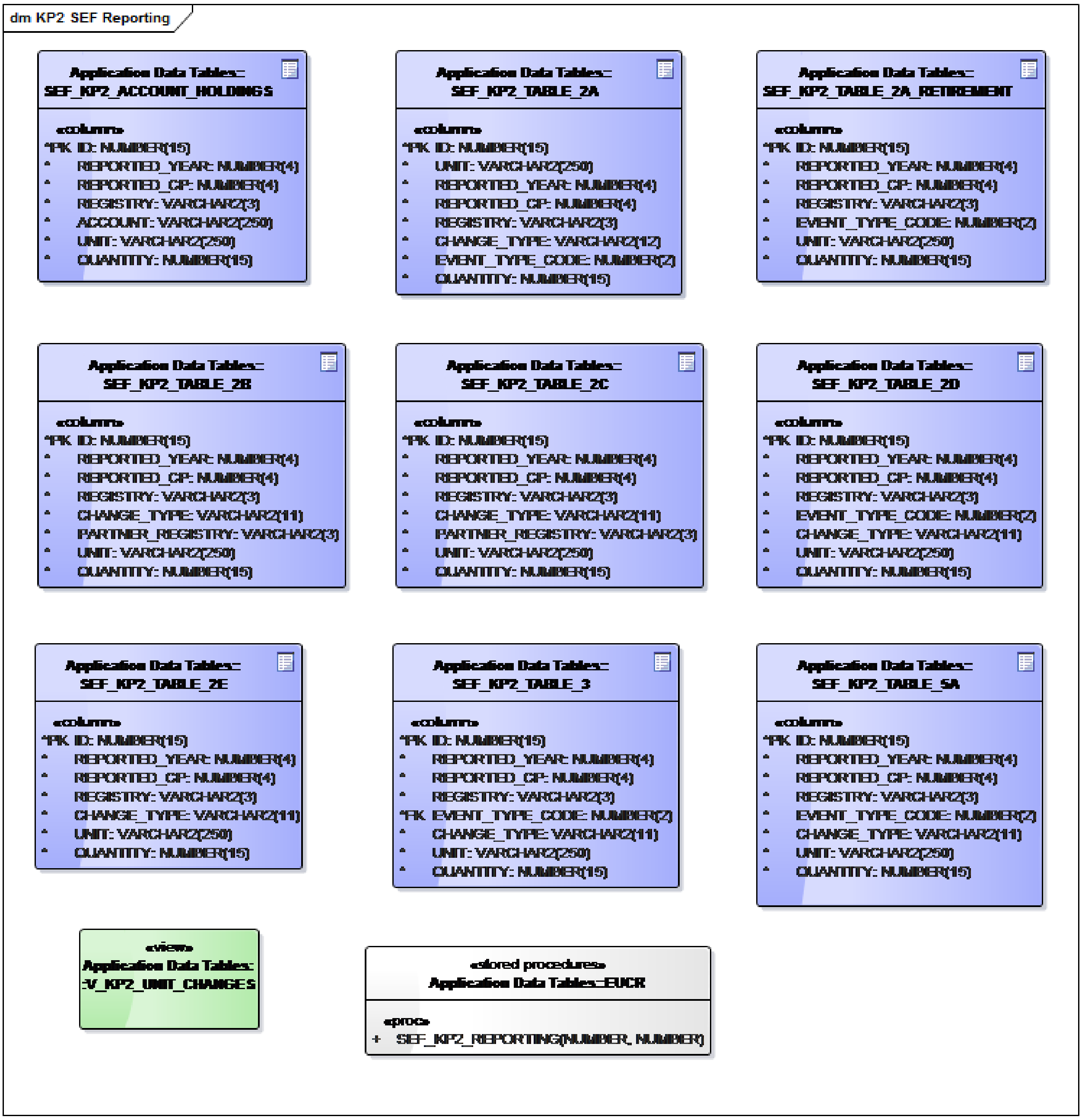
Table 6 (b). Memo item: Corrective transactions relating to replacement

	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



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