NATIONAL GREENHOUSE GAS INVENTORY DOCUMENT OF THE CZECH REPUBLIC

SUBMISSION UNDER UNFCCC AND PARIS AGREEMENT

REPORTED INVENTORIES 1990–2022

Prague

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Czech Hydrometeorological Institute

Ministry of the Environment of the Czech Republic

Elaborated by institutions involved in National Inventory System:

KONEKO, CDV, CHMI, IFER, CRI, GCRI, CENIA
with contribution of MoE and OTE

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Title: National Greenhouse Gas Inventory Report of the Czech Republic (reported inventories 1990- 2022)
Contact: Zuzana Roskova
Organization: Czech Hydrometeorological Institute
Address: Na Sabatce 17, Praha 4 – Komorany, 143 06 Czech Republic
E-mail: zuzana.roskova@chmi.cz
ISBN **978-80-7653-070-6**

Authors of individual chapters

Editors		Risto Saarikivi	(CHMI)
		Zuzana Roskova	(CHMI)
		Barbora Koci	(CHMI)
		Jitka Slamova	(CHMI)
Executive Summary		Zuzana Roskova	(CHMI)
		Risto Saarikivi	(CHMI)
Chapter 1	Introduction and General Issues	Zuzana Roskova	(CHMI)
		Risto Saarikivi	(CHMI)
Chapter 2	Trend in Total Emissions	Zuzana Roskova	(CHMI)
Chapter 3	Energy	Vladimir Neuzil	(KONEKO)
	(CRF sector 1)	Barbora Votavova	(KONEKO)
		Andrea Vesela	(KONEKO)
		Leos Pelikan	(CDV)
		Zuzana Kacmarova	(CDV)
Chapter 4	Industrial Processes and Product Use	Zuzana Roskova	(CHMI)
	(CRF sector 2)	Barbora Koci	(CHMI)
		Jitka Slamova	(CHMI)
Chapter 5	Agriculture	Jana Beranova	(IFER)
	(CRF sector 3)	Jan Klir	(CRI)
		Jana Wollnerova	(CRI)
Chapter 6	LULUCF	Emil Cienciala	(IFER)
	(CRF sector 4)	Radka Mašková	(IFER)
		Ondřej Černý	(IFER)
		Alexander Ač	(GCRI)
Chapter 7	Waste	Miroslav Havránek	(CENIA)
	(CRF sector 5)	Petr Bažil	(CENIA)
		Risto Saarikivi	(CHMI)
Chapter 9	Indirect CO_2 and Nitrous oxide emissions	Risto Saarikivi	(CHMI)
Chapter 10	Recalculations and Improvements	Zuzana Roskova	(CHMI)
		Risto Saarikivi	(CHMI)
Annexes		Zuzana Roskova	(CHMI)
		Jitka Slamova	(CHMI)
		Emil Cienciala	(IFER)
		Barbora Votavova	(KONEKO)
		Miroslav Havranek	(CENIA)

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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 Nařízení EU č. 2018/1999 a jeho prováděcích nažízeních (konkrétně Prováděcí nař. č.. 2020/1208). Tato verze národní inventarizační zprávy prezentuje úrovně emisí skleníkových plynů pro časovou řadu 1990 až 2022 s důrazem na poslední vykazovaný rok, tedy 2022. 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.

Tato inventarizační zpráva je první, která pro vykazování emisí v CO_2 ekvivalentu používá potenciály globálního ohřevu dle 5. Hodnotící zprávy IPCC (Fifth Assessment Report – IPCC) – největší změna je patrná pro emise CH_4 a N_2O přepočítané na CO_2 ekvivalent.

Obě části submise, kterými je Národní inventarizační zpráva společně s oficiálními tabulkami pro reporting (CRF – Common Reporting Format), jsou každoročně odesílány k 15. březnu Evropské Komisi a ke konci roku 2024 sekretariátu Rámcové Úmluvy OSN o změně klimatu což je zavedeno v rámci nových podmínek Pařížské dohody nově už ve formátu CRT (Common Reporting Tables) a NID (National Inventory Document).

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 2018/1999 and Commission Implementing Regulation 2020/1208.. This edition of National Inventory Report (NIR) deals with national greenhouse gas inventories for the period 1990 to 2022 with specific accent on the latest year 2021 while keeping track of already performed/planned changes according to the previous versions. By the term Submission 2024 (occurring in the following text) are meant emissions and removals of greenhouse gases for the time series 1990–2022 submitted in 2024.

Inventories of emissions and removals of greenhouse gases were prepared in accordance with the IPCC methodology: IPCC 2006 Guidelines. 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).

This submission is the first using the global warming potentials provided by the Fifth Assessment Report of IPCC. The most apparent is the change for CH_4 and N_2O while computation CO_2 ekvivalent.

Both parts of the submission, which is National Inventory Report and the data output - Common Reporting Format (CRF) Tables, are submitted annually by 15th March to European Commission. Since 2024 is the last submission postponed from 15th April to end of the year 2024 to UNFCCC by Paris Agreement. The format of reporting starting 15th September 2024 changes from CRF to CRT (Common Reporting Tables) and NID (National Inventory Document) instead of NIR.

ES 3 Summary of national emission and removal related trends

ES 3.1 GHG inventory

In 2022, the most important GHG in the Czech Republic was CO_2 contributing 81.7% to total national GHG emissions and removals expressed in CO_2 eq., followed by CH_4 10.9% and N_2O 4.3%. PFCs, HFCs, SF_6 and NF_3 contributed for 3% to the overall GHG emissions in the country.

Tab. ES 1 provides data on GHG emissions in comparison of overall trend from 1990 to 2022. For overview of GHG emissions and removals by categories please see chapter ES 3.

Tab. ES 1 GHG emission/removal overall trends

	Base year	2022	Base year	2022	Trend
	[kt CO_2 eq.]		%		
CO_2 emissions without net CO_2 from LULUCF	164 250.45	95 107.76	82.38	81.24	-42.10
CO_2 emissions with net CO_2 from LULUCF	155 375.92	98 451.81	81.54	81.73	-36.64
CH_4 emissions without CH_4 from LULUCF	26 813.44	13 059.82	13.45	11.15	-51.29
CH_4 emissions with CH_4 from LULUCF	26 832.80	13 080.32	14.08	10.86	-51.25
N_2O emissions without N_2O from LULUCF	8 235.99	5 183.35	4.13	4.43	-37.06
N_2O emissions with N_2O from LULUCF	8 255.83	5 196.86	4.33	4.31	-37.05
F-gases	86.83	3725.91	0.04	3.09	
Total (without LULUCF)	199 386.71	117 076.83			-41.28
Total (with LULUCF)	190 551.38	120 454.89			-36.79
Total (without LULUCF, with indirect)	201 338.92	117 703.95			-41.54
Total (with LULUCF, with indirect)	192 503.59	121 082.01			-37.10

Over the period 1990 - 2022 CO_2 emissions and removals decreased by 36.6%, CH_4 emissions decreased by 51.2% during the same period mainly due to lower emissions from 1 Energy and 3 Agriculture; N_2O emissions decreased by 37% over the same period due to emission reduction in 3 Agriculture. 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

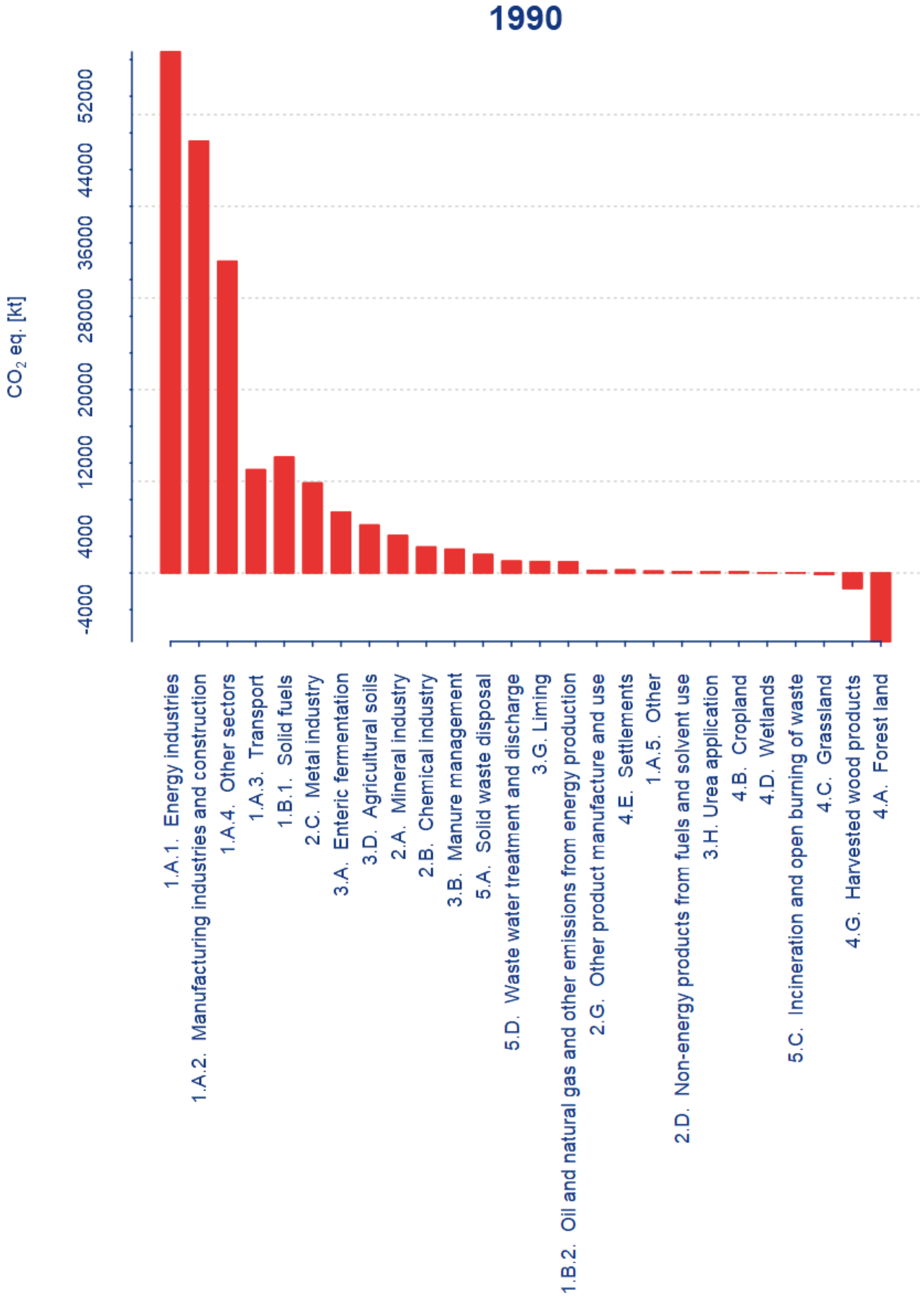

Fig. ES 1 Sources and sinks of greenhouse gases in 1990 (kt CO_2 eq.)

ES 4.1 GHG inventory

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

	Base year kt CO_2 eq.	2022 kt CO_2 eq.	2022 Total share [%]	2022 Sectoral share [%]	Trend %
1. Energy	163204.12	87907.24	72.98	100.00	-46.14
A. Fuel combustion (sectoral approach)	149368.82	85463.09	70.95	97.22	-42.78
1. Energy industries	56830.03	42769.93	35.51	48.65	-24.74
2. Manufacturing industries and construction	47105.11	11317.57	9.40	12.87	-75.97
3. Transport	11249.47	19390.69	16.10	22.06	72.37
4. Other sectors	33989.81	11715.76	9.73	13.33	-65.53
5. Other	194.42	269.14	0.22	0.31	38.43
B. Fugitive emissions from fuels	13835.30	2444.15	2.03	2.78	-82.33
1. Solid fuels	12637.63	1927.17	1.60	2.19	-84.75
2. Oil and natural gas and other emissions from energy production	1197.66	516.98	0.43	0.59	-56.83
C. CO_2 transport and storage	NO	NO	NA	NA	0.00
2. Industrial Processes	17115.22	15045.20	12.49	100.00	-12.09
A. Mineral industry	4082.45	3288.22	2.73	21.86	-19.45
B. Chemical industry	2825.39	2053.53	1.70	13.65	-27.32
C. Metal industry	9811.61	5658.30	4.70	37.61	-42.33
D. Non-energy products from fuels and solvent use	125.56	119.97	0.10	0.80	-4.46
E. Electronic industry	NO,NE	53.55	0.04	0.36	100.00
F. Product uses as ODS substitutes	NO	3609.06	3.00	23.99	100.00
G. Other product manufacture and use	270.21	261.86	0.22	1.74	-3.09
H. Other	NO	0.71	NA	NA	100.00
3. Agriculture	15747.95	8422.28	6.99	100.00	-46.52
A. Enteric fermentation	6611.86	3680.70	3.06	43.70	-44.33
B. Manure management	2571.36	762.11	0.63	9.05	-70.36
C. Rice cultivation	NO	NO	NA	NO	0.00
D. Agricultural soils	5219.49	3633.76	3.02	43.14	-30.38
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	1236.71	153.77	0.13	1.83	-87.57
H. Urea application	108.53	191.94	0.16	2.28	76.85
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	-8835.33	3378.06	2.80	100.00	-138.23
A. Forest land	-7471.53	5528.01	4.59	163.64	-173.99
B. Cropland	115.91	45.28	0.04	1.34	-60.94
C. Grassland	-143.86	-500.87	-0.42	-14.83	248.17
D. Wetlands	24.10	56.53	0.05	1.67	134.54
E. Settlements	318.74	194.87	0.16	5.77	-38.86
F. Other land	NO,NA	NO,NA	NA	NO	0.00
G. Harvested wood products	-1680.47	-1946.26	-1.62	-57.61	15.82
H. Other	NO	NO	NA	NA	0.00
5. Waste	3319.42	5702.11	4.73	100.00	71.78
A. Solid waste disposal	2007.82	3724.92	3.09	65.33	85.52
B. Biological treatment of solid waste	NE,IE	803.80	0.67	14.10	100.00
C. Incineration and open burning of waste	20.43	106.65	0.09	1.87	422.08
D. Waste water treatment and discharge	1291.18	1066.74	0.89	18.71	-17.38
E. Other	NO	NO	NA	NA	0.00
Total CO_2 equivalent emissions without land use, land-use change and forestry	199386.71	117076.83			-41.28
Total CO_2 equivalent emissions with land use, land-use change and forestry	190551.38	120454.89			-36.79
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	201338.92	117703.95			-41.54
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	192503.59	121082.01			-37.10

In 2022, 87 907.24 kt CO_2 eq., that are 72.98% of national total emissions (including 4 Land Use, Land-Use Change and Forestry) arose from 1 Energy; 97.22% of these emissions arise from fuel combustion activities. The most important sub-category of 1 Energy with 48.65% of total sectoral emissions in 2022 is 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction responses for 13.33% and 1.A.3 Transport for 22.06% of total sectoral emissions. From 1990 to 2022 emissions from 1 Energy decreased by 46.14%.

2 Industrial Processes is the second largest category with 12.49% of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2022 (15 045.2 kt CO_2 eq.); the largest sub-category is 2.C Metal Production with 37.61% of sectoral share. From 1990 to 2022 emissions from 2 Industrial Processes decreased by 12%.

3 Agriculture is the third largest category in the Czech Republic with 6.99% share of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2022 (8 422.28 kt CO_2 eq.); 43.14% of these emissions arose from 3.D Agricultural Soils. From 1990 to 2022 emissions from 3 Agriculture decreased by 46.52%.

4 Land Use, Land-Use Change and Forestry is contributing with 2.8% to the total GHG emissions (3 378.06 kt CO_2 eq.). Subcategory 4.A. Forest Land contributes to these emissions by more than 100%; the total emissions are lowered thanks to the removal in 4.G Harwested Wood Products and 4.C Grassland.

5 Waste contribution to the total GHG emissions is (including 4 Land Use, Land-Use Change and Forestry) 4.73% in 2022; 65.33% share of these emissions arose from 5.A Solid waste disposal. Emissions from 5 Waste increased from 1990 to 2022 by 71.78% to 5 702.11 kt CO_2 eq.

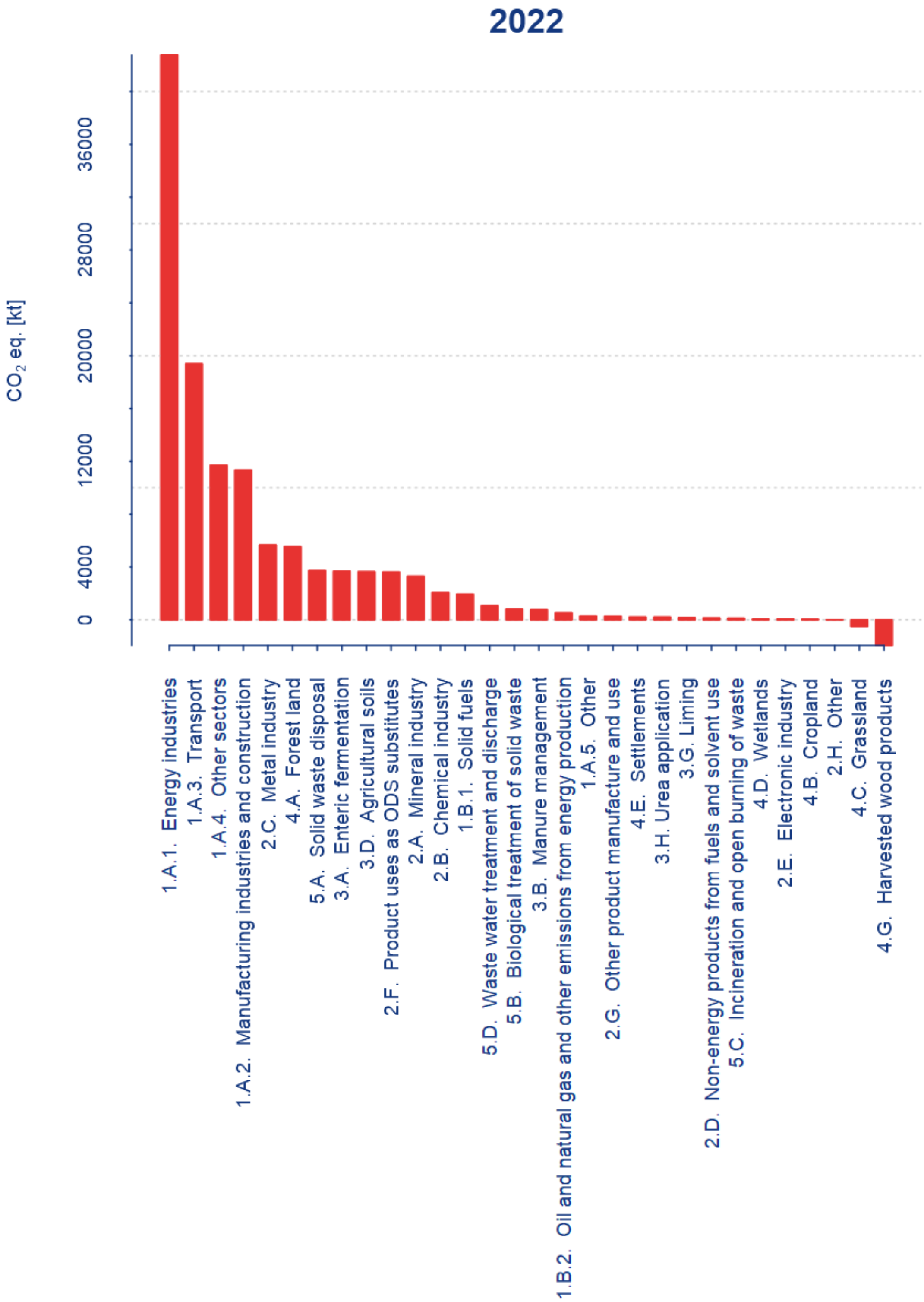

Fig. ES 2 Sources and sinks of greenhouse gases in 2022 (kt CO_2 eq.)

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 2022 are presented in Tab. ES 3.

Tab. ES 3 Indirect GHGs and SO_2 for 1990 to 2022 [kt]

	NO_X	CO	NMVOC	SO_X	NH_3
1990	762.65	2936.17	1753.81	1753.81	10.00
1991	723.26	2858.47	1649.74	1649.74	9.34
1992	679.16	2847.24	1381.96	1381.96	8.76
1993	553.05	2609.87	1302.42	1302.42	8.37
1994	458.26	1640.10	1158.97	1158.97	10.56
1995	392.13	2306.71	1058.82	1058.82	5.34
1996	374.58	2453.24	914.32	914.32	3.75
1997	346.72	2263.33	694.36	694.36	3.96
1998	330.10	1801.25	425.31	425.31	3.64
1999	305.41	1557.06	231.87	231.87	3.49
2000	314.05	1526.77	233.69	233.69	3.20
2001	311.36	1495.11	228.68	228.68	3.05
2002	304.97	1419.47	223.37	223.37	2.98
2003	309.49	1444.75	218.36	218.36	3.01
2004	310.52	1411.24	215.08	215.08	2.77
2005	308.20	1261.95	208.47	208.47	3.25
2006	299.26	1269.07	206.76	206.76	3.15
2007	298.28	1256.43	212.07	212.07	3.21
2008	280.74	1183.24	170.10	170.10	3.25
2009	264.18	1213.36	168.77	168.77	3.19
2010	260.29	1273.92	163.88	163.88	3.13
2011	247.61	1255.04	167.51	167.51	3.22
2012	235.63	1230.09	160.20	160.20	3.32
2013	222.69	1256.88	145.25	145.25	3.33
2014	218.42	1188.17	134.49	134.49	3.21
2015	211.71	1192.56	129.86	129.86	3.18
2016	202.98	1177.53	115.63	115.63	3.34
2017	197.74	1166.22	109.73	109.73	3.25
2018	189.71	1140.15	96.58	96.58	3.37
2019	176.84	1076.80	79.09	79.09	3.22
2020	162.25	1086.68	67.15	67.15	3.15
2021	166.17	1124.25	61.55	61.55	3.25
2022	159.28	1051.25	64.65	64.65	3.07
Trend %	**-79.11**	**-64.20**	**-65.78**	**-96.31**	**-69.34**
NEC	**286**	**-**	**220**	**265**	**101**

Emissions of indirect greenhouse gases decreased from the period from 1990 to 2022: for NO_X by 79.1%, for CO by 64.2%, for NMVOC by 65.78% and for SO_2 by 96.3%. The most important emission source for indirect greenhouse gases and SO_2 are fuel combustion activities, for details see chapter 9 in Part 1: Annual inventory report.

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 was 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.

Further, in 2015 the Paris Agreement was negotiated by the UNFCCC Parties. The Paris Agreement is a legally binding international treaty on climate change. Our reporting follows the requirements of the Paris Agreement and specifically negotiated modalities, procedures and guidelines (nefotiated in Katowice, 2018.

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) 2018/1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council.

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 super vision 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.

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 (2024) for the EU contains all the data sets for 1990 - 2022 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 GWPs.

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. Zuzana Roskova 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
- Crop Research Institute (CRI), Prague, is co-responsible for compilation of the inventory in sector 3. Agriculture (IFER has the main responsibility)
- Global Change Research Institute of the Czech Academy of Sciences (GCRI), Brno, is co-responsible for compilation of the inventory in sector 4. Land Use, Land Use Change and Forestry (IFER has the main responsibility)
- Czech Environmental Information Agency (CENIA), 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. In 2019 the national inventory system was enhanced by increased fundign and inclusion of another two organisations, which are newly officially part of the NIS and are supporting the inventory in sectors 3. Agriculture (CRI) and 4. LULUCF (GCRI).

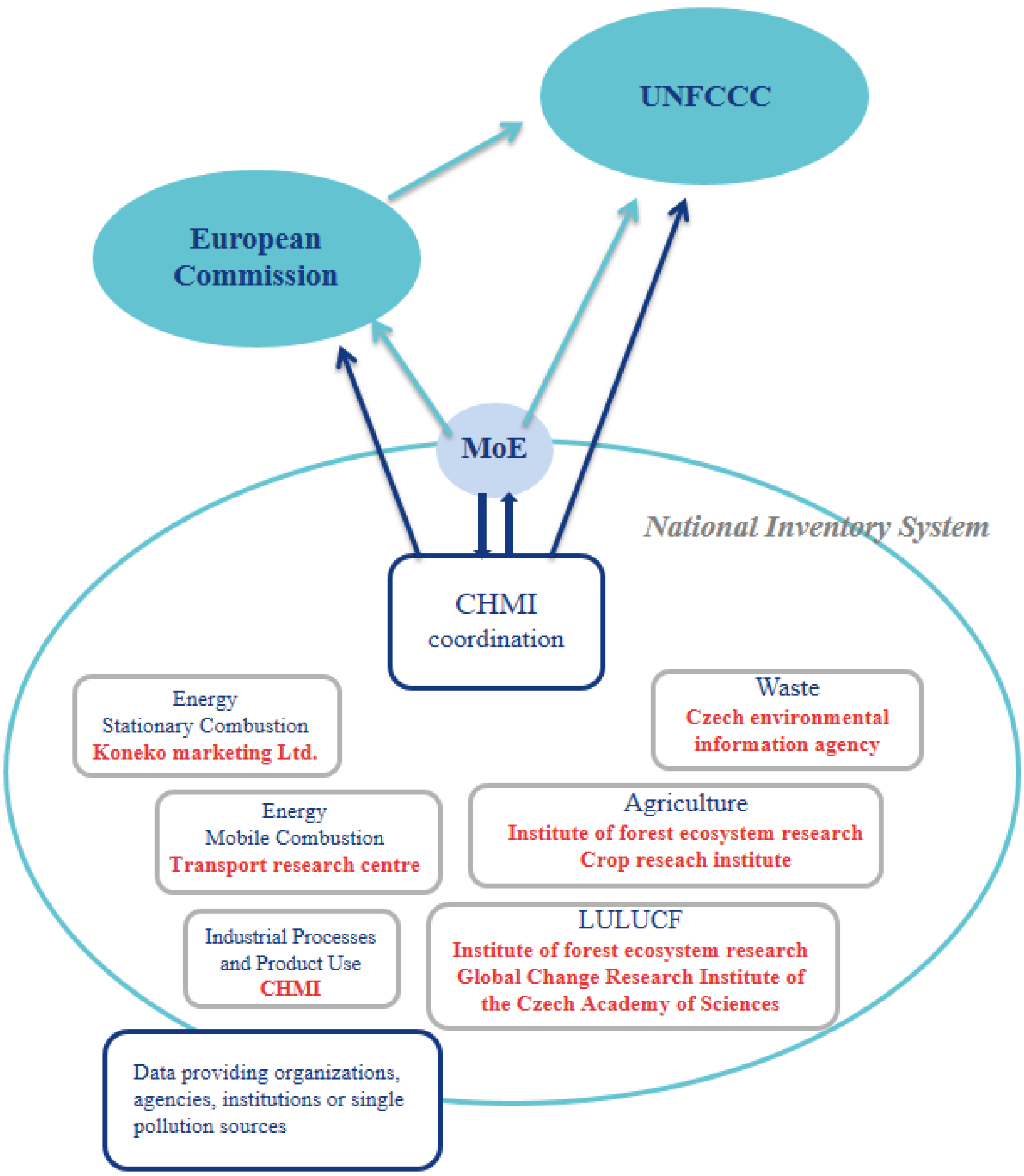

Fig. 1-1 Institutional arrangements of National Inventory System in the Czech Republic

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 2024 submission contains estimates for the calendar year of 2022. 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, Paris Agreement, IPCC guidelines and EU reporting requirements (Regulation Eu 2018/1999). 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.

Annuall 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. In 2019 the meeting was organised in Poland and was focusing mainly on uncertainty issues and LULUCF. Due to the COVID pandemic, no meeting like this was organised in 2020. In 2022 the meeting was organised in online mode only with Slovak National Inventory team. In 2023 we have had bilateral meeting with Slovakian National inventory team 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. Zuzana Rošková	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.

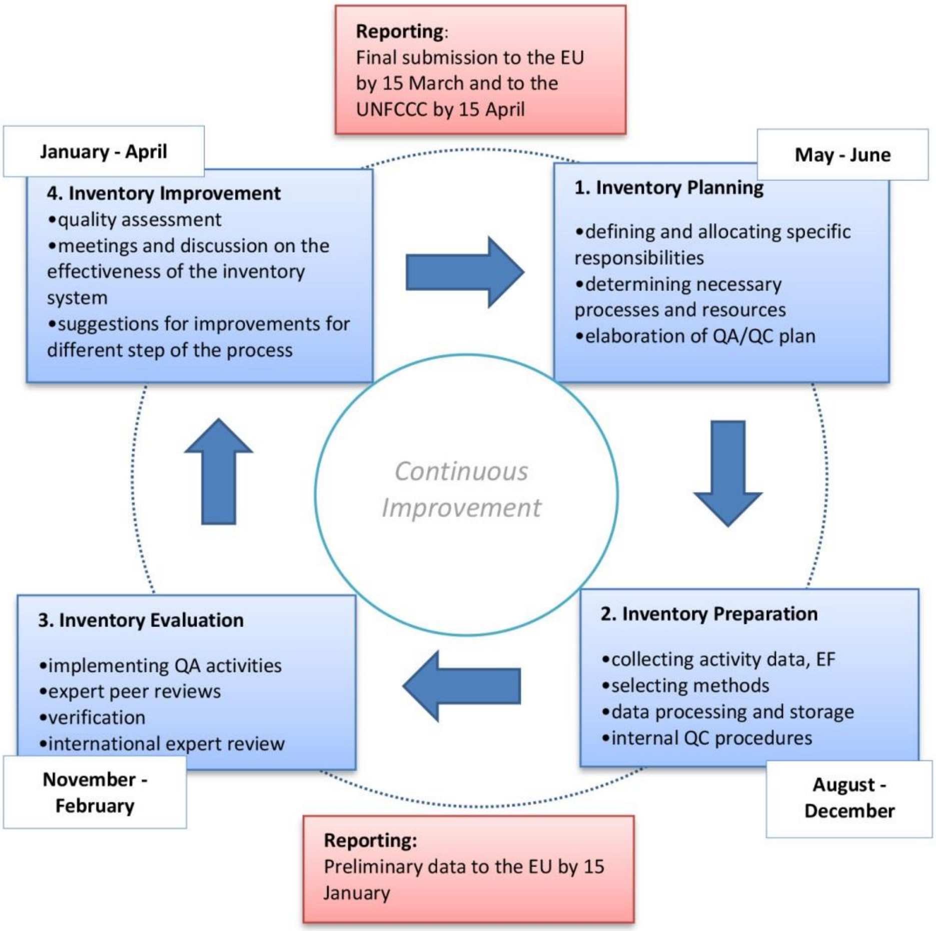

Fig. 1-2 Timeschedule of submissions and QA/QC prodedures

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). 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 (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 inventory submissions are the following:

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

- The calculation is correct
- Inventory uncertainties are estimated.

7) Timeliness

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

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

1.2.3.6 Quality control procedures

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

The QC procedures used in the Czech GHG inventory comply with the IPCC good practice guidance. General inventory QC checks (IPCC 2006 Guidelines, Table 6.1) 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. Zuzana Roskova). Key findings are summarised in the sector-specific chapters of the NIR.

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

Each sector-solving institution – KONEKO, CDV, CHMI (Industrial processes), IFER, CRI, GCRI and CENIA – will suggest to the NIS coordinator/manager (CHMI, Ms. Zuzana Roskova) 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). 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.

1.2.3.7 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 September)

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 (Zuzana Roskova)
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) (Zuzana Roskova)

Time period	Activity	Responsible person
Up to 5 January	CRF Tables submission to MoE for the approval	MoE and Sector coordinating group
Up to 15 January	CRF Tables submitted to the European Commission within the reporting procedure pursuant to Article 7of the Decision No. 525/2013/EC	MoE

The reporting pursuant to the Article 7 of the Decision No. 525/2013/EC includes also the text output containing several NIR elements. The text is created in the NIS coordinating institution (CHMI) and the control is carried out by the NIS coordinator. The text is submitted to MoE together with the CRF tables by 5 January.

The prepared output for the European Commission will contain only the QC procedures, Tier 1, realized by 5 January. The final submission for UNFCCC has the deadline by 15 September 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.

1.2.3.8 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 fifth of sectors per year. Further, in later years the cooperation was focused on different sectors, i. e. Energy (2013), Agriculture and LULUCF (2015), IPPU and uncertainties (2016), Waste and QAQC procedures (2018) and LULUCF and uncertainties (2019). Due to the COVID pandemic, no peer review meeting was organised in 2020. In 2021 the meeting was organised, but only with Slovak National Inventory team in online mode focused on Energy, EU ETS data, QAQC procedures and cooperation with the air pollutant team regarding indirect emissions. Sectoral experts have expressed a need for in person peer cooperation with the Slovaks, and purpose is to continue in person meetings again in 2024.

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.

1.2.3.9 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.

1.2.3.10 Final approval of the inventory before submission

Regarding the national GHG inventory submission to the UNFCCC, 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

1.2.3.11 Sectoral specifications of QA/QC plan

1.2.3.11.1 Energy – stationary combustion

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

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

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

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

Sectoral administrator, Andrea Veselá:

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

<u>The QC procedures at the Tier 1</u> are related with the processing, manipulation, documentation, storing and transmission of information. The first step of the control (auto-control) is carried out by the expert responsible for the sectoral approach (Vladimír Neužil), followed up by the control carried out by the QA/QC expert familiar with the topic (Andrea 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 Guidelines and QA/QC plan
Ms. Andrea Veselá	Emission calculation in stationary sources, auto-control (1st step of QC procedure, Tier 1)
Ms. Barbora Votavová	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

1.2.3.11.2 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 archiving 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 are 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 archiving 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. Leoš Pelikán) 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 (Mrs. Zuzana Kačmárová) 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. Leoš Pelikán (Head of Sustainable Transport Section)	Sectoral QA/QC guarantor responsible for the compliance of all QA/QC procedures with the 2006 IPCC Guidelines and QA/QC plan.
Mrs. Zuzana Kačmárová	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)

1.2.3.11.3 Energy – fugitive emissions

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

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

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

- develops and updates the sectoral QA/QC plan
- organizes the QC procedure (Tier 1 and Tier 2) and is responsible for the compliance of all QA/QC procedures with the IPCC 2006 Guidelines and the QA/QC plan

- suggests external experts for QA procedures
- is responsible for the submission of all documents and calculation sheets for the storing in the coordinating institution

Sectoral administrator, Andrea 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 Guidelines and the QA/QC plan.
Ms. Barbora Votavová	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. Barbora Votavová	Control of the correct data input from calculation sheets to the respective module of CRF Reporter
External expert	Ensuring the QA procedure

1.2.3.11.4 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. Barbora Koci and Ms. Jitka Slamova.

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. Barbora Kočí	Ms. Jitka Slámová	Mr. Gemrich – 2.A.1 Mr. Prokopec – 2.A.2
2.B	Ms. Jitka Slámová	Ms. Barbora Kočí	Mr. Bernauer
2.C	Ms. Barbora Kočí	Ms. Jitka Slámová	Mr.Toman
2.D	Ms. Jitka Slámová	Ms. Barbora Kočí	Mr. Vladimír Neužil
2.E	Ms. Jitka Slámová	Ms. Barbora Kočí	Mr. Martin Beck
2.F	Ms. Zuzana Rošková	Ms. Barbora Kočí	Mr. Martin Beck
2.G	Ms. Barbora Kočí	Ms. Jitka Slámová	Mr. Bernauer

1.2.3.11.5 Agriculture

The Institute of Forest Ecosystem Research (IFER) is a sector-solving institution for this category. The experts (Dr. Klír, Dr. Wollnerová) representing the Crop Research Institute (CRI) have joined the team since 2019. These experts have been also involved in the QA/QC procedures.

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. Direct inputs and independent controlling were performed by the experts from CRI (Chapters Manure Management and Agricultural Soils).

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.

Ministry of Agriculture of the Czech Republic, Czech University of Life Sciences, Institute of Animal Science Prague, Research Institute for Cattle Breeding, Research Institute of Agricultural Engineering, Institute of Agricultural Economics and Czech Hydrometeorological Institute are the additional institutions contributing information used in agriculture sector inventory.

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)
Experts from CRI	Consultation of QA/QC procedures and GHG estimation

1.2.3.11.6 LULUCF

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

The sector specific QA/QC plan for LULUCF is an integral part of the general QA/QC plan. The LULUCF greenhouse gas inventory 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 member 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 and Tier 3 inventory estimates. 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. Tier 3 estimates are facilitated by CBM-CFS3 modelling tool (Kurz et al. 2009, Kull et al. 2019). 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 and other software 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
Ms. Radka Mašková (IFER) **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
Experts from GCRI	Consultation of QA/QC procedures and GHG estimation

1.2.3.11.7 Waste

CENIA, Czech Environmental Information Agency (CENIA) 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. The inner quality assurance and quality control procedure consists of the setting of responsible persons for emission calculation – Mr. Miroslav Havránek, Mr. Petr Bažil, Ms. Ivana Kopecká and Mr. Risto Saarikivi (who is focusing on waste in more general terms). Mr. Havránek implemented the IPCC methodology and calculated emission till 2020. Since 2021 Ms. Kopecká and updates the methodologies. From autumn 2022, the agenda was gradually handed over to Petr Bažil, who performed the calculation of the emissions for the reference year 2021. Mr. Risto Saarikivi supervises 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 filled by Mr. Bažil with help of Ms. Kopecká and 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. Mr. Havránek helps with solving issues and proposes and recommends improvements. He has a long-time experience in this sector. Worksheets and all activity data are stored (so far indefinitely) by both NIS coordinator and CENIA. 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 **Mr. Petr Bažil**	Sector guarantor of QA/QC implementation. 1st step of QC procedure, Tier 1 and Tier 2 (auto-control)
Mr. Risto Saarikivi	2nd step of QC procedure, Tier 1 and Tier 2

1.2.3.11.8 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

In the Czech national inventory team there was a change of coordinator and national inventory compiler and there are two new sector experts for IPPU. The main pillars of the national inventory system declared in the Czech Republic's Initial Report under the Kyoto Protocol are operational and running.

1.3 Inventory preparation, and data collection, processing and storage

1.3.1 Activity data collection

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

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

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

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

1.3.2 Data processing and storage

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

Also, in the majority of other sectors, data are processed in a similar way - by using a system of joined spreadsheets taken from the *Workbook* and slightly modified in order to respect national circumstances.

The following examples of such cases of processing can be mentioned: agriculture, waste, fugitive emissions. For LULUCF, a specific spreadsheet system is used, respecting the national methodology.

Archiving of the inventory is carried out annualy, the archive consist of the all necessary calculation sheets and models including relevant background information, methodologies descriptions and sectoral chapters as well as the whole final inventory. The archive is stored in the official archive depository at CHMI, is bcked up 3x times on different servers and in regularly saved in the overall CHMI archive.

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 and locally parameterized models.

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

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

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

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

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

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

1.5 Brief description of key categories

The IPCC 2006 Guidelines (IPCC, 2006) provides two approaches of determining the key categories (key sources). Key categories by definition contribute to 95% percent of the overall uncertainty in a level (in emissions per year) or in a trend. Approach 2 follows from this definition, and requires thorough analysis of the uncertainty and use of sophisticated statistical procedures and evaluation of sources in terms of the appropriate characteristics.

Tab. 1-10 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2022 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	41.01	88.41	LA, TA
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	88.32	74.21	LA, TA
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	90.37	97.62	LA
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	79.94	80.53	LA, TA

1.A.3.b Road Transportation	CO_2	55.25	76.69	LA, TA
1.A.3.b Road Transportation	N_2O	78.14	83.31	LA, TA
1.A.4 Other Sectors - Solid Fuels	CO_2	81.65	67.87	LA, TA
1.A.4 Other Sectors - Solid Fuels	CH_4	87.57	78.74	LA, TA
1.A.4 Other Sectors - Gaseous Fuels	CO_2	83.25	87.56	LA, TA
1.A.4 Other Sectors - Biomass	CH_4	76.34	82.05	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	51.45	44.41	LA, TA
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	85.89	89.86	LA, TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	74.15	85.61	LA, TA
2.C.1 Iron and Steel Production	CO_2	59.01	95.24	LA
2.F.1 Refrigeration and Air conditioning	F-gases	34.03	61.36	LA, TA
3.A Enteric Fermentation	CH_4	69.06	93.27	LA
3.B Manure Management	CH_4	93.54	89.17	TA
3.B Manure Management	N_2O	86.74	92.37	LA
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	65.88	92.83	LA
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	84.57	98.10	LA
3.G Liming	CO_2	97.00	86.65	TA
4.A.1 Forest Land remaining Forest Land	CO_2	25.53	33.03	LA, TA
4.A.2 Land converted to Forest Land	CO_2	89.04	96.23	LA
4.C.1 Grassland remaining Grassland	CO_2	89.73	90.55	LA, TA
4.G Harvested wood products	CO_2	47.60	84.48	LA, TA
5.A Solid Waste Disposal	CH_4	12.96	52.90	LA, TA
5.B Biological treatment of solid waste	CH_4	62.69	71.53	LA, TA
5.D Wastewater treatment and discharge	CH_4	71.91	91.21	LA

Tab. 1-11 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2022 evaluated without LULUCF (Approach 2)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.A.1 Energy industries - Solid Fuels	CO_2	36.44	79.64	LA, TA
1.A.1 Energy industries - Solid Fuels	N_2O	90.18	97.57	LA
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	88.61	67.23	LA, TA
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	97.93	88.92	TA
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	89.42	95.82	LA
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	77.87	73.02	LA, TA
1.A.3.b Road Transportation	CO_2	46.24	63.34	LA, TA
1.A.3.b Road Transportation	N_2O	75.57	77.59	LA, TA
1.A.4 Other Sectors - Solid Fuels	CO_2	80.07	53.40	LA, TA
1.A.4 Other Sectors - Solid Fuels	CH_4	87.64	70.17	LA, TA
1.A.4 Other Sectors - Gaseous Fuels	CO_2	82.11	83.08	LA, TA
1.A.4 Other Sectors - Biomass	CH_4	73.26	75.52	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	41.37	16.43	LA, TA
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	85.49	89.80	LA, TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	70.46	81.56	LA, TA
2.C.1 Iron and Steel Production	CO_2	51.05	98.02	LA
2.F.1 Refrigeration and Air conditioning	F-gases	27.50	43.95	LA, TA
3.A Enteric Fermentation	CH_4	63.94	96.46	LA
3.B Manure Management	CH_4	92.76	86.96	TA
3.B Manure Management	N_2O	86.58	90.49	LA, TA
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	59.86	88.01	LA, TA
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	83.80	99.15	LA
3.G Liming	CO_2	96.62	84.59	TA
5.A Solid Waste Disposal	CH_4	16.61	30.46	LA, TA
5.B Biological treatment of solid waste	CH_4	55.77	59.24	LA, TA
5.D Wastewater treatment and discharge	CH_4	67.59	85.89	LA, TA

Tab. 1-12 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2022 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	30.72	69.85	LA, TA
1.A.1 Energy industries - Liquid Fuels	CO_2	95.91	93.22	TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	81.33	84.79	LA, TA
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	67.77	18.04	LA, TA
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	94.76	80.09	LA, TA
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	63.87	86.39	LA, TA
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	95.19	92.13	LA, TA
1.A.3.b Road Transportation	CO_2	45.67	47.03	LA, TA
1.A.4 Other Sectors - Solid Fuels	CO_2	78.95	59.36	LA, TA
1.A.4 Other Sectors - Solid Fuels	CH_4	96.97	89.03	TA
1.A.4 Other Sectors - Liquid Fuels	CO_2	89.00	87.59	LA, TA
1.A.4 Other Sectors - Gaseous Fuels	CO_2	50.54	77.08	LA, TA
1.A.4 Other Sectors - Biomass	CH_4	91.74	92.68	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	88.03	64.96	LA, TA
2.A.1 Cement Production	CO_2	86.57	96.43	LA
2.A.2 Lime Production	CO_2	93.89	96.16	LA
2.A.4 Other Process Uses of Carbonates	CO_2	92.33	89.71	LA, TA
2.B.1 Ammonia Production	CO_2	93.45	99.27	LA
2.B.2 Nitric Acid Production	N_2O	99.01	94.76	TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	89.80	93.74	LA, TA
2.C.1 Iron and Steel Production	CO_2	59.78	91.57	LA, TA
2.F.1 Refrigeration and Air conditioning	F-gases	76.45	73.50	LA, TA
3.A Enteric Fermentation	CH_4	73.63	94.27	LA, TA
3.B Manure Management	CH_4	96.51	90.99	TA
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	83.57	95.19	LA, TA
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	91.14	98.78	LA
3.G Liming	CO_2	98.70	90.36	TA
4.A.1 Forest Land remaining Forest Land	CO_2	55.32	34.35	LA, TA
4.A.2 Land converted to Forest Land	CO_2	94.33	97.94	LA
4.G Harvested wood products	CO_2	85.11	95.54	LA
5.A Solid Waste Disposal	CH_4	70.72	82.59	LA, TA
5.B Biological treatment of solid waste	CH_4	92.91	88.34	LA, TA
5.D Wastewater treatment and discharge	CH_4	90.51	98.15	LA

Tab. 1-13 Identification of key categories by level assessment (LA) and trend assessment (TA) for 2022 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	33.19	58.92	LA, TA
1.A.1 Energy industries - Liquid Fuels	CO_2	96.32	94.37	TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	82.70	83.54	LA, TA
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	68.06	20.07	LA, TA
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	95.08	77.59	LA, TA
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	63.84	85.82	LA, TA
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	95.54	93.80	TA
1.A.3.b Road Transportation	CO_2	49.35	36.17	LA, TA
1.A.4 Other Sectors - Solid Fuels	CO_2	80.14	49.90	LA, TA
1.A.4 Other Sectors - Solid Fuels	CH_4	97.21	89.59	TA
1.A.4 Other Sectors - Liquid Fuels	CO_2	89.33	87.07	LA, TA
1.A.4 Other Sectors - Gaseous Fuels	CO_2	54.61	69.75	LA, TA
1.A.4 Other Sectors - Biomass	CH_4	92.29	91.74	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	88.28	65.13	LA, TA
2.A.1 Cement Production	CO_2	86.71	95.41	LA, TA
2.A.2 Lime Production	CO_2	94.61	96.33	LA

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
2.A.4 Other Process Uses of Carbonates	CO_2	92.93	88.83	LA, TA
2.B.1 Ammonia Production	CO_2	94.14	98.62	LA
2.B.2 Nitric Acid Production	N_2O	99.08	94.93	TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	90.20	93.12	LA, TA
2.C.1 Iron and Steel Production	CO_2	59.42	98.33	LA
2.F.1 Refrigeration and Air conditioning	F-gases	77.44	74.22	LA, TA
3.A Enteric Fermentation	CH_4	74.39	97.15	LA
3.B Manure Management	CH_4	96.98	92.43	TA
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	85.13	90.33	LA, TA
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	91.64	99.62	LA
3.G Liming	CO_2	98.75	91.05	TA
5.A Solid Waste Disposal	CH_4	71.24	80.77	LA, TA
5.B Biological treatment of solid waste	CH_4	93.56	87.99	LA, TA
5.D Wastewater treatment and discharge	CH_4	90.96	95.73	LA

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.

It is obvious from Tab. 1-11 (Approach 2) and Tab. 1-13 (Approach 1), that 1.A.1. Energy Industries - Liquid Fuels, 1.A.2 Manufacturing Industries and Construction - Liquid Fuels, 1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels, 1.A.4 Other Sectors - Solid Fuels, 2.B.2 Nitric Acid Production, 3.B Manure Management, 3.G. Liming were considered additionally as key categories in trend assessment. When applying the Approach 1 the categories 1.A.1 Energy industries - Liquid Fuels, 1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels, 1.A.4 Other Sectors - Solid Fuels, 2.B.2 Nitric Acid Production, 3.B Manure Management, 3.G Liming were considered additionally as key categories in trend assessment when the LULUCF categories were not considered. When applying the Approach 2 categories 1.A.1. Energy Industries - Solid Fuels, N_2O was considered additional as key category in level assessment when the LULUCF categories were not considered and 1.A.2 Manufacturing Industries and Construction - Liquid Fuels, 3.B Manure Management, 3.D.1 - Direct N_2O Emissions From Managed Soils, 5.D. Wastewater treatment and discharge were considered additionally as key categories in trend assessment when the LULUCF categories were not considered.

On the whole, 33 (Approach 1) and 28 (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	**28**
KC identified by LA	28	**26**
KC identified by TA	26	**20**
KC identified by LA + TA concurrently	21	**18**
KC identified by only LA	7	**8**
KC identified by only TA	5	**2**
Key Categories (KC) without LULUCF:	30	**26**
KC identified by LA	24	**23**
KC identified by TA	24	**21**
KC identified by LA + TA concurrently	18	**18**
KC identified by only LA	6	**5**
KC identified by only TA	**6**	**3**

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 2022 after above mentioned revision of the input parameters are given in Annex 2.

Further, uncertainty bases are yearly evaluated for LULUCF, Waste and Energy sector, which are then used for the overall uncertainty analysis.

Results of uncertainty assessment were obtained (i) for all sectors including LULUCF and (ii) for comparison also for all sectors without LULUCF. The estimated overall uncertainty in level assessment (case with LULUCF) reached 3.57%. The corresponding uncertainty in trend is 1.7%. For the case without LULUCF the estimated overall uncertainty in level assessment is 3.15% and 1.66% in trend.

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

1.7 General assessment of completeness

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

Additionally this year was used the ‘completeness’ function of 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. 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

As it is apparent from the graphs below, the total emissions had an slight increasing trend from 2014 to 2019. In 2020 the emissions decreased in comparison with previous year. This decrease was caused mainly by the decrease in emissions from Energy sector which was affected by COVID-19 pandemic situation. In 2021 the emissions had slightly increased again. Please see details in the respective chapter of the NIR.

2.1 Description and interpretation of emission trends for aggregated GHG emissions

Tab. 2-1 presents a summary of GHG emissions excl. bunkers emissions for the period from 1990 to 2022. 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 1990–2022 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	164250.45	26832.80	8235.99	NO	NO	NO	86.83	201313.55	192478.23
1991	148883.28	25443.42	6462.79				86.66	182610.78	172274.75
1992	145705.82	23495.97	5720.28				88.03	176618.42	166085.78
1993	140124.10	22951.11	5016.02				89.22	169805.56	158442.96
1994	132668.12	21537.12	5127.81				90.35	160985.25	150868.83
1995	131622.32	21175.02	5458.59	86.89	0.01	NO	91.40	159950.44	149568.92
1996	135018.76	21187.31	5139.51	215.49	0.68	NO	101.32	163153.61	153049.43
1997	130941.74	20591.32	5220.40	389.02	1.62	NO	99.06	158682.41	149619.64
1998	125715.92	19678.22	5183.79	529.49	1.54	NO	97.89	152611.38	143893.07
1999	116672.03	18704.80	5012.07	636.10	1.08	NO	98.88	142429.51	133490.88
2000	127236.14	17631.81	5619.34	800.04	4.43	NO	111.73	152636.19	142952.22
2001	127144.52	16959.09	5936.88	998.32	9.15	NO	101.85	152317.20	142661.70
2002	123967.85	16596.30	5525.60	1098.75	15.17	NO	125.00	148460.26	139010.52
2003	127571.89	16460.55	5043.49	1212.19	8.36	NO	149.14	151546.36	142596.83
2004	128291.81	15909.12	5753.10	1343.12	12.41	NO	124.32	152501.24	143837.50
2005	125690.86	16541.88	5611.67	1347.96	14.38	NO	115.28	150439.30	141717.43
2006	126537.10	16767.69	5609.86	1600.80	29.02	NO	108.34	151810.92	144146.17
2007	128366.40	16212.63	5735.93	1958.20	27.20	NO	96.67	153500.96	146070.08
2008	122934.90	16276.20	5767.98	2217.19	37.05	NO	91.39	148404.55	139721.81
2009	114982.54	15458.08	4792.40	2233.98	42.14	NO	91.79	138572.33	130135.07
2010	117476.26	15721.11	4770.72	2450.62	44.34	0.14	85.30	141524.81	133813.24
2011	115189.18	15650.53	5528.19	2660.72	8.08	0.55	91.36	140090.97	131757.53
2012	111287.35	15587.77	5461.73	2764.27	6.17	0.83	95.28	136118.89	127563.12
2013	106722.49	14896.04	5192.34	2893.55	4.18	1.32	85.59	130620.31	122710.76
2014	104246.04	14888.14	5296.69	3073.55	3.12	2.22	82.36	128418.04	120566.48
2015	105000.92	14943.34	5893.07	3324.47	2.11	2.01	80.67	130057.11	122203.40
2016	106648.40	14516.50	6011.67	3542.93	1.78	2.01	81.04	131571.67	124625.76
2017	107745.84	14272.38	5792.18	3749.86	1.97	3.12	76.30	132367.78	127029.71
2018	106335.55	14167.23	5402.89	3815.33	2.07	2.91	72.72	130499.02	130487.31
2019	101008.82	13800.85	5221.93	3838.56	1.57	2.36	70.09	124591.16	131084.48
2020	91673.77	13096.94	4815.35	3747.36	0.97	2.02	67.16	114040.85	123740.54
2021	96645.18	13213.83	5090.52	3738.83	30.95	1.46	64.68	119425.24	126013.19
2022	95107.76	13080.32	5183.35	3610.40	47.86	1.95	65.70	117687.98	121066.04
%[2)]	**-42.10**	**-51.29**	**-37.06**	**4212.56**	**10769.90**	**NA**	**-24.33**	**-41.54**	**-37.10**

Note: Global warming potentials (GWPs) used (100 years time horizon): CH_4 = 28; N_2O = 265; SF_6 = 23 500; NF_3 = 16 100; 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 2022 the total GHG emissions (incl. indirect emissions and incl. LULUCF) decreased by approximately 11% or 12 747.20 kt CO_2 eq. resulting in total emissions of 121 066.04 kt CO_2 eq. The total emissions excluding LULUCF decreased by 20% or 23 836.83 kt CO_2 eq. The difference in the trend between including/excluding LULUCF is caused by huge increase in emissions from LULUCF in recent years.

The total GHG emissions and removals in 2022 were -37:10% below the base year level incl. LULUCF and indirect emissions and -41.54%, when excl. LULUCF.

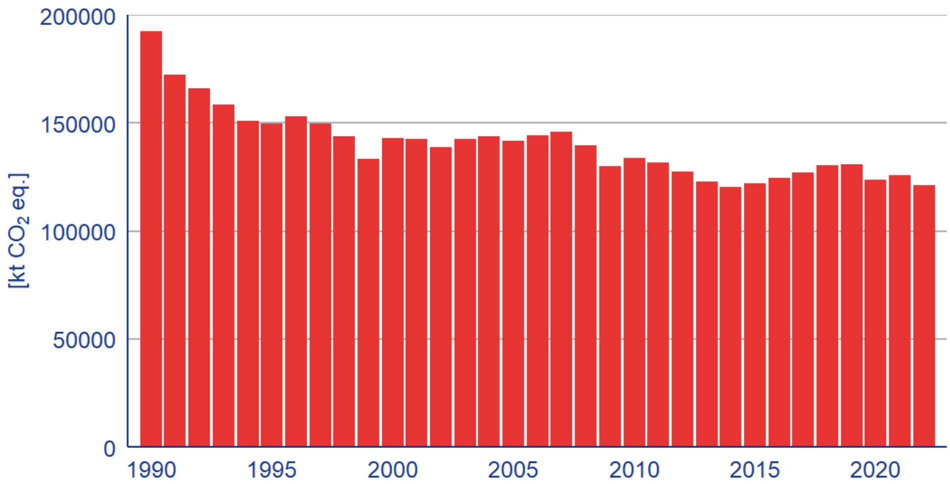

Fig. 2-1 Total trend of GHG emissions, [kt CO_2 eq.]

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. Apparent is also decrease in 2020 caused by COVID-19 pandemic.

2.2 Description and interpretation of emission trends by sector

2.2.1 Description and interpretation of emission trends by gas

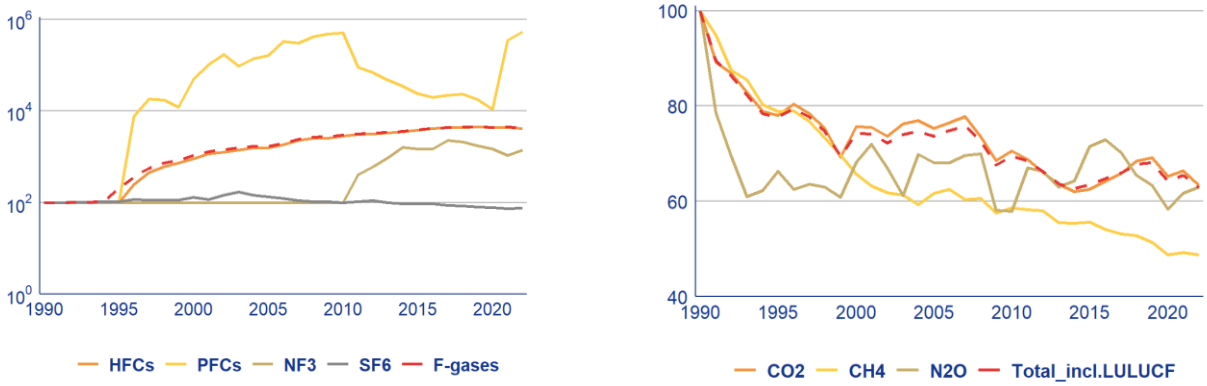

Fig. 2-2 Trend in CO_2, CH_4 and N_2O emissions 1990 - 2022 in index form (base year = 100%) and Trend in HFCs, PFCs (1995 – 2022) and SF_6 (1990 – 2022) actual emissions in index form (base year = 100%)

The major greenhouse gas in the Czech Republic is CO_2, which represents 82.3% of total GHG emissions and removals in 2022, compared to 83% in the base year (excl. indirect emissions, excl. LULUCF). It is followed by CH_4 (11% in 2022, 13% in the base year), N_2O (4% in 2022, 5% in the base year) and F-gases (3% in 2022, 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 72% of the amount produced in 1990. Inter-annual decrease in CO_2 emissions (excl. LULUCF, excl. indirect emissions) from 2010 to 2022 by 19% results the total decrease of 42.10% from 1990 to 2022. Quoting in absolute figures, CO_2 emissions and removals decreased from 164 250.44 to 95 107.76 kt CO_2 in the period from 1990 to 2022, 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).

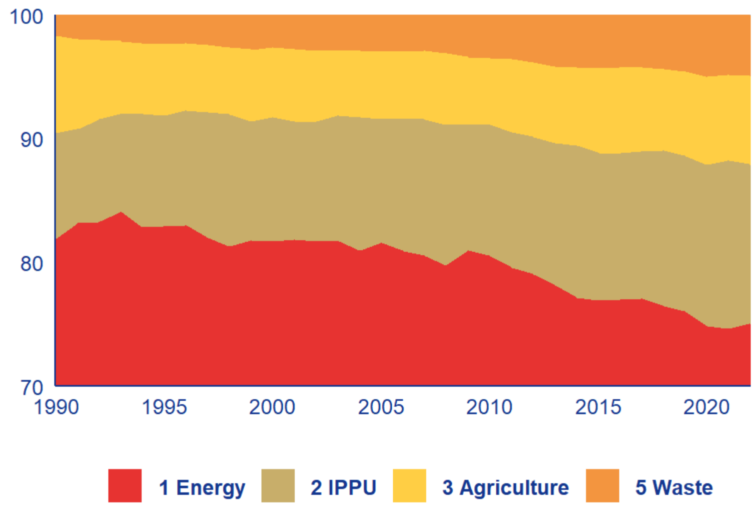

Fig. 2-3 Percentual share of GHGs (Y-axis begins at 70% - part of CO_2 share is hidden)

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 2022 from the 1.A.3 Transport category from 11 077.63 to 19 189.63 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 2022 CH_4 emissions were 51.25% 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.A Enteric Fermentation and 5.A Solid Waste Disposal on Land.

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 2022 from 8 235.99 to 5 196.86 kt CO_2 eq. (incl. LULUCF). In 2022 N_2O emissions were 37.05% below the base year level, mainly due to lower emissions from 3 Agriculture and 2.B Chemical Industry and despite increase from the 5 Waste.

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.G Other product manufacture and use).

HFCs

HFCs actual emissions increased remarkably between 1995 and 2022 from 86.89 to 3 610.40 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 2022, HFCs emissions were more than 42-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 were decreasing up to 2020 (0.97 kt CO_2 eq.), however in 2022 there is apparent rapid increase again to 47.86 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 89.22 kt CO_2 eq. Between 1995 and 2022 they inter-annually fluctuated with maximum of 149.14 kt CO_2 eq. In 2022 SF_6 reached amount of 65.70 kt CO_2 eq., the level was 24.33% lower than the base year (1995).

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

NF_3

With the technological progress a new gas is used since 2010 in semiconductor manufacturing. NF_3 is a gas, used mainly for manufacturing of LCD displays, solar panels and etching semiconductors. Base year for this gas is 1995. In 2022 the emissions of NF_3 equalled to 1.95 kt CO_2 eq.

2.2.2 Description and interpretation of emission trends by categories

Tab. 2-2 presents a summary of GHG emissions by categories for the period from 1990 to 2022:

- Category 1 Energy
- Category 2 Industrial Processes and Product Use
- Category 3 Agriculture
- Category 4 Land Use, Land-Use Change and Forestry
- Category 5 Waste

The dominant category is the 1 Energy, which caused for 75.1% of total GHG emissions in 2022 (81.9% in 1990) incl. LULUCF and indirect emissions, followed by the sectors 2 Industrial Processes and Product Use and 3 Agriculture, which caused for 12.9% and 7.1% of total GHG emissions in 2022 (8.6% and 7.9% in 1990, resp.), 5 Waste sector covered 4.9% (1.7% in 1990) and 4 LULUCF category caused 7% (removals prevailed in 1990). The trend of GHG emissions by categories is presented in Fig. 2-4 (indexed relative to the base year).

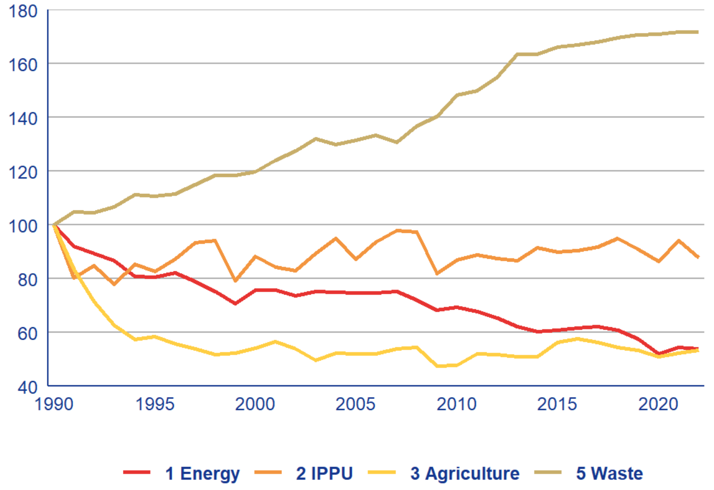

Fig. 2-4 Emission trends in 1990-2022 by categories in index form (base year = 100)

Tab. 2-2 Summary of GHG emissions by category 1990–2022 [kt CO_2 eq.]

	1 Energy	2 IPPU	3 Agriculture	4 LULUCF	5 Waste
1990	163204.12	17115.22	15747.95	-8835.33	3319.42
1991	150464.78	13767.97	13146.72	-10336.04	3482.86
1992	145724.75	14522.80	11272.09	-10532.64	3468.80
1993	141387.77	13351.21	9874.73	-11362.60	3542.85
1994	132043.93	14607.00	9060.36	-10116.41	3689.59
1995	131369.36	14160.54	9214.88	-10381.51	3671.07
1996	134178.20	14956.03	8797.92	-10104.18	3698.76
1997	128901.85	15981.74	8499.89	-9062.77	3815.72
1998	122929.68	16137.99	8179.49	-8718.32	3934.44
1999	115394.19	13547.56	8231.56	-8938.63	3933.21
2000	123740.37	15137.16	8528.71	-9683.97	3979.80
2001	123672.96	14424.27	8926.15	-9655.50	4118.03
2002	120399.33	14193.63	8495.31	-9449.74	4230.67
2003	122943.62	15280.69	7822.09	-8949.53	4378.88
2004	122614.65	16253.68	8237.86	-8663.74	4315.41
2005	121841.88	14914.54	8192.26	-8721.87	4362.37
2006	121943.42	16047.68	8221.81	-7664.75	4425.41
2007	122753.89	16780.69	8505.25	-7430.88	4340.86
2008	117523.76	16679.19	8563.57	-8682.74	4546.62
2009	111392.65	14033.46	7505.18	-8437.25	4658.77
2010	113213.37	14881.87	7519.34	-7711.58	4922.25
2011	110723.38	15220.26	8208.17	-8333.45	4971.95
2012	106911.98	14980.28	8157.85	-8555.77	5145.52
2013	101479.46	14858.11	8023.82	-7909.55	5431.57
2014	98462.27	15663.25	8034.23	-7851.57	5425.52
2015	99457.16	15396.58	8875.44	-7853.71	5512.08
2016	100690.32	15471.95	9093.25	-6945.91	5545.24

	1 Energy	2 IPPU	3 Agriculture	4 LULUCF	5 Waste
2017	101465.94	15702.63	8889.34	-5338.06	5579.54
2018	99297.44	16267.70	8594.26	-11.71	5630.50
2019	94283.80	15558.12	8422.67	6493.35	5669.27
2020	84886.54	14779.81	8051.05	9699.69	5675.72
2021	88699.77	16135.46	8239.51	6587.95	5702.11
2022	87907.24	15045.20	8422.28	3378.06	5702.11
[1]%	-0.89	-6.76	2.22	-48.72	0.00
[2]%	-46.14	-12.09	-46.52	-138.23	71.78
[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	2022
Total (net emissions)	**190551.38**	**148034.33**	**141702.07**	**140589.18**	**132825.26**	**121387.55**	**120454.89**
1. Energy	**163204.12**	**131369.36**	**123740.37**	**121841.88**	**113213.37**	**99457.16**	**87907.24**
A. Fuel combustion (sectoral approach)	149368.82	120104.82	115191.92	114216.83	106777.45	94524.12	85463.09
1. Energy industries	56830.03	61734.87	62034.93	63138.26	62175.65	53666.27	42769.93
2. Manufacturing industries and construction	47105.11	24464.51	23422.11	18842.92	12112.49	9869.85	11317.57
3. Transport	11249.47	10409.82	12237.76	17362.88	16790.04	17463.13	19390.69
4. Other sectors	33989.81	23278.66	17318.39	14605.37	15377.55	13152.44	11715.76
5. Other	194.42	216.95	178.73	267.40	321.70	372.43	269.14
B. Fugitive emissions from fuels	13835.30	11264.54	8548.46	7625.05	6435.93	4933.03	2444.15
1. Solid fuels	12637.63	10337.18	7569.76	6623.56	5436.18	4246.64	1927.17
2. Oil and natural gas and other emissions from energy production	1197.66	927.35	978.70	1001.49	999.75	686.39	516.98
2. Industrial Processes	**17115.22**	**14160.54**	**15137.16**	**14914.54**	**14881.87**	**15396.58**	**15045.20**
A. Mineral industry	4082.45	3019.09	3633.37	3345.75	3048.42	3084.24	3288.22
B. Chemical industry	2825.39	2694.75	2828.76	2706.44	2330.82	2066.89	2053.53
C. Metal industry	9811.61	7981.27	7434.79	7080.15	6610.22	6496.16	5658.30
D. Non-energy products from fuels and solvent use	125.56	103.75	140.30	120.85	113.00	140.71	119.97
E. Electronic industry	NO,NE	NO,NE	11.16	6.17	38.28	5.20	53.55
F. Product uses as ODS substitutes	NO	86.90	802.15	1357.33	2458.45	3326.21	3609.06
G. Other product manufacture and use	270.21	274.78	286.27	297.50	282.43	276.61	261.86
H. Other	NO	NO	0.37	0.36	0.26	0.57	0.71
3. Agriculture	**15747.95**	**9214.88**	**8528.71**	**8192.26**	**7519.34**	**8875.44**	**8422.28**
A. Enteric fermentation	6611.86	4275.50	3604.25	3376.57	3309.43	3492.23	3680.70
B. Manure management	2571.36	1760.28	1573.66	1311.80	939.40	734.83	762.11
D. Agricultural soils	5219.49	2953.97	3117.03	3290.28	3045.11	4209.64	3633.76
G. Liming	1236.71	115.86	117.89	67.18	64.53	171.20	153.77
H. Urea application	108.53	109.27	115.88	146.42	160.86	267.54	191.94
4. Land use, land-use change and forestry	**-8835.33**	**-10381.51**	**-9683.97**	**-8721.87**	**-7711.58**	**-7853.71**	**3378.06**
A. Forest land	-7471.53	-9714.12	-8495.86	-7364.64	-6055.51	-7208.72	5528.01
B. Cropland	115.91	153.45	127.80	101.81	100.74	81.65	45.28
C. Grassland	-143.86	-301.83	-370.73	-359.50	-360.26	-427.11	-500.87
D. Wetlands	24.10	12.16	35.28	26.69	36.73	26.87	56.53
E. Settlements	318.74	294.74	289.41	306.68	186.27	150.35	194.87
G. Harvested wood products	-1680.47	-827.19	-1270.88	-1433.82	-1620.46	-477.68	-1946.26
5. Waste	**3319.42**	**3671.07**	**3979.80**	**4362.37**	**4922.25**	**5512.08**	**5702.11**
A. Solid waste disposal	2007.82	2440.80	2830.43	3072.49	3468.89	3582.05	3724.92
B. Biological treatment of solid waste	NE,IE	NE,IE	NE,IE	62.64	218.67	749.71	803.80
C. Incineration and open burning of waste	20.43	59.97	51.22	107.20	120.24	106.36	106.65
D. Waste water treatment and discharge	1291.18	1170.29	1098.15	1120.05	1114.44	1073.95	1066.74
Memo items:							
International bunkers	674.58	583.49	498.01	977.37	961.51	904.39	812.36
Aviation	674.58	583.49	498.01	977.37	961.51	904.39	812.36
CO_2 emissions from biomass	6445.39	5788.68	6658.55	8758.22	12491.35	16540.59	19771.00
Long-term storage of C in waste disposal sites	15558.30	19691.70	24677.97	30258.81	36422.71	41699.66	49906.96
Indirect N_2O	961.78	490.59	386.29	377.06	317.51	249.03	206.32
Indirect CO_2	1926.85	1534.59	1250.15	1128.25	987.98	815.85	627.11
Total CO_2 equivalent emissions without LULUCF	199386.71	158415.84	151386.04	149311.05	140536.83	129241.26	117076.83
Total CO_2 equivalent emissions with LULUCF	190551.38	148034.33	141702.07	140589.18	132825.26	121387.55	120454.89
Total CO_2 equivalent emissions, including indirect CO_2, without LULUCF	201313.55	159950.44	152636.19	150439.30	141524.81	130057.11	117687.98
Total CO_2 equivalent emissions, including indirect CO_2, with LULUCF	192478.23	149568.92	142952.22	141717.43	133813.24	122203.40	121066.04

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 2020 is 45.6%. Between 2017 to 2022 emissions from category 1 Energy rapidly decreased by 11.5%.

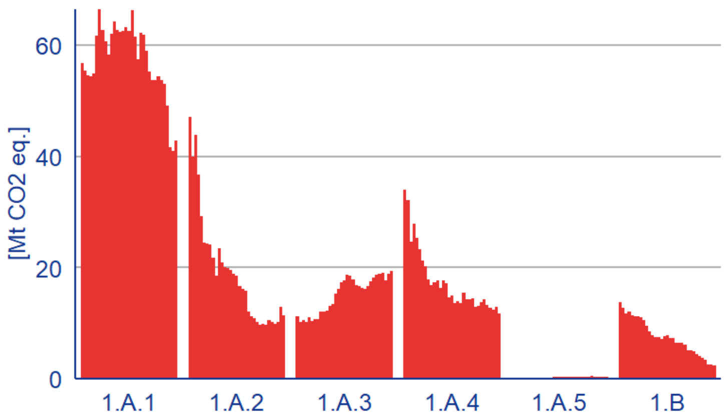

Fig. 2-5 Trends in Energy by categories 1990-2022 (Mt CO_2 eq.)

From the total 87 907.24 kt CO_2 eq. in 2022 97% 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 27% of all CH_4 emissions in 2022.

CO_2 emissions from fossil fuels combustion (category 1.A Energy) are the main source in Czech Republic's inventory with a share of 97% in total emissions from Energy sector. CO_2 emissions from category 1 Energy contributes for 74% to total GHG emissions, CH_4 for 3% and N_2O for 0.5% in 2022 (excl. LULUCF).

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 2022. In early 90's emissions decreased rather rapidly. They reached decade minimum in 1993 and since then they have fluctuated. By the end of nineties they reached their decade minimum due to global economic recession. Between 1990 and 2022, emissions from this category decreased by 12.09%. In 2022 emissions amounted for 15 045.20 kt CO_2 eq.

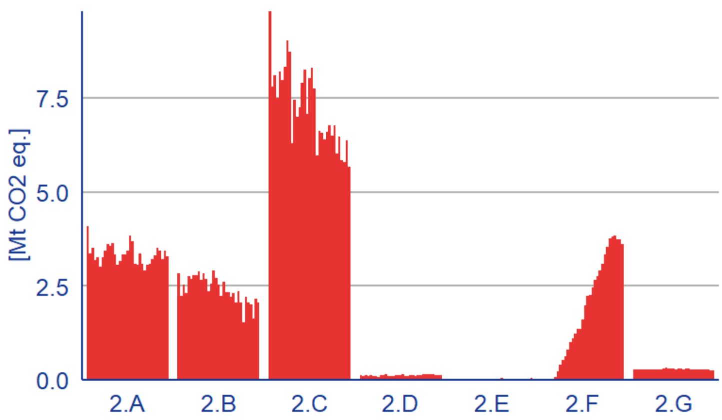

Fig. 2-6 Trends in IPPU by categories 1990-2022 (Mt CO_2 eq.)

The main categories in the 2 Industrial Processes and Product Use category are 2.C Metal Industry (40%), 2.F Product Uses as ODS substitutes (23%), 2.A Mineral Industry (22%) and 2.B Chemical Industry (14%) of the sectoral emissions in 2022 (Fig. 2-6).

The most important GHG of the 2 Industrial Processes and Product Use category was CO_2 with 74% of sectoral emissions, followed by F-gases (23%).

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.

Agriculture amounted to 8 422.28 kt CO_2 eq. in 2022 which corresponds to 7% of national total emissions (excl. indirect emissions, excl. LULUCF). The most important sub-category 3.A Enteric Fermentation (N_2O emissions) contributed by 44% to sectoral total in 2022, followed by the 3.D Agricultural Soils (CH_4 emissions, 43%).

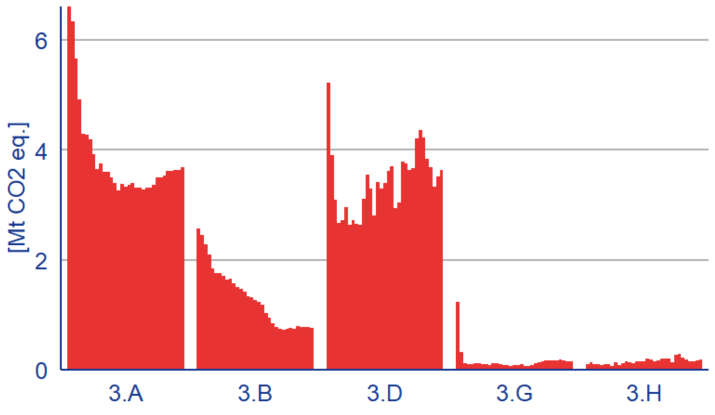

Fig. 2-7 Trends in Agriculture by categories 1990-2022 (Mt CO_2 eq.)

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 31% 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 -10 687.22 kt CO_2 eq. in 1993 and minimum in 2017 (-4 498.83 kt CO_2 eq.).

Emissions and removals amounted to 3 378.06 kt CO_2 eq. in 2022, which corresponds to 3% of total national emissions.

LULUCF category is no longer a sink for CO_2. Starting with 2015 the removals decreased and resulted in emissions since 2019. The situation is caused by the extreme drought-induced accelerating bark-beetle outbreak calamity experienced in the Czech forestry in the recent years (since 2015).

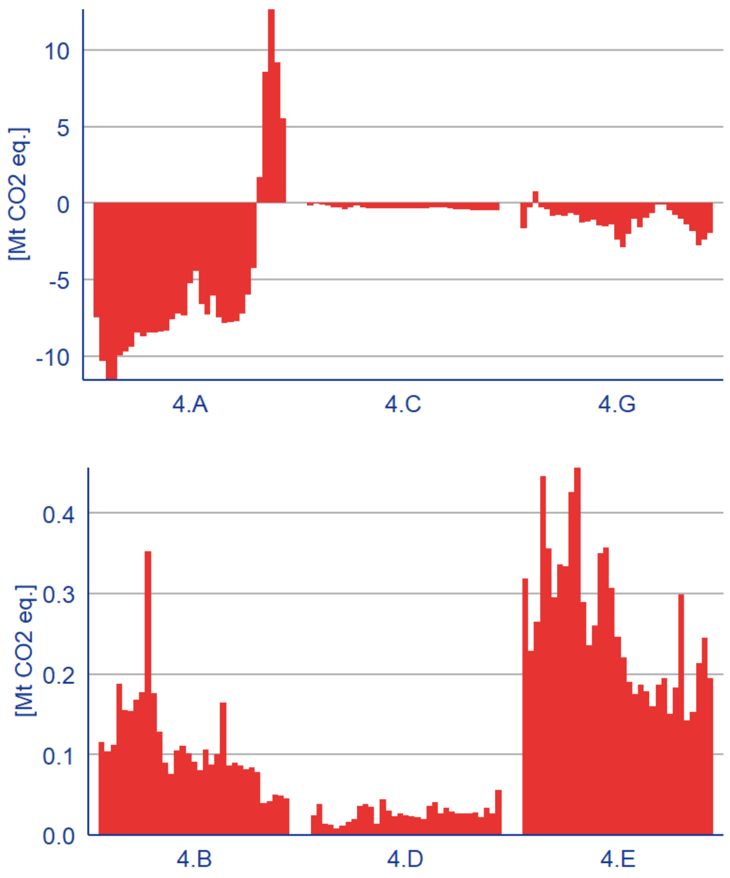

Fig. 2-8 Trends in LULUCF by separate source and sink categories 1990 – 2022 (Mt CO_2 eq.)

Waste (IPCC Category 5)

GHG emissions from category 5 Waste substantially increased during the whole period. In 2022 emissions amounted for 5 702.11 kt CO_2 eq., which is 72% 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.B Biological treatment of solid waste. The share of category 5 Waste in total emissions was 5% in 2022.

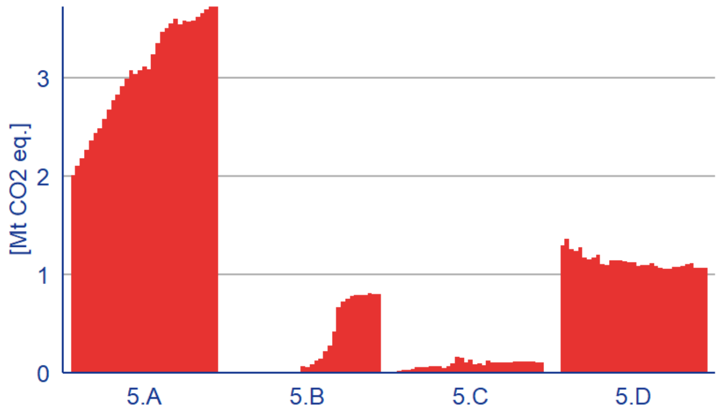

Fig. 2-9 Trends in Waste by categories 1990-2022 (Mt CO_2 eq.)

The main source is solid 5.A Solid Waste Disposal, which accounted for 65% of sectoral emissions in 2022, followed by 5.D Wastewater Treatment and Discharge (19%) and 5.B Biological treatment of solid waste (14%). Trends of the separate sub-categories in Waste sector can be observed on Fig. 2-9.

94% of all emissions from Waste category are CH_4 emissions; CO_2 contributes by 2% and N_2O by 4%.

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.

3 Energy (CRF Sector 1)

3.1 Overview of sector

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

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

Processing of the activity data is based on the total energy balance of the Czech Republic. The energy balance is prepared by CzSO, and is divided into issues for Solid Fuels, Liquid Fuels, Natural Gas, renewable energy sources and production of heat and electrical energy. Information on the energy balance forms the basis for preparing a database of activity data in the Reference and Sectoral Approaches. The Reference Approach is based on data from the source part of the energy balance; the Sectoral Approach involves processing of data on fuel consumption in a structure corresponding to the requirements of the IPCC categorization.

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

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

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

3.1.1 Key categories in sector 1 Energy

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

On the whole, 17 key sources have been identified in sector 1, the most important of which are the first 4 given Tab 3-1. This group of sources contributes 59% to total greenhouse gas emissions (without LULUCF).

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

The results of the inventory, including the activity data, are submitted in the standard CRF format. For direct greenhouse gases, the consumption of fuels and “implied” emission factors are also given. However, for stationary sources, the fuel consumption is given in the CRF format in aggregated structure, i.e. as Solid, Liquid and Gaseous Fuels according to IPCC definition. All the CRF Tables in sector 1.A were appropriately completed for the entire required time interval of 1990 to 2022.

In 1.B Fugitive Emissions from Fuels category, especially 1.B.1.a Coal Mining and Handling was evaluated as a key category (Tab. 3-1). Category 1.B.2.b was also identified as a key category by the latest assessment.

Tab. 3-1 Overview of key categories in 1 Energy (2022)

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	32.26	33.19
1.A.3.b Road Transportation	CO_2	LA, TA	LA, TA	Yes	Yes	Yes	Yes	15.71	16.16
1.A.4 Other Sectors - Gaseous Fuels	CO_2	LA, TA	LA, TA	Yes	Yes	Yes	Yes	5.11	5.26
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	LA, TA	LA	Yes	Yes	Yes	Yes	4.30	4.42
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	LA, TA	LA, TA	Yes	Yes	Yes	Yes	4.10	4.22
1.A.4 Other Sectors - Solid Fuels	CO_2	LA, TA	LA, TA	Yes	Yes	Yes	Yes	2.62	2.70
1.A.1 Energy industries - Gaseous Fuels	CO_2	LA, TA		Yes	Yes			2.49	2.56
1.B.1.a Coal Mining and Handling	CH_4	LA, TA	LA, TA	Yes	Yes	Yes	Yes	1.53	1.58
1.A.4 Other Sectors - Liquid Fuels	CO_2	LA, TA		Yes	Yes			1.02	1.05
1.A.4 Other Sectors - Biomass	CH_4	LA, TA	LA, TA	Yes	Yes	Yes	Yes	0.64	0.66
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	LA, TA	TA	Yes	Yes		Yes	0.45	0.47
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	LA, TA	LA, TA	Yes	Yes	Yes	Yes	0.45	0.46
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4		LA, TA			Yes	Yes	0.40	0.41
1.A.1 Energy industries - Liquid Fuels	CO_2	TA		Yes	Yes			0.36	0.37
1.A.4 Other Sectors - Solid Fuels	CH_4	TA	LA, TA	Yes	Yes	Yes	Yes	0.23	0.23
1.A.3.b Road Transportation	N_2O		LA, TA			Yes	Yes	0.14	0.15
1.A.1 Energy industries - Solid Fuels	N_2O		LA				Yes	0.13	0.13

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

3.1.2 Emissions Trends

CO_2 emissions from the 1.A sector decreased by 43% from 146 Mt CO_2 in 1990 to 84 Mt CO_2 in 2022. Furthermore CO_2 emissions from the 1.B sector decreased by 90% from 458 kt in 1990 to 44 kt in 2022, as well as CH_4 emissions from 1.B sectors decreased by 82% from 478 kt in 1990 to 86 kt in 2022. Fig. 3-1 indicates overall trend in CO_2 and CH_4 emissions in the whole time series for both sectors. Furthermore, Fig. 3-1 provides data for trends in 1 Energy for each gas reported in sector.

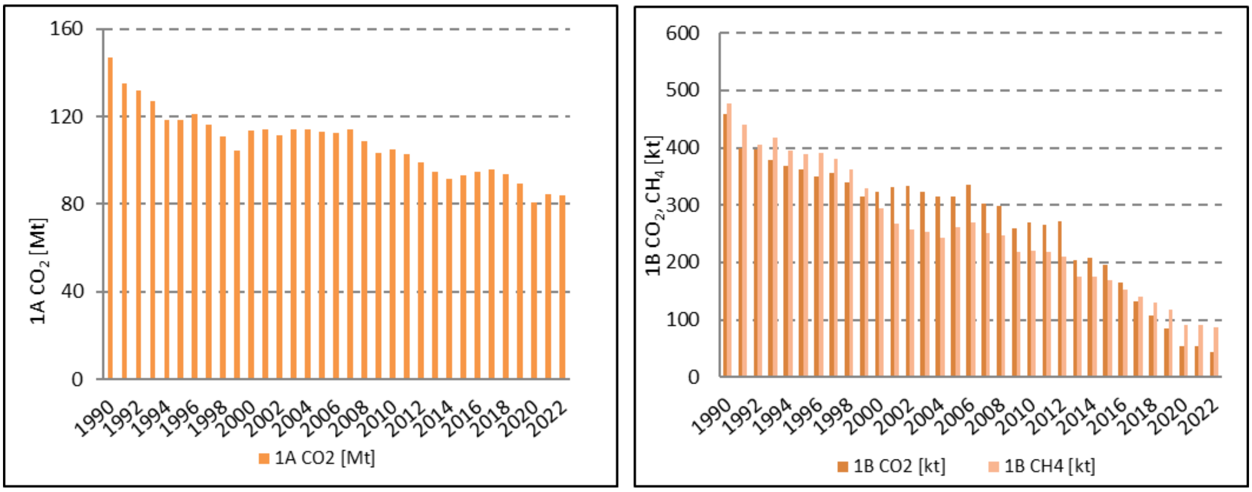

Fig. 3-1 Trend total CO_2 (Sectoral Approach) in 1.A and trend of CO_2 and CH_4 from 1.B sector in period 1990 – 2022

Tab. 3-2 Emissions of greenhouse gases and their trend from 1990 – 2022 from IPCC Category 1 Energy

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]
1990	147 099	552.81	2.36
1991	135 613	509.56	2.20
1992	132 067	467.33	2.16
1993	127 484	476.49	2.12
1994	118 935	448.35	2.09
1995	118 523	438.73	2.12
1996	121 234	441.35	2.21
1997	116 383	426.49	2.18
1998	111 129	401.14	2.15
1999	104 682	362.07	2.17
2000	113 903	329.18	2.34
2001	114 655	303.11	2.00
2002	111 694	292.04	1.99
2003	114 333	287.99	2.06
2004	114 299	277.24	2.09
2005	113 050	294.43	2.07
2006	112 884	303.89	2.08
2007	114 195	285.32	2.15
2008	109 091	281.41	2.09
2009	103 746	254.40	1.98
2010	105 460	258.10	1.99
2011	103 005	256.67	2.01
2012	99 424	248.55	1.99
2013	94 926	215.38	1.97
2014	91 949	213.66	2.00
2015	93 079	208.55	2.03
2016	94 754	192.31	2.08
2017	95 842	180.88	2.11
2018	93 948	171.13	2.10

	CO_2 [kt]	CH_4 [kt]	N_2O [kt]
2019	89 329	157.32	2.07
2020	80 676	131.63	1.98
2021	84 380	134.32	2.11
2022	83 783	127.63	2.11
Trend 1990/2022	**-43%**	**-77%**	**-11%**

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 2022.

The greatest increase in emissions was recorded in subsector 1.A.3 Transport between 1990 and 2007, when emissions increased by 164%. 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 2014 and 2019 is apparent slight increase by 2.3 Tg. For the last year 2022 occurs slight increase again. Emissions from

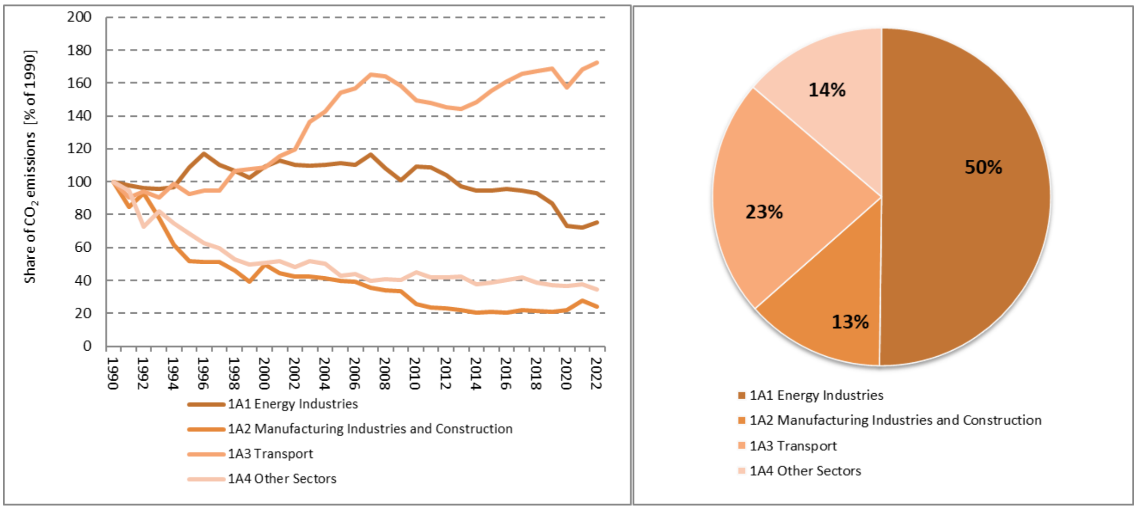

Fig. 3-2 Share and development of CO_2 emissions from 1990 – 2022 in individual sub-sectors; share of CO_2 emissions in individual subsectors in 2022 [kt]

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 32 Tg CO_2 in 1990 to 11 and 11 Tg CO_2 in 2022, respectively.

Fig. 3-3 demonstrate that the fugitive emissions from Solid fuels also indicate substantial decrease in the whole time-series, i.e. 91% for CO_2 emission and 85% for CH_4 emissions. Fugitive CH_4 emissions from Oil and Natural Gas also indicate decrease for 57% 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.

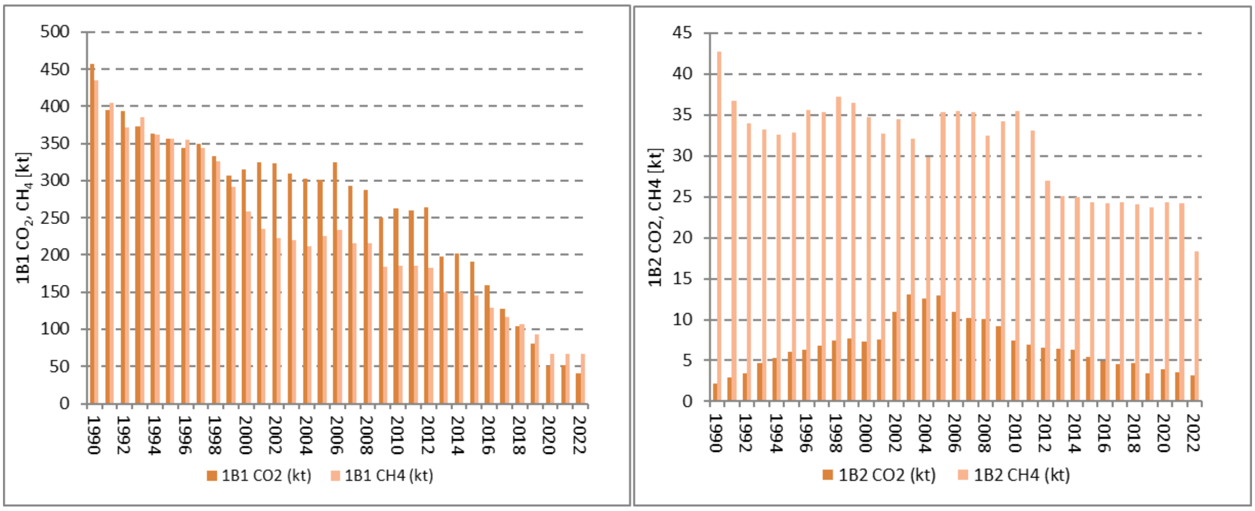

Fig. 3-3 CO_2 and CH_4 trend from the sector Fugitive Emissions from Solid Fuels and from the sector Fugitive Emissions from Oil and Natural Gas.

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 – 2022 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	163 204	149 369	56 830	47 105	11 249	33 990	194	13 835	12 638	1 198
1991	150 465	137 727	55 452	39 853	10 190	32 076	156	12 738	11 708	1 030
1992	145 725	133 971	54 626	43 890	10 613	24 642	201	11 753	10 800	953
1993	141 388	129 297	54 297	36 746	10 174	27 891	188	12 091	11 157	934
1994	132 044	120 637	54 818	29 181	11 093	25 331	214	11 407	10 488	919
1995	131 369	120 105	61 735	24 465	10 410	23 279	217	11 265	10 337	927
1996	134 178	122 888	66 489	24 250	10 636	21 303	211	11 290	10 288	1 002
1997	128 902	117 916	62 782	24 057	10 616	20 263	198	10 986	9 990	996
1998	122 930	112 429	60 652	21 702	12 004	17 899	172	10 501	9 451	1 050
1999	115 394	105 893	58 200	18 504	12 124	16 900	166	9 501	8 471	1 029
2000	123 740	115 192	62 035	23 422	12 238	17 318	179	8 548	7 570	979
2001	123 673	115 863	64 217	20 876	13 021	17 589	160	7 810	6 886	924
2002	120 399	112 867	62 770	19 995	13 486	16 379	237	7 532	6 556	976
2003	122 944	115 551	62 422	19 934	15 367	17 587	240	7 393	6 482	911
2004	122 615	115 528	62 541	19 567	16 077	17 076	268	7 086	6 237	850
2005	121 842	114 217	63 138	18 843	17 363	14 605	267	7 625	6 624	1 001
2006	121 943	114 059	62 588	18 542	17 658	15 018	254	7 884	6 880	1 004
2007	122 754	115 403	66 235	16 657	18 607	13 564	339	7 351	6 351	1 000
2008	117 524	110 288	61 506	16 072	18 470	13 871	368	7 236	6 317	919
2009	111 393	105 006	57 437	15 780	17 796	13 638	356	6 387	5 419	967
2010	113 213	106 777	62 176	12 112	16 790	15 378	322	6 436	5 436	1 000
2011	110 723	104 335	61 893	11 144	16 617	14 303	378	6 388	5 454	935
2012	106 912	100 774	59 023	10 799	16 329	14 314	309	6 138	5 377	761
2013	101 479	96 370	55 200	10 258	16 201	14 407	303	5 110	4 400	710
2014	98 462	93 360	53 768	9 731	16 716	12 834	312	5 102	4 396	707
2015	99 457	94 524	53 666	9 870	17 463	13 152	372	4 933	4 247	686
2016	100 690	96 249	54 432	9 610	18 130	13 679	398	4 441	3 758	683
2017	101 466	97 412	53 648	10 470	18 634	14 206	454	4 054	3 369	685
2018	99 297	95 527	52 934	10 222	18 826	13 229	315	3 771	3 090	680
2019	94 284	90 922	49 176	9 780	19 000	12 670	297	3 362	2 693	669
2020	84 887	82 274	41 592	10 266	17 703	12 398	315	2 613	1 929	684
2021	88 700	86 100	41 006	12 972	18 912	12 843	366	2 600	1 918	682
2022	87 917	85 473	42 770	11 318	19 400	11 716	269	2 444	1 927	517
Total Trend 1990 - 2022	**-46%**	**-43%**	**-25%**	**-76%**	**72%**	**-66%**	**38%**	**-82%**	**-85%**	**-57%**

3.2 Fuel combustion activities (CRF 1.A)

3.2.1 Comparison of the sectoral approach with the reference approach

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

From 2015 submission onward, it is required to use the Reference Approach in line with IPCC 2006 Guidelines (IPCC, 2006). Main difference between the new reference approach in contrast with the old one, used until now (IPCC 1997), is that instead of the concept of "long-term stored carbon" (stored carbon), used for some non-energy fuels, now a new, broader concept is used - "excluded carbon", which includes not only the stored carbon, but also carbon used and emitted as CO_2 in other sectors, not only in 1.A (most often in sector 2 IPPU). This means that from the total carbon, calculated on the base of apparent domestic consumption (Apparent consumption, AC) is deducted the "excluded carbon". It is mainly the case of carbon contained in fossil fuels used: (i) as raw materials for further treatment in the industry (feedstocks), (ii) as reductants and (iii) as non-energy products. Overview of materials, containing "excluded carbon" is given in Tab. 3-4.

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

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

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

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

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

In Tab. 3-5 and Tab. 3-6 are reported values, set by the reference approach for the years 1990, 1995, 2000, 2005, 2010, 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022 and a comparison between the reference and sectoral approach for the same years. In Tab. 3-7 is summarized comparison for all time period. In majority of cases relative differences are less than 2%.

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

Year	Type of fossil fuels	Apparent Consumption [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]
1990	Liquid Fuels	358.54	71.77	286.78	296.23	-3.19
	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	0.26		0.26	0.26	0.00
	Total	**1 893.79**	**158.49**	**1 735.30**	**1 681.14**	**3.22**
1995	Liquid Fuels	321.28	96.96	224.31	232.82	-3.66
	Solid Fuels	937.64	71.03	904.15	866.61	4.33
	Gaseous Fuels	274.74		274.74	260.80	5.35
	Other Fuels	0.65		0.65	0.68	-4.15
	Total	**1 534.31**	**167.99**	**1 403.86**	**1 360.91**	**3.16**
2000	Liquid Fuels	312.99	87.58	225.41	240.01	-6.08
	Solid Fuels	901.78	66.29	835.48	822.67	1.56
	Gaseous Fuels	314.52		314.52	305.05	3.10
	Other Fuels	1.28		1.28	1.39	-7.93
	Total	**1 530.56**	**153.87**	**1 376.69**	**1 369.12**	**0.55**
2005	Liquid Fuels	387.91	111.37	276.54	292.26	-5.38
	Solid Fuels	847.06	75.47	771.58	762.94	-1.12
	Gaseous Fuels	323.04		323.04	318.87	-1.29
	Other Fuels	5.69		5.69	5.69	0.08
	Total	**1 563.70**	**186.84**	**1 376.86**	**1 379.76**	**-0.21**
2010	Liquid Fuels	370.18	99.60	270.58	277.43	-2.47
	Solid Fuels	780.54	71.50	709.05	703.19	0.83
	Gaseous Fuels	338.55	3.80	334.75	309.77	8.06
	Other Fuels	5.89		5.89	6.20	-4.96
	Total	**1 495.16**	**174.90**	**1 320.26**	**1 296.59**	**1.83**
2015	Liquid Fuels	354.66	81.87	272.78	278.53	-2.06
	Solid Fuels	682.81	73.80	607.45	595.94	1.93
	Gaseous Fuels	272.03	4.02	268.01	263.19	1.83
	Other Fuels	8.14		8.14	8.56	-4.84
	Total	**1 317.64**	**159.69**	**1 156.39**	**1 146.22**	**0.89**
2016	Liquid Fuels	330.88	52.81	278.08	278.44	-0.13
	Solid Fuels	685.73	77.19	607.46	598.68	1.47
	Gaseous Fuels	294.46	4.21	290.25	285.64	1.61
	Other Fuels	9.32		9.32	9.77	-4.60
	Total	**1 320.39**	**134.20**	**1 185.11**	**1 172.54**	**1.07**
2017	Liquid Fuels	381.63	102.24	279.40	286.76	-2.57
	Solid Fuels	657.82	67.92	588.64	600.01	-1.90
	Gaseous Fuels	302.19	3.72	298.46	294.59	1.31
	Other Fuels	9.17		9.17	9.62	-4.70
	Total	**1 350.81**	**173.88**	**1 175.67**	**1 190.99**	**-1.29**
2018	Liquid Fuels	388.22	103.21	285.01	288.33	-1.15
	Solid Fuels	656.34	71.45	584.28	587.85	-0.61
	Gaseous Fuels	302.19	3.74	298.45	278.81	7.04
	Other Fuels	10.14		10.14	10.58	-4.15
	Total	**1 356.89**	**178.40**	**1 177.89**	**1 165.57**	**1.06**
2019	Liquid Fuels	390.69	104.02	286.66	290.00	-1.15
	Solid Fuels	592.79	66.07	526.18	529.83	-0.69
	Gaseous Fuels	300.38	4.08	296.30	292.60	1.26
	Other Fuels	10.64		10.64	11.12	-4.26
	Total	**1 294.49**	**174.18**	**1 119.78**	**1 123.55**	**-0.33**
2020	Liquid Fuels	354.36	83.99	270.37	272.58	-0.81
	Solid Fuels	511.35	63.57	447.24	452.69	-1.20

Year	Type of fossil fuels	Apparent Consumption [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]
	Gaseous Fuels	305.33	4.00	301.34	298.26	1.03
	Other Fuels	10.01		10.01	10.55	-5.16
	Total	**1 181.06**	**151.55**	**1 028.96**	**1 034.07**	**-0.49**
2021	Liquid Fuels	388.72	100.07	288.65	292.97	-1.48
	Solid Fuels	536.05	71.09	464.95	465.84	-0.19
	Gaseous Fuels	327.17	3.45	323.72	320.43	1.03
	Other Fuels	9.62		9.62	10.13	-5.04
	Total	**1 261.56**	**174.62**	**1 086.95**	**1 089.37**	**-0.22**
2022	Liquid Fuels	395.32	98.36	288.65	298.24	-3.22
	Solid Fuels	561.03	62.79	464.95	486.97	-4.52
	Gaseous Fuels	266.25	2.49	323.72	260.68	24.18
	Other Fuels	9.38		9.62	9.84	-2.19
	Total	**1 231.99**	**163.64**	**1 086.95**	**1 055.73**	**2.96**

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

Year	Type of fossil fuels	Apparent Consumption [kt CO_2]	Carbon excluded [kt CO_2]	RA [kt CO_2]	SA [kt CO_2]	(RA-SA)/SA [%]
1990	Liquid Fuels	26 349.44	5 392.00	20 957.44	22 055.35	-4.98
	Solid Fuels	126 345.82	9 280.00	117 065.82	113 360.35	3.27
	Gaseous Fuels	11 990.12	0.00	11 990.12	11 200.98	7.05
	Other Fuels	24.04		24.04	24.04	0.00
	Total	**164 709.42**	**14 672.00**	**150 037.42**	**146 640.74**	**2.32**
1995	Liquid Fuels	23 431.20	7 197.00	16 234.20	17 162.76	-5.41
	Solid Fuels	89 857.58	7 600.00	82 257.58	86 592.46	-5.01
	Gaseous Fuels	15 110.05	0.00	15 110.05	14 343.44	5.34
	Other Fuels	59.83		59.83	61.98	-3.48
	Total	**128 458.67**	**14 797.00**	**113 661.67**	**118 160.65**	**-3.81**
2000	Liquid Fuels	22 778.76	6 481.00	16 297.76	17 570.35	-7.24
	Solid Fuels	86 604.97	7 093.00	79 511.97	79 108.45	0.51
	Gaseous Fuels	17 297.33	0.00	17 297.33	16 776.79	3.10
	Other Fuels	117.00		117.00	125.38	-6.68
	Total	**126 798.05**	**13 574.00**	**113 224.05**	**113 580.97**	**-0.31**
2005	Liquid Fuels	40 144.58	20 072.29	20 072.29	21 518.14	-6.72
	Solid Fuels	146 735.88	73 367.94	73 367.94	73 181.95	0.25
	Gaseous Fuels	35 529.19	17 764.59	17 764.59	17 535.52	1.31
	Other Fuels	500.73		500.73	501.09	-0.07
	Total	**222 910.37**	**111 204.82**	**111 705.55**	**112 736.70**	**-0.91**
2010	Liquid Fuels	27 101.06	7 394.00	19 707.06	19 977.92	-1.36
	Solid Fuels	74 538.80	7 296.00	67 242.80	67 549.56	-0.45
	Gaseous Fuels	18 717.09	210.00	18 507.09	17 126.77	8.06
	Other Fuels	512.00		512.00	535.46	-4.38
	Total	**222 910.37**	**111 204.82**	**111 705.55**	**112 736.70**	**-0.91**
2015	Liquid Fuels	26 058.09	6 134.00	19 924.09	20 033.59	-0.55
	Solid Fuels	65 174.64	7 471.00	57 703.64	57 527.58	0.31
	Gaseous Fuels	15 075.90	223.00	14 852.90	14 586.54	1.83
	Other Fuels	702.53		702.53	734.51	-4.35
	Total	**107 011.17**	**13 828.00**	**93 183.17**	**92 882.23**	**0.32**
2016	Liquid Fuels	24 265.15	3 980.15	20 285.00	20 092.80	0.96
	Solid Fuels	65 417.75	7 825.99	57 591.76	57 804.30	-0.37
	Gaseous Fuels	16 342.55	233.15	16 109.40	15 854.22	1.61
	Other Fuels	804.19		804.19	838.58	-4.10
	Total	**106 829.64**	**12 039.29**	**94 790.34**	**94 589.90**	**0.21**
2017	Liquid Fuels	27 932.59	7 526.16	20 406.43	20 647.41	-1.17
	Solid Fuels	62 882.14	6 928.51	55 953.64	57 900.85	-3.36
	Gaseous Fuels	16 759.76	206.53	16 553.24	16 339.36	1.31

Year	Type of fossil fuels	Apparent Consumption [kt CO_2]	Carbon excluded [kt CO_2]	RA [kt CO_2]	SA [kt CO_2]	(RA-SA)/SA [%]
	Other Fuels	788.64		788.64	823.25	-4.20
	Total	**108 363.15**	**14 661.19**	**93 701.95**	**95 710.86**	**-2.10**
2018	Liquid Fuels	28 436.53	7 642.59	20 793.94	20 753.71	0.19
	Solid Fuels	62 808.15	7 247.67	55 560.48	56 713.25	-2.03
	Gaseous Fuels	16 759.72	207.40	16 552.32	15 464.26	7.04
	Other Fuels	875.37		875.37	909.00	-3.70
	Total	**108 879.77**	**15 097.66**	**93 782.11**	**93 840.22**	**-0.06**
2019	Liquid Fuels	28 642.51	7 681.46	20 961.05	20 849.96	0.53
	Solid Fuels	56 799.93	6 670.68	50 129.25	51 235.08	-2.16
	Gaseous Fuels	16 650.18	226.18	16 423.99	16 220.46	1.25
	Other Fuels	903.68		903.68	939.92	-3.86
	Total	**102 996.30**	**14 578.33**	**88 417.97**	**89 245.42**	**-0.93**
2020	Liquid Fuels	25 990.24	6 240.13	19 750.10	19 605.39	0.74
	Solid Fuels	48 912.60	6 467.61	42 444.99	43 590.54	-2.63
	Gaseous Fuels	16 930.38	221.52	16 708.87	16 539.26	1.03
	Other Fuels	845.80		845.80	887.43	-4.69
	Total	**92 679.02**	**12 929.26**	**79 749.76**	**80 622.62**	**-1.08**
2021	Liquid Fuels	28 573.69	7 413.99	21 159.70	21 035.50	0.59
	Solid Fuels	51 096.23	7 175.98	43 920.25	44 644.34	-1.62
	Gaseous Fuels	18 137.63	191.45	17 946.18	17 765.23	1.02
	Other Fuels	841.23		841.23	880.24	-4.43
	Total	**98 648.78**	**14 781.42**	**83 867.35**	**84 325.32**	**-0.54**
2022	Liquid Fuels	28 964.89	7 267.80	21 697.09	21 426.18	1.26
	Solid Fuels	53 580.84	6 337.36	47 243.47	46 942.75	0.64
	Gaseous Fuels	14 850.32	139.01	14 711.31	14 529.80	1.25
	Other Fuels	804.60		804.60	839.90	-4.20
	Total	**98 200.64**	**13 744.17**	**84 456.47**	**83 738.64**	**0.86**

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

Year	Appar. cons. [PJ]	Carbon excluded [PJ]	Reference approach [PJ]	Sectoral approach [PJ]	(RA-SA)/SA [%]	Activity data [kt CO_2]	Carbon excluded [kt CO_2]	Reference approach [kt CO_2]	Sectoral approach [kt CO_2]	(RA-SA)/SA [%]
1990	1 893.79	158.49	1 735.30	1 681.14	3.22	164 709	14 672	150 037	146 641	2.32
1991	1 702.58	114.01	1 588.57	1 553.39	2.27	148 049	10 766	137 283	135 215	1.53
1992	1 640.02	120.19	1 519.83	1 540.14	-1.32	140 211	11 327	128 884	131 670	-2.12
1993	1 579.18	108.30	1 470.88	1 493.01	-1.48	134 585	10 250	124 335	127 106	-2.18
1994	1 511.02	130.62	1 380.40	1 394.97	-1.04	127 864	12 125	115 739	118 567	-2.39
1995	1 534.31	167.99	1 366.32	1 398.46	-2.30	128 459	14 797	113 662	118 161	-3.81
1996	1 576.75	174.02	1 402.74	1 448.53	-3.16	130 456	15 311	115 145	120 885	-4.75
1997	1 591.93	171.18	1 420.75	1 396.81	1.71	132 368	15 251	117 117	116 027	0.94
1998	1 542.54	167.22	1 375.32	1 348.16	2.01	127 082	14 935	112 147	110 789	1.23
1999	1 424.49	149.05	1 275.43	1 281.17	-0.45	115 474	12 876	102 598	104 368	-1.70
2000	1 530.56	153.87	1 376.69	1 369.12	0.55	126 798	13 574	113 224	113 581	-0.31
2001	1 555.74	151.23	1 404.50	1 389.09	1.11	127 887	13 262	114 625	114 324	0.26
2002	1 537.36	158.85	1 378.51	1 356.21	1.64	126 239	14 023	112 215	111 360	0.77
2003	1 558.48	167.48	1 391.01	1 389.49	0.11	128 122	14 871	113 251	114 010	-0.67
2004	1 527.10	195.67	1 331.43	1 394.02	-4.49	124 541	17 064	107 477	113 984	-5.71
2005	1 563.70	186.84	1 376.86	1 379.76	-0.21	127 737	16 032	111 706	112 737	-0.91
2006	1 591.18	196.82	1 394.37	1 378.93	1.12	130 360	17 090	113 270	112 548	0.64
2007	1 591.56	187.37	1 404.19	1 387.61	1.19	131 364	16 424	114 939	113 892	0.92
2008	1 530.32	192.37	1 337.95	1 333.70	0.32	125 143	16 524	108 619	108 792	-0.16
2009	1 406.91	158.87	1 248.05	1 265.41	-1.37	114 661	13 513	101 147	103 487	-2.26
2010	1 495.16	174.90	1 320.26	1 296.59	1.83	120 868	14 899	105 969	105 190	0.74
2011	1 416.33	167.37	1 248.95	1 254.84	-0.47	115 981	14 342	101 639	102 739	-1.07

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 [%]
2012	1 364.62	170.23	1 194.39	1 214.90	-1.69	111 079	14 512	96 567	99 154	-2.61
2013	1 356.64	167.65	1 188.99	1 169.06	1.70	110 248	14 393	95 855	94 721	1.20
2014	1 291.21	179.77	1 111.44	1 127.78	-1.45	104 929	15 384	89 545	91 741	-2.39
2015	1 316.08	159.69	1 156.39	1 146.22	0.89	107 085	13 902	93 183	92 882	0.32
2016	1 319.32	134.20	1 185.11	1 172.54	1.07	106 838	12 048	94 790	94 590	0.21
2017	1 349.56	173.88	1 175.67	1 190.99	-1.29	108 362	14 660	93 702	95 711	-2.10
2018	1 356.29	178.40	1 177.89	1 165.57	1.06	108 879	15 097	93 782	93 840	-0.06
2019	1 293.96	174.18	1 119.78	1 123.55	-0.33	102 996	14 578	88 418	89 245	-0.93
2020	1 180.51	151.55	1 028.96	1 034.07	-0.49	92 679	12 929	79 750	80 623	-1.08
2021	1 261.56	174.62	1 086.95	1 089.37	-0.22	98 649	14 781	83 867	84 325	-0.54
2022	1 231.99	163.64	1 068.35	1 055.73	1.20	98 201	13 744	84 456	83 739	0.86

In years 1990, 1992, 1993, 1994, 1995, 1996, 2004, 2009, 2012, 2014 and 2017 is difference between referece and sectoral approach higher than 2%. These differences are mainly caused by statistical differences (SD), how demonstrate Tab. 3-8. For some years, the ratio between RA and SA did not decrease under 2% even though SD was substracted. This effect can be caused by stock changes which have not been properly reported into CzSO. This assumption is based on the fact that difference between RA and SA for the surrounding years is very low.

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

Years	(RA-SA)/SA [%]	Statistical diffrences (SD) [TJ]	Share SD from sectoral approach [%]	(RA-SA)/SA without SD [%]
1990	2.32	63 291.46	3.64	-1.32
1992	-2.12	12 102.63	0.75	-2.87
1993	-2.18	-7 623.93	-0.49	-1.69
1994	-2.39	-15 358.56	-1.05	-1.33
1995	-3.81	-9 473.82	-0.65	-3.15
1996	-4.75	-6 487.39	-0.43	-4.32
2004	-5.71	-14 378.42	-0.98	-4.73
2009	-2.26	-13 980.44	-1.02	-1.24
2012	-2.61	-3 620.18	-0.27	-2.34
2014	-2.39	6 373.25	0.49	-2.89
2017	-2.10	-3 217.46	-0.24	-1.86

3.2.2 International bunker fuels

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

Basic activity data are available in the CzSO energy balance (CzSO, 2023). 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	2004
[TJ/year]	7 344	6 040	6 996	5 823	7 257	7 820	5 603	5 217	4 902	5 633	6 665	6 762	6 976	8 432	12 070
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
[TJ/year]	13 182	14 073	14 462	14 895	14 246	13 120	12 990	12 297	11 864	12 254	12 341	13 250	14 852	17 147	17 537
Year	**2020**	**2021**	**2022**												
[TJ/year]	4 763	6 408	11 085												

3.2.3 Feedstocks and non-energy use of fuels

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

Non-energy fuels are divided into three categories:

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

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

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

Some types of liquid fuels are designed mainly for non-energy use. This is primarily naphtha, for which CzSO indicates, since 2001, that virtually the entire amount is consumed for non-energy purposes by the chemical industry, mainly as petrochemicals (2.B). Less significant is the non-energy use of LPG. Since Naphtha is major feedstock, the emission from sector 2.B.8 Petrochemical and Carbon Black Production is reported in the CRF Table 1.A(d) as arising from this feedstock. Following the recommendation of the 2019 review the emissions from non-energy use od fuels from LPG and Gas/Diesel are reported in the CRF 1AD as well. There is apparent decrease of Ethylene production in 2016 after the accident in 2015 (see also Chapter 4), when the rest of the LPG was used for other petrochemical production.

Another important type of liquid fuels consumed for non-energy purposes of fuels is a group marked as Other Oils. Their most significant share is Other Petroleum Products, which finds application in the production of hydrogen by partial oxidation with steam for subsequent production of ammonia and further part of it is also used as a Solvent Use. In 2021, the consumption of Other Petroleum Products for non-energy purposes (particularly in sub-sectors 2.B, 2.D) was 15 PJ. CO_2 produced during ammonia production (2.B.1) is reported in Table 1.A(d) under Other Oil. The rest of the Other Oil used in non-energy use is processed for the Solvents. Following the IPCC 2006 Gls., from Solvent Use (2.D.3) there is no CO_2 produced.

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

The liquid fuels, used specially for non-energy purposes, include also bitumen, whose consumption in 2022 was 19 PJ and lubricants with consumption in 2022 of 6 PJ. While in the case of using bitumen there are no emissions of CO_2 (Stored carbon), in the case of lubricants use, annually a part is oxidized to CO_2 (Reported in 2.D.1). Consequently, CO_2 reported in Table1.A(d) under Lubricants is the CO_2 which is arising in 2.D.1.

Solid fuels for non-energy purposes are mainly used as reductants. These include coke (Coke Oven Coke), from which in 2022 were used 45 PJ in the production of iron and steel (2.C.1). Consequently, CO_2 reported in Table 1.A(d) under Coke Oven Coke is the CO_2 which is arising in 2.C.1 from Metallurgical coke use. In the Other bituminous coal in 2022 were used 6 PJ as non-energy use. Other bituminous coal was used as reductant in 2.C.1 as well.

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

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

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

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

Non-energy Fuels	NCV	EF
	[GJ/kt]	[t CO_2/TJ]
LPG	45 945[1)]	65.86[1)]
Naphtha	43 600	73.30
Gas/Diesel Oil	42 600	74.10
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	38 931	73.30
Refinery Gas	46 023	55.08[1)]
Coke Oven Coke	28 037[2)]	107.00

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

3.2.4 Methodological issues

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

The data for the whole time series was constructed on the basis of data from the CzSO Questionnaire (CzSO, 2023), where the data on fuel consumption are provided in various ways. Data are available for Solid and Liquid Fuels in mass units (kt p.a.), where the net caloric values of these fuels are also tabulated. The consumption of gaseous fuels derived from fossil fuels is given in TJ p.a. Natural Gas is given in thousand m^3 and the consumption in TJ is also tabulated; however, in this case it is calculated using the gross caloric value. The Energy balance in mass units (kt p.a.) for last reported year (2022) is given in Annex 4, Tables A4-1 – A4-7.

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

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

3.2.4.1 Collection of activity data

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

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

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

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

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

3.2.4.2 Conversion of activity data to the CRF format

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

The Title page shall contain particularly the following information:

- the name and description of the file
- the author of the file
- the date of creation of the file
- the dates of the latest up-dating, in order

- the source of the data employed
- description of transfer of specific data from the source files
- the means of aggregation of the data base employed in conversion
- explanations and comments.

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

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

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

3.2.4.3 Calculations of emissions

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

Coke Oven Gas, Gas Works Gas and biofuels are given directly in terajoules in the CzSO Questionnaires (CzSO, 2023), 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, 2023) in thousand m^3 and in TJ; however, the data in TJ is determined using the gross caloric value. Volume reported by CzSO in thousand m^3 is related to the „trade conditions“, i.e. temperature 15°C and pressure 101.3 kPa.

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

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

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

where NCV and GCV are expressed in MJ/m^3 in the reference temperatures of 15 ˚C (i.e. trade conditions). However, improved values of the ratio NCV/GCV is not far from the IPCC default value 0.9. For example, to the NCV = 34.533 MJ/m^3 corresponds the ratio NVC/GCV=0.9021 calculated from the equation above. This equation was used for calculation of NCV from GCV for all time period.

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

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

General CO_2 emission factors and NCV are provided in Tab. 3-11. With regards that values in following table are used in Czechia companies with obligation to report their emission to 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-years mean i.e. mean of years 2018 – 2022. This adjustment decrease inaccuracies in emission reporting to EU ETS, which are caused by time discrepancy (companies will use the values for reporting year 2023).

Tab. 3-11 Net calorific values (NCV), CO_2 emission factors and oxidation factors used in the submission 2024

Fuel (IPCC 2006 Guidelines definitions)	NCV [TJ/kt]	CO_2 EF [a] [t CO_2/TJ]	Oxidation factor	CO_2 EF [b] [t CO_2/TJ]
Crude Oil	42.560	73.300	1	73.3
Gas/Diesel Oil	43.065	74.100	1	74.1
Residual Fuel Oil	39.500	77.400	1	77.4
LPG [d]	45.945	65.860	1	65.86
Naphtha	43.600	73.300	1	73.3
Bitumen	40.193	80.700	1	80.7
Lubricants	40.193	73.300	1	73.3
Petroleum Coke	39.400	97.500	1	97.5
Other Oil	38.899	73.300	1	73.3
Coking Coal [d]	29.470	93.545	1	93.55
Other Bituminous Coal [d]	26.505	95.166	0.9707	92.38
Lignite (Brown Coal) [d]	13.622	100.557	0.9846	99.01
Brown Coal Briquettes	22.777	97.500	0.9846	96.00
Coke Oven Coke	28.603	107.000	1	107.00
Coke Oven Gas TJ/mill. m^3) [c]	16.925	44.4	1	44.4
Natural Gas (TJ/Gg) [d]	48.649	55.511	1	55.51
Natural Gas (TJ/mill. m^3) [d]	34.607	55.511	1	55.51

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 2020 to obtain new, more accurate values for the uncertainties. The results are given in below and Annex 2.

Activity data

Information on fuel consumption is taken from CzSO (CzSO, 2023).

Uncertainties:

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

Uncertainties also arise during data processing. CzSO obtains data in mass units – tons per year (1st level of uncertainty). The resultant balance is expressed in energy units – TJ p.a. Recalculation from mass units to energy units must be performed using the fuel calorific value. The determination of these values is accompanied by uncertainties following from the method employed (mostly laboratory expertise) (2nd level of uncertainty). The average fuel calorific value valid for all of Czechia 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.

In 2020 was carried out an extensive study aiming to update to uncertainties in the Energy sector. The study follows that the lowest uncertainties of activity data should be expected in sector 1.A.1., since all individual enterprises in this sector are the economic units with more than 20 employees, which means that all fuel consumption is subject to questionnaire of the CzSO. Higher uncertainties should be expected in sector 1.A.2. These are a large number of small individual enterprises, of which only a certain number are the economic units. The highest uncertainties should be expected in sector 1.A.4. This is a diverse group of sources that are scattered throughout Czechia and their economic units are relatively small.

Due to the high variability between subcategories described above, the uncertainties was set for each type of fuel and the specific subcategory e.g., uncertainty of 1.A.1.a-Solid fuels, 1.A.1.a-Natural Gas etc. Three independent experts estimate of 'basic' uncertainties were done in detail scale described in this paragraph and then experts estimate averaged. To determine uncertainties on coarser scale (e.g, 1.A.1 or 1.A.2) is used weighted average, where fuel consumption (TJ) is used as a weights in calculation (for details see Veselá et al. 2020).

For specific uncertainties of activity data used for introduction into the trend in total national emissions see Annex 2.

Emission factors

The above mentioned study had aim to update uncertainties of EF as well. Country-specific EF for calculation CO_2 emissions are used for the most important type of fuels in Czechia inventory (Brown Coal+Lignite, Bitumenous Coal, Cokign Coal, Gas Work Gas, Natural Gas, Refinery Gas and LPG). For the rest of fuel is used default EF, from which the most important for inventory is Coke and Fuel Oil. The country-specific EF is determined with knowledge of carbon content in fuels and net caloric values. In this case, the uncertainties are dependent on the accuracy of laboratory determination of net calorific values and laboratory analyses of fuels, where low uncertainties could be expected. Due to the fact that Coke and Fuel oils (in which we use default EF) have a very stable composition (carbon content), regardless of national specifics, it can be considered that these fuels have the same composition all over the world and low uncertainties could be expected.

Generally, the formation of CH_4 and N_2O is not widely explore, it is necessary to consider high uncertainties (up to hundreds percent). According to our internal results that have been collected so far, it is not yet confirmed that CH_4 emissions at small and large equipment significantly differed.

The determination of EF uncertainties was carried out according the same methodology as in case of AD uncertainties i.e. three independent experts estimate of 'basic' uncertainties, which were averaged (see above or for details Veselá et al. 2020).

For specific uncertainties of emission factors used for introduction into the trend in total national emissions see Annex 2.

Time - series consistency

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

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

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

Example:

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

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

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

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

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

3.2.6 QA/QC and verification

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

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

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

The QC procedures are related to the processing, manipulation, documentation, storing and transmission of information. The first step of the control is carried out by the expert responsible for the Sectoral Approach (Vladimir Neuzil), followed up by the control carried out by the QA/QC experts familiar with the topic (Andrea Veselá, external employee of KONEKO). At this control level individual steps are controlled according official QA/QC methodology (IPCC, 2006). To minimize technical errors both in CRF and in NIR we set up automatically connect for values transcription. In this way we connect files of CzSO, all computation files, QA/QC files and files for creation tables for NIR.

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

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

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

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

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 subcategories:

- 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)

This division is used in the new methodology (IPCC, 2006). Due to the activity data (from CzSO) inconsistency, it was decided to do not make activity data division into three subcategories as is shown above. The activity data are moving from one subcategory to another one according to new rules and for the Energy sector it would mean to do recalculations almost every year. The sum of the data in 1.A.1.a category remain same. Therefore the data will be reported as sum in the category 1.A.1.a.i.

The fraction of CO_2 emissions from sector 1.A.1 equalled 51 % in 2022 in the whole Energy sector (1.A) – combustion of fuels.

In 2022, the fraction of CO_2 emissions in subsector 1.A.1.a equalled 95% of total CO_2 emissions in sector 1.A.1 .

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

This category encompasses all facilities that produce electric energy and heat supplies, where this production is their main activity and they supply their products to the public mains. From the total installed capacity of electricity generation 19.34 GWe in 2022, 10.19 GWe are accounted for thermal power plants:

Nuclear	4 290	MWe
Hydro	2 100	MWe
Solar photovoltaic	2 421	MWe
Wind	339	MWe
Combustible fuels	10 193	MWe
Total capacity	**19 343**	**MWe**

In the final energy balance of CzSO (CzSO, 2023), 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)	**84 848**
Main activity producer electricity plants	68 729
Main activity producer CHP plants	8 782
Autoproducer electricity plants	625
Autoproducer CHP plants	6 712
Heat production (TJ)	**110 314**
Main activity producer CHP plants	77 120
Main activity producer heat plants	17 989
Autoproducer CHP plants	6 991
Autoproducer heat plants	8 087

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. For few years back it can be seen that CO_2 emissions have decreasing trend.

The trend in emissions is mainly shaped by the development and structures of the electricity generation installations involved, since these installations account for the majority of the pertinent emissions. As is clear from the figure, Solid Fuels are the main driving force for emissions in this source category. Brown Coal and Lignite are the most important, with total consumption of 425 PJ, corresponding to 41 945 kt CO_2/year on an average for the whole 1990 – 2022 period.

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 was conducted research in order to update these emission factors. The detailed description of the research is provided in Annex 3. As mentioned above, this means that approximately 95% of the emissions from fuels in this category were determined using country-specific emission factors, i.e. at the level of Tier 2.

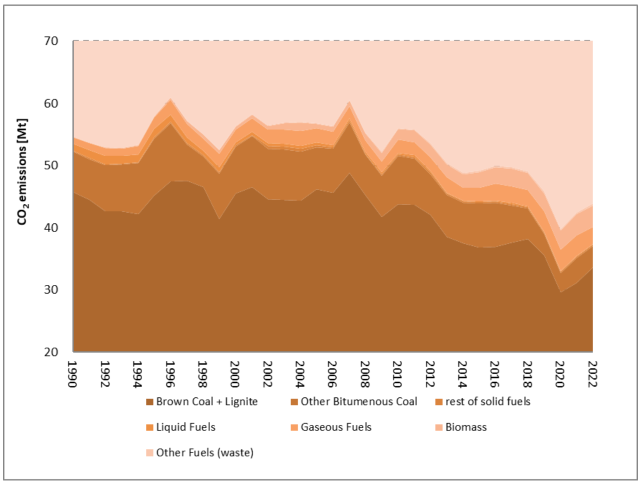

Fig. 3-4 Development of CO_2 emissions in 1.A.1.a category

Since submission in 2014 country specific oxidation factors for Other Bituminous Coal, Brown Coal and Lignite and Brown Coal Briquettes were applied. The detailed description of the research is given in Annex 3.

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

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

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

1.A.1.a, 2022								
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	644.32	55.08	1	35.49	1	0.00064	0.1	0.00006
LPG	367.56	65.86	1	24.21	1	0.00037	0.1	0.00004
Heating and Other Gasoil	127.80	74.10	1	9.47	3	0.00038	0.6	0.00008

1.A.1.a, 2022									
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	276.50	77.40	1	21.40	3	0.00083	0.6	0.00017
Fuel oil - High Sulphur	474.00	77.40	1	36.69	3	0.00142	0.6	0.00028
Other Bituminous Coal	37 145.37	95.26*)	0.9707*)	3 434.83	1	0.03715	1.5	0.05572
Brown Coal + Lignite	339 061.46	100.63*)	0.9846*)	33 594.15	1	0.33906	1.5	0.50859
Coal Tars	21.54	80.70	1	1.74	1	0.00002	1.5	0.00003
Brown Coal Briquets	1.02	97.5*)	0.9846*)	0.10	1	0.00000	1.5	0.00000
Coke oven gas	5 182.93	44.40	1	230.12	1	0.00518	0.1	0.00052
Natural Gas	49 860.39	55.78*)	1	2 780.98	1	0.04986	0.1	0.00499
Waste - fossil fraction	2 850.40	91.70	1	261.38	30	0.08551	4	0.01140
Waste - biomass fraction	4 275.60	100.00	1	427.56	30	0.12827	4	0.01710
Wood/Wood Waste	26 077.76	112.00	1	2 920.71	30	0.78233	4	0.10431
Gaseous Biomass	1 694.898	54.60	1	92.54	1	0.00169	0.1	0.00017
Total year 2022	**433 162.89**			**40 169.17**		**1.43273**		**0.70346**
Total year 2021	425 009.38			38 782.75		1.42426		0.67731
Index 2022/2021	1.02			1.04		1.01		1.04
Total year 1990	568 512.77			54 560.85		0.61880		0.81167
Index 2022/1990	0.76			0.74		2.32		0.87

*) *Country specific data*

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 (NG) plays a role in this source category. Use of NG does not exhibit a substantially oscillating trend. At the beginning of the period, it shows increasing trend, but later only minor changes were observed, which can be considered insignificant. Between years 1994 and 1995 the share of gaseous fuels in total consumption was 1.8 and 2.4 %, which corresponds to a fluctuation of 0.6 % in terms of all fuels in the sector. Such fluctuations are common and are based on the fuel market as well as on legislative requirements.

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.

2022							
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
Brown Coal Briquets	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Gas Works Gas	CzSO	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
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

3.2.7.1.1 Other Fuels (CRF 1.A.1.a.ii): Waste Incineration for energy purposes

This category consists of emissions caused by incineration of municipal solid waste for energy purposes. Originally this chapter was part of 5.C Waste Incineration but, based on the suggestion of ICR (in-country review), this chapter was shifted under the energy sector. This chapter is prepared by CENIA, Czech Environmental Information Agency – the organization responsible for the Waste sector. If the waste is incinerated for the purpose of obtaining energy in a dedicated facility (i.e., a waste incineration plant), it is reported to the Energy sector. All other waste is reported in the waste category.

Source of data about waste incineration is (V)ISOH -(Public) information system of waste management of the MoE. (V)ISOH contains bottom up data from waste management companies (individual data) and it is consistently used as a data source by waste sector as well. Its obligatory to report in to this system and about 60 thous. subjects reports in system each year. Data in (V)ISOH are crosschecked between subjects and on selected cases verified by Czech Environmental Inspection where discrepancies appear. Data in (V)ISOH are based on evidence, data from other sources are based on statistics. (V)ISOH is official data source for national environmental policies, their design and evaluation. Waste incineration in inventory is split between energy and waste sector in a way that all waste (predominantly municipal solid waste) that is incinerated in so called ZEVO´s (waste incinerator with energy use) is accounted in energy sector, rest of incinerated waste is accounted in waste sector.

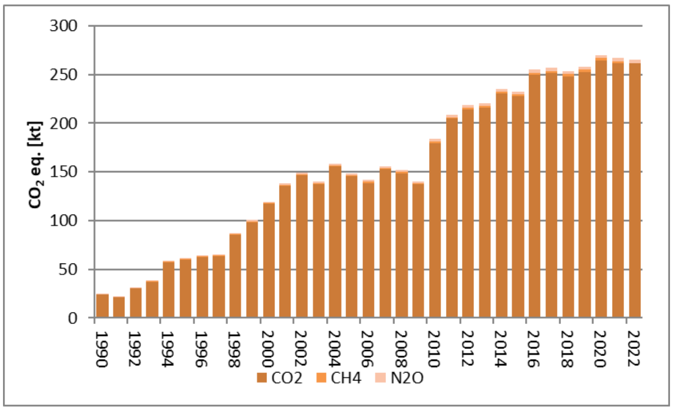

Fig. 3-5 trend of GHG emissions from waste incineration for energy purposes

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 as it is shown in Fig. 3-5.

Tab. 3-12 shows four municipal solid waste (MSW) incineration plants in the Czech Republic. One is located in Prague (ZEVO Malesice), one in Brno (SAKO), one in Liberec (Termizo) and the newest one since 2016 in Plzeň (ZEVO Plzeň, Chotíkov). MSW is sometimes co-incinerated in other facilities, too.

Tab. 3-12 Capacity of municipal waste incineration plants in the Czech Republic, 2022

Incinerator (city)	Capacity (kt) 2022
TERMIZO (Liberec)	96
Pražské služby a.s. (Praha)	330
SAKO a.s. (Brno)	248
Plzeňská teplárenská a.s. (Plzeň)	120

There are also several dozen facilities incinerating or co-incinerating waste without energy use. This waste is reported under 5C.

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

See chapter 3.2.5.

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

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.

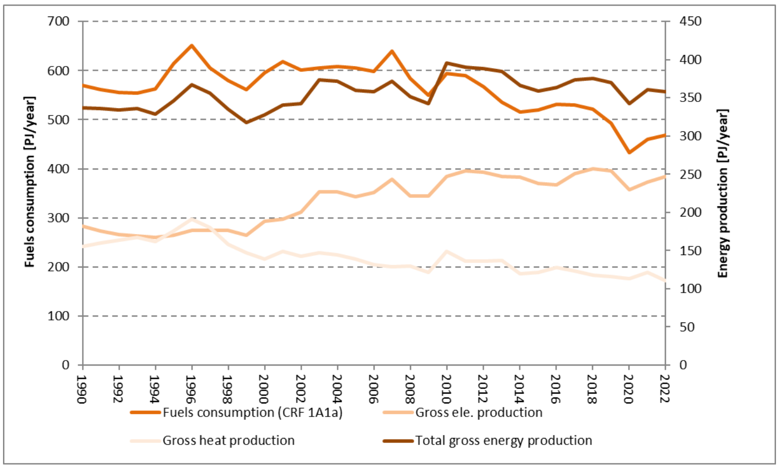

Fig. 3-6 The ratio between the total consumption of fuels from the heat sources in the category 1.A1.a and overall energy production

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

For additional information please see chapter 3.2.6.

3.2.7.3.1 Other Fuels (CRF 1.A.1.a.ii): Waste Incineration for energy purposes

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

3.2.7.4 Category-specific recalculations (CRF 1.A.1.a)

Based on the changes of Activity data (CzSO, 2023) recalculation was done for the Solid fuels for the year 2021, see the Tab. 3-13.

In the Tab. 3-14 is listed the recalculation of Gaseous fuel due to the change of Activity data in CzSO, 2023, for the year 2018.

Tab. 3-13 Changes after recalculation in 1.A.1.a.i for Solid Fuels.

Fuel consumption		2021	CH_4 emissions		2021
Submission 2023	TJ	364 286.90	Submission 2023	TJ	0.36
Submission 2024	TJ	381 412.32	Submission 2024	TJ	0.38
Difference	TJ	17 125.42	Difference	TJ	0.02
Submission 2024	%	4.70	Submission 2024	%	4.70
CO_2 emissions		2021	N_2O emissions		2021
Submission 2023	TJ	35 421.15	Submission 2023	TJ	0.54
Submission 2024	TJ	37 260.94	Submission 2024	TJ	0.56
Difference	TJ	1 839.79	Difference	TJ	0.03
Submission 2024	%	5.19	Submission 2024	%	4.87

Tab. 3-14 Changes after recalculation in 1.A.1.a for Gaseous Fuel.

Fuel consumption		2018	CH_4 emissions		2018
Submission 2023	TJ	47471.0648	Submission 2023	TJ	0.0475
Submission 2024	TJ	47471.9120	Submission 2024	TJ	0.0475
Difference	TJ	0.8472	Difference	TJ	0.0000
Submission 2024	%	0.0018	Submission 2024	%	0.0018
CO_2 emissions		2018	N_2O emissions		2018
Submission 2023	TJ	2632.2480	Submission 2023	TJ	0.0047
Submission 2024	TJ	2632.8547	Submission 2024	TJ	0.0047
Difference	TJ	0.6067	Difference	TJ	0.0000
Submission 2024	%	0.0230	Submission 2024	%	0.0018

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

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.

3.2.7.6 Category description (CRF 1.A.1.b)

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

1.A.1.b, 2022								
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	5292.65	55.08*)	1	291.50	1	0.00529	0.1	0.00053
Natural Gas	3846.08	55.78*)	1	214.52	1	0.00385	0.1	0.00038
Total year 2022	**9138.73**			**506.01**		**0.00914**		**0.00091**
Total year 2021	8681.43			479.35		0.00868		0.00087
Index 2022/2021	1.05			1.06		1.05		1.05
Total year 1990	8705.45			492.56		0.01017		0.00124
Index 2022/1990	1.05			1.03		0.90		0.74

*) *Country specific data*

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

2022							
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 constitutes approximately 1% of the total amount in 2022. All fuels used in the internal refinery processes, internal consumption (reported by companies as “own use”) for production of electricity and heat and heat supplied to the public mains are included in emission calculations in this subcategory. This corresponds primarily to the ORLEN UNIPETROL RPA Ltd. company in the Czech Republic. The company changed name in the year 2017 from Česká rafinérská Inc. 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 2022. It contributed 0.6% to CO_2 emissions in the whole Energy sector.

In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported under the item:

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

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

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

No consumption of Solid Fuels occurred in this category.

Liquid Fuels are of the greatest importance and exhibit an increasing trend in the whole period. The fluctuations that have occurred over the years can be explained as resulting from differences in production quantities (see also Fig. 3-8). The maximum production equal to 716 kt CO_2 occurred in 2008, followed by a value of 697 kt CO_2 in 2006. Thereafter, production decreased to the resulting level of 357 kt CO_2 in 2015, resp. 291 kt CO_2 in 2022. There is apparent decrease of Ethylene production in 2016 after the accident in 2015, when the rest of the LPG was used for other petrochemical production. The explanation of the ethylene production decrease is already included in NIR in the respective chapter in IPPU sector.

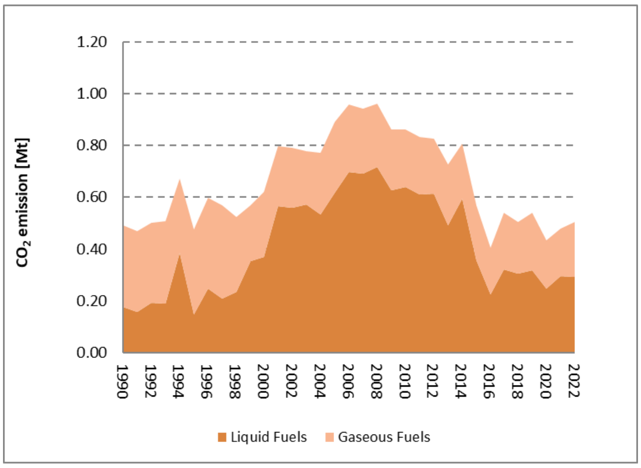

Fig. 3-7 Development of CO_2 emissions in 1.A.1.b category

The second greatest role is played by Natural Gas, with emissions in the range between 238 kt CO_2 in 2004 and 360 kt CO_2 in 1997 and resulting with decrease to 215 kt CO_2 in 2022.

3.2.7.7 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.

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

See chapter 3.2.5.

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

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

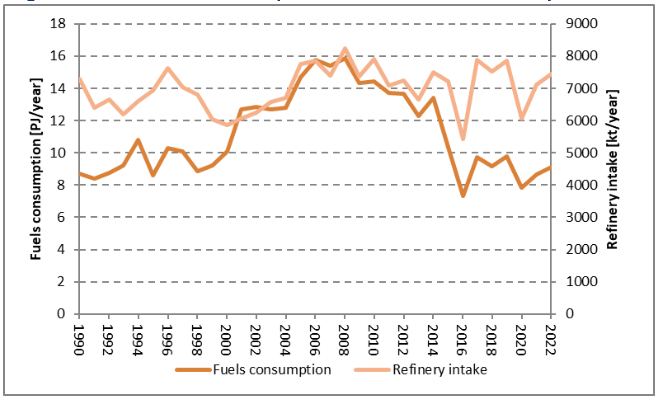

Fig. 3-8 Comparison of fuel consumption in the sector 1.A.1.b and amount of crude oil processed

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

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

3.2.7.10 Category-specific recalculations (CRF 1.A.1.b)

Based on the change of Net Calorific value in the CzSO, 2023 for the year 2018, recalculation for the Gaseous fuels had to be done. The recalculation is listed in the Tab. 3-15.

Tab. 3-15 Changes after recalculation in 1.A.1.b for Gaseous Fuel.

Fuel consumption		2018	CH_4 emissions		2018
Submission 2023	TJ	3621.0664	Submission 2023	TJ	0.0036
Submission 2024	TJ	3621.1310	Submission 2024	TJ	0.0036
Difference	TJ	0.0646	Difference	TJ	0.0000
Submission 2024	%	0.0018	Submission 2024	%	0.0018
CO_2 emissions		2018	N_2O emissions		2018
Submission 2023	TJ	200.7864	Submission 2023	TJ	0.0004
Submission 2024	TJ	200.8327	Submission 2024	TJ	0.0004
Difference	TJ	0.0463	Difference	TJ	0.0000
Submission 2024	%	0.0230	Submission 2024	%	0.0018

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

No further improvements in this subcategory are currently planned.

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

This category is divided into two subcategories:

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

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

3.2.8.1 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, 2022								
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	127.80	74.10	1	9.47	3	0.00038	0.6	0.00008
Brown Coal + Lignite	13 083.16	100,63*)	0.9846*)	1 296.28	1	0.01308	1.5	0.01962
Coke Oven Gas	6 497.2	44.40	1	288.47	1	0.00650	0.1	0.00065
Natural Gas	110.4	55.78*)	1	6.16	1	0.00011	0.1	0.00001

Total year 2022	**19 818.52**	**1 600.38**	**0.02007**	**0.02036**
Total year 2021	16 684.08	1 258.12	0.01694	0.01491
Index 2022/2021	1.19	1.27	1.19	1.37
Total year 1990	28 984.58	1 516.42	0.03348	0.00824
Index 2022/1990	0.68	1.06	0.60	2.47

[*)] Country specific data

The table shows that while the index for 2022/1990 of fuel consumption is 0.68, the same index for CO_2 emissions is significantly higher. It is caused by the high proportion of coke oven gas in the fuel structure in 1990, which has a relatively low emission factor. Later, part of coke oven gas was reallocated to other subsectors (1.A.1.a and 1.A.2.a). Even more markedly the high proportion of coke oven gas, combined with relatively low emission factor, compared to other fuels, occurred in N_2O emissions.
The origin of the data, the emission factors used and the method of calculating the level of emissions for each gas is presented in details in the following outline.

2022							
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
Coke Oven Gas	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1

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

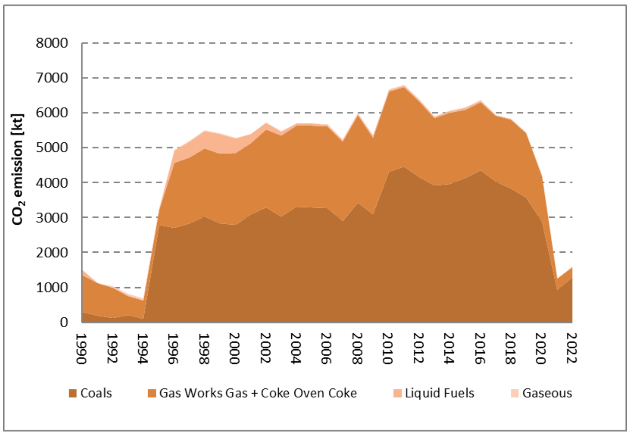

Fig. 3-9 Development of CO_2 emissions in 1.A.1.c.ii category

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 included Coke plants and the production of Gas Works Gas. Other energy industries, such as facilities for extraction of Natural Gas and Petroleum are of minor importance in the Czech Republic.

The visible decrease for the 2021 was caused by shutting down the fuel combine Vřesová where was produced Gas Works Gas from brown coal. Due to this effect there was an increase of coal in the Czech market, which led to higher consumption of Lignite in Manufacturing industries and construction (1.A.2).

The fraction of CO_2 emissions in subsector 1.A.1.c in CO_2 emissions in sector 1.A.1 was equalled 4 % in 2022. It contributed only 2 % to CO_2 emissions in the whole Energy sector 1.A.

In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported in capture Energy Sector under the items:

- Coal Mines
- Oil and Gas Extraction
- Coke Ovens (Energy)
- 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
- 19.20 Manufacture of refined petroleum products (this class also includes: manufacture of Peat Briquettes, manufacture of Hard-coal and Lignite fuel Briquettes)

Fig. 3-9 provides an overview of emission trends in source category 1.A.1.c. The figure clearly shows the sharp increase in emissions in 1995 – 2012 period. The use of Coal predominated in the whole period followed by the consumption of Gas Works Gas and Coke Oven Gas. There is very low use of Liquid Fuels and Natural Gas in this category. The sharp increase in the fuel consumption in 1995 is dependent on the economic situation of the respective companies, where the fuels are used. The Czech Republic is using official data reported by the official reporting authority in the Czech Republic and not even this authority would have updated data for the activity data which occurred 20 years ago.

Sokolovská Uhelná Inc. makes the greatest contribution to the consumption of Solid fuels. The section for processing Brown Coal was established in 1950 and also produced Gas Works Gas and other chemical products. Formally, the existence of this combine ended in 1974 when this facility was moved under the Hnědouhelné doly a briketárny company. Together with this step was established Fuel combine Vřesová. The new combined-cycle power station started to operate in 1996. This power station was closed in September 2020 (http://www.suas.cz).

Between 1990 and 1995, production of Coal Gas, which was distributed in the Czech Republic by Gas Work Vřesová, has been gradually phased out. On Fig. 3-9 can be seen a decline in production of Coal Gas and the starting up of production of Gas Works Gas for the production of electricity and the supply heat. 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 operating.

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

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

The amount of coal that was used for the production of technological steam is not directly accessible from the CzSO energy balance. Data from CHMI REZZO national emission database was used to determine the amount of coal. The quantity of coal for production of technological steam is given in Tab. 3-16.

Tab. 3-16 Consumption of Lignite for production of technological steam in Fuel combine Vřesová 1995 – 2022

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**	**2018**	**2019**	**2020**	**2021**	**2022**					
Lignite [kt/year]	2 140	2 054	1 904	1 449	2	0					

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

No other specific approaches were used in this category.

3.2.8.3 Uncertainties and time-series consistency (CRF 1.A.1.c.ii)

See chapter 3.2.5.

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

Fig. 3-10 contains a comparison between consumption of lignite in sector 1.A.1.c (data from the REZZO national emission database) and the total amount of lignite, entering the transformation process (gasified coal) in the Czech Republic (data CzSO) in the period 1995-2022.

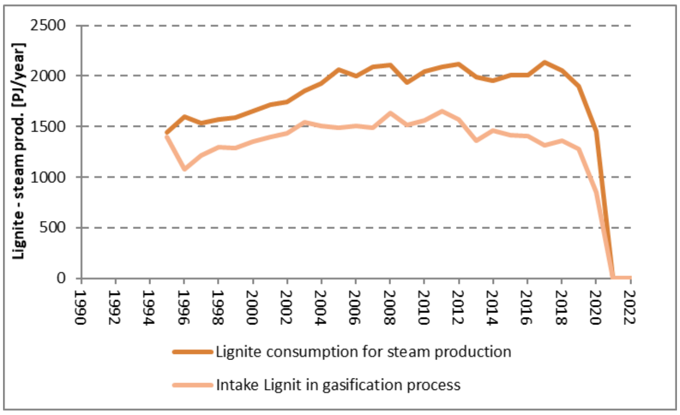

Fig. 3-10 Comparison of lignite consumption for steam production and gasification

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

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

3.2.8.5 Category-specific recalculations (CRF 1.A.1.c.ii)

Based on the update of activity data from CzSO recalculation for Solid fuels for the year 2002 and 2021 were done. For the resulted changes see tables below for Solid Fuels (Tab. 3-17).

Furthermore, activity data was changed in CzsO, 2023 for Natural gas in 2021 and therefore recalculation was performed, see the Tab. 3-18.

These recalculations resulted from the change of the activity data (CzSO, 2023).

Tab. 3-17 Changes after recalculation in 1.A.1.c.ii for Solid Fuels.

Fuel consumption		2002	2021	CH_4 emissions		2002	2021
Submission 2023	TJ	62028.40	16475.23	Submission 2023	TJ	0.06	0.02
Submission 2024	TJ	62004.10	16455.81	Submission 2024	TJ	0.06	0.02
Difference	TJ	-24.30	-19.41	Difference	TJ	0.00	0.00
Submission 2024	%	-0.04	-0.12	Submission 2024	%	-0.04	-0.12
CO_2 emissions		2002	2021	N_2O emissions		2002	2021
Submission 2023	TJ	5552.65	1244.92	Submission 2023	TJ	0.05	0.01
Submission 2024	TJ	5550.37	1243.08	Submission 2024	TJ	0.05	0.01
Difference	TJ	-2.28	-1.84	Difference	TJ	0.00	0.00
Submission 2024	%	-0.04	-0.15	Submission 2024	%	-0.07	-0.20

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

Fuel consumption		2021	CH_4 emissions		2021
Submission 2023	TJ	100.46	Submission 2023	TJ	0.00
Submission 2024	TJ	100.47	Submission 2024	TJ	0.00
Difference	TJ	0.01	Difference	TJ	0.00
Submission 2024	%	0.01	Submission 2024	%	0.01
CO_2 emissions		2021	N_2O emissions		2021
Submission 2023	TJ	5.57	Submission 2023	TJ	0.00
Submission 2024	TJ	5.57	Submission 2024	TJ	0.00
Difference	TJ	0.00	Difference	TJ	0.00
Submission 2024	%	0.01	Submission 2024	%	0.01

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

Currently there are no planned improvements in this category.

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

3.2.9.1 Category description (CRF 1.A.2.a)

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

1.A.2.a, 2022								
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	2 253.03	98.30	1	221.47	10	0.02253	1.5	0.00338
Other Bituminous Coal	10.99	94.08*)	0.9707*)	1.00	10	0.00011	1.5	0.00002
Brown Coal + Lignite	453.65	98.94*)	0.9846*)	44.19	10	0.00454	1.5	0.00068
Coke	7 298.54	107.00	1	780.94	10	0.07299	1.5	0.01095
Coke Oven Gas	4 531.98	44.40	1	201.22	1	0.00453	0.1	0.00045
Natural Gas	6 694.71	55.78*)	1	373.40	1	0.00669	0.1	0.00067
Wood/Wood Waste	0.64	112.00	1	0.07	30	0.00002	4.0	0.00000
Total year 2022	**21 242.89**			**1 622.23**		**0.11141**		**0.01615**
Total year 2021	28 604.68			2 115.85		0.13829		0.01992

Index 2022/2021	0.74	0.77	0.81	0.81
Total year 1990	155 319.22	14 860.68	1.39496	0.20941
Index 2022/1990	0.14	0.11	0.08	0.08

**) Country specific data*

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

2022							
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Anthracite	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other Bituminous Coal	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Coke	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
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, cast iron, steel and alloys and is related only to ferrous metals. In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported in section Industry Sector under the item: Iron and Steel. There are embodied the fuels of economic part according to NACE Rev. 2 Iron and steel: NACE Divisions 24.1 – 24.3 and 24.51, 24.52.

The fraction of CO_2 emissions in subsector 1.A.2.a in CO_2 emissions in sector 1.A.2 equalled 14 % in 2022. It contributed only 2% to CO_2 emissions in the whole Energy sector.

Important facility belongs to this category is ArcelorMittal Ostrava (changed its name to Liberty Ostrava a.s. in 2021), a.s. and Třinecké železárny a.s. Both metallurgical plants include iron ore sinter production, blast furnaces, coke production, iron processing in oxygen converters for steel and casting of steel in electric furnaces and in tandem furnaces. Production of steel using Siemens-Martin process was stopped before 1990.

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

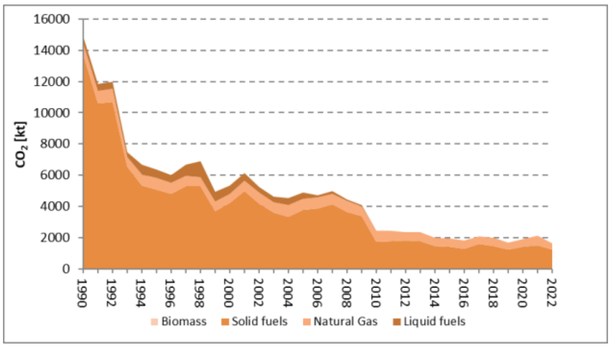

Fig. 3-11 Development of CO_2 emissions in source category 1.A.2.a

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

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

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

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

See chapter 3.2.5.

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

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

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

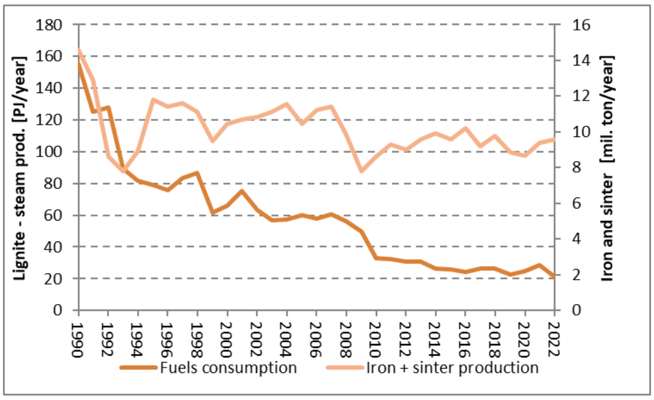

Fig. 3-12 The trend in the manufacture of agglomerates of iron ore and iron, in comparison with the development of fuel consumption in the sector 1.A.2.a

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

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

Based on changes of activity data in CzSO, 2023, fuel consumptions of Solid for the year 2021 were corrected. See the differences in the Tab. 3-19. Due to the change of Activity data of Natural Gas, Gaseous fuels were recalculated for the year 2018 and 2021 , see the Tab. 3-20.

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

Fuel consumption		**2021**
Submission 2023	TJ	17356.45
Submission 2024	TJ	17404.96
Difference	TJ	48.51
Submission 2024	%	0.28
CO_2 emission		**2021**
Submission 2023	kt	1490.04
Submission 2024	kt	1494.97
Difference	kt	4.93
Submission 2024	%	0.33
CH_4 emission		**2021**
Submission 2023	kt	0.13

Submission 2024	kt	0.13
Difference	kt	0.00
Submission 2024	%	0.38
N_2O emission		**2021**
Submission 2023	kt	0.02
Submission 2024	kt	0.02
Difference	kt	0.00
Submission 2024	%	0.39

Tab. 3-20 Changes after recalculation in 1.A.2.a for Gaseous fuels.

Fuel consumption		**2018**	**2021**
Submission 2023	TJ	9458.448	11198.553
Submission 2024	TJ	9458.617	11199.717
Difference	TJ	0.169	1.164
Submission 2024	%	0.002	0.010
CO_2 emission		**2018**	**2021**
Submission 2023	kt	524.466	620.818
Submission 2024	kt	524.587	620.882
Difference	kt	0.121	0.065
Submission 2024	%	0.023	0.010
CH_4 emission		**2018**	**2021**
Submission 2023	kt	0.009	0.011
Submission 2024	kt	0.009	0.011
Difference	kt	0.000	0.000
Submission 2024	%	0.002	0.010
N_2O emission		**2018**	**2021**
Submission 2023	kt	0.001	0.001
Submission 2024	kt	0.001	0.001
Difference	kt	0.000	0.000
Submission 2024	%	0.002	0.010

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

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

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

3.2.10.1 Category description (CRF 1.A.2.b)

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

1.A.2.b, 2022								
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	25.51	98.94*)	0.9846	2.49	10	0.00026	1.5	0.00004
Coke	120.42	107.00	1	12.88	10	0.00120	1.5	0.00018
Natural Gas	2 383.16	55.78*)	1	132.92	1	0.00238	0.1	0.00024
Total year 2022	**2 529.09**			**148.29**		**0.00384**		**0.00046**
Total year 2021	3 217.04			186.39		0.00466		0.00055
Index 2022/2021	0.79			0.80		0.82		0.84
Total year 1990	1 476.34			101.96		0.00572		0.00081
Index 2022/1990	1.71			1.45		0.67		0.56

*) *Country specific data*

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

2022							
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
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

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, 2023), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Non-Ferrous Metals

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

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

Important facility belongs to this category is Kovohutě Příbram. The fraction of CO_2 emissions in subsector 1.A.2.b in CO_2 emissions in sector 1.A.2 equalled 1.3% in 2022. It contributed only 0.2% to CO_2 emissions in the whole Energy sector.

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

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

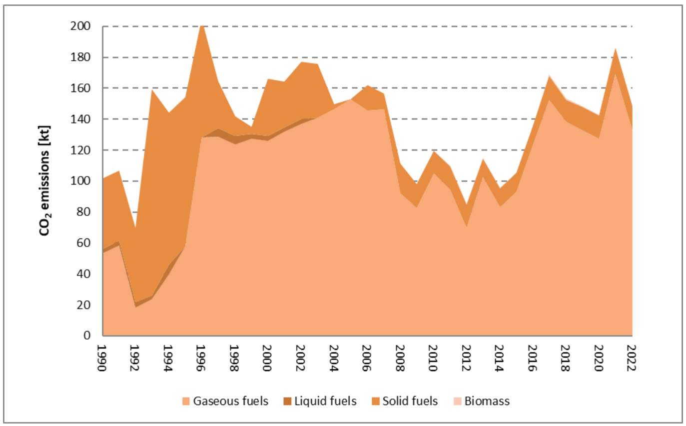

Fig. 3-13 Development of CO_2 emissions in source category 1.A.2.b

The trend of CO_2 emissions corresponds to the trend of consumption of individual types of fuels. After a decline in the early 90s, it is apparent a sharp increase in emissions, which was caused by the recovery in the industry. The recovery of the industry has happened in this sector, especially due to the increase in demand for parts, made of ferrous metals in the emerging automotive industry. Decrease in emissions at the end of the period was caused by the crisis between 2008 and 2012, as well as the reduction of the energy intensity of production. With this is also related a shift from fossil fuels in favour of natural gas. This effect can be seen especially in the year 2021. However, due to the war in Ukraine, the Natural gas consumption is decreasing again, see the last year 2022. Furthermore, electrical energy is increasingly used for heating the melting furnaces, which has a positive impact on greenhouse gas emissions.

3.2.10.2 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.

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

See chapter 3.2.5.

3.2.10.4 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.

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

Based on the change of activity data of Solid fuels (CzSO, 2023), recalculation was done for the year 2021, see the Tab. 3-21. Based on the change of activity data of Natural Gas (CzSO, 2023), Gaseous fuels were recalculated for the year 2018, 2021, see the Tab. 3-22.

Tab. 3-21 Changes after recalculation in 1.A.2.b for Solid fuels.

Fuel consumption		2021
Submission 2023	TJ	160.322
Submission 2024	TJ	160.275
Difference	TJ	-0.047
Submission 2024	%	-0.029
CO_2 emission		2021
Submission 2023	kt	16.936
Submission 2024	kt	16.932
Difference	kt	-0.005
Submission 2024	%	-0.027
CH_4 emission		2021
Submission 2023	kt	0.002
Submission 2024	kt	0.002
Difference	kt	0.000
Submission 2024	%	-0.029
N_2O emission		2021
Submission 2023	kt	0.000
Submission 2024	kt	0.000
Difference	kt	0.000
Submission 2024	%	-0.029

Tab. 3-22 Changes after recalculation in 1.A.2.b for Gaseous fuels.

Fuel consumption		2018	2021
Submission 2023	TJ	2496.196	4777.859
Submission 2024	TJ	2496.240	3056.762
Difference	TJ	0.045	-1721.097
Submission 2024	%	0.002	-56.305
CO_2 emission		2018	2021
Submission 2023	kt	138.413	264.872
Submission 2024	kt	138.445	169.459
Difference	kt	0.032	-95.413
Submission 2024	%	0.023	-56.305
CH_4 emission		2018	2021
Submission 2023	kt	0.002	0.005
Submission 2024	kt	0.002	0.003
Difference	kt	0.000	-0.002
Submission 2024	%	0.002	-56.305
N_2O emission		2018	2021
Submission 2023	kt	0.000	0.000
Submission 2024	kt	0.000	0.000

Difference	kt	0.000	0.000
Submission 2024	%	0.002	-56.305

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

Currently there are no planned improvements in this category.

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

3.2.11.1 Category description (CRF 1.A.2.c)

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

1.A.2.c, 2022								
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	155.07	65.86*)	1	10.21	1	0.00016	0.1	0.00002
Fuel Oil - High Sulphur	79.00	77.40	1	6.11	3	0.00024	0.6	0.00005
Other Oil	4 944.24	73.30	1	362.41	3	0.01483	0.6	0.00297
Other Bituminous Coal	5.07	94.08*)	0.9707*)	0.46	10	0.00005	1.5	0.00001
Brown Coal + Lignite	22 141.13	98.94*)	0.9846*)	2 156.88	10	0.22141	1.5	0.03321
Natural Gas	12 905.71	55.78*)	1	719.82	1	0.01291	0.1	0.00129
Wood/Wood Waste	26.99	112.00	1	3.02	30	0.00081	4.0	0.00011
Gaseous Biomass	663.94	54.60	1	36.25	1	0.00066	0.1	0.00007
Total year 2022	**40 230.22**			**3 255.90**		**0.25107**		**0.03771**
Total year 2021	40 779.66			3 247.03		0.24483		0.03656
Index 2022/2021	0.99			1.00		1.03		1.03
Total year 1990	33 576.71			2 996.37		0.26480		0.03975
Index 2022/1990	1.20			1.09		0.95		0.95

*) *Country specific data*

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

2022							
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 - High Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other Oil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other Bituminous Coal	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
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, sro) and in Kralupy (Synthos Kralupy as). Due to the historical linkage between the two units, it is very difficult to determine the fuel combusted in the refinery and petrochemical parts of the two plants separately. Furthermore, other major plants for processing organic chemistry products are in operation in the Czech Republic (DEZA a.s. Meziříčí – processing of coal tar, SYNTHESIA a.s. Pardubice - basic organic chemistry) and a number of factories for manufacturing of inorganic products

(SPOLANA a.s. Neratovice, SPOLCHEMIE a.s. Ústí nad Labem, PRECHEZA a.s. Přerov and others). The largest plants are also equipped with energy resources, with a significant share of electricity and heat (autoproducers); this results in relatively high consumption of fossil fuels (see Fig. 3-14). Heat is generated using abundant natural gas and, to a lesser extent, liquid fuels or, in some cases, electrical energy. In total, the national emission database recorded 1 000 production units that fall within sector 1.A.2.c. The fluctuation in fuel consumption are influenced by many factors, including economic development, the production plan of companies and their stocks, meteorological conditions and efforts to reduce the energy intensity of processes in the chemical industry.)

In the CzSO Questionnaire (CzSO, 2023), 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 29% in 2022. It contributed 4% to CO_2 emissions in the whole Energy sector.

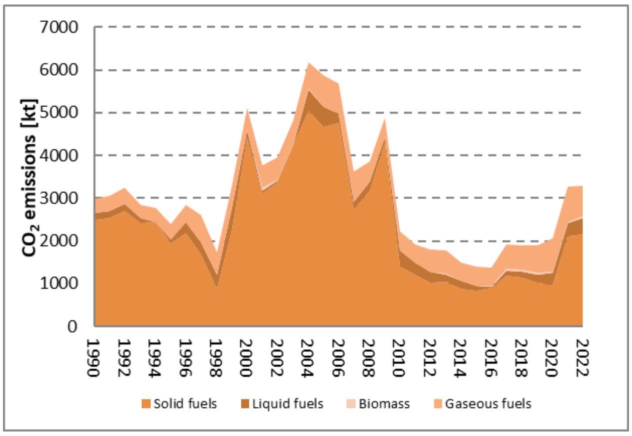

Fig. 3-14 Development of CO_2 emissions in source category

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

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

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

Given that in the IPCC 2006 Gl. (IPCC, 2006) is used an updated approach to the allocation of feedstocks and non-energy use of fuels into IPPU. The new distribution of liquid fuels is to be considered as category specific methodological issue. This methodological approach is in the same time based on the new reallocation of fuel consumption for energy and non-energy use in the questionnaire from CzSO, 2023. The reallocation of feedstocks and non-energy use of fuels in IPPU is in details described in chapter 3.2.3.

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

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

See chapter 3.2.5.

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

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

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

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

Based on changes of Activity data in CzSO, 2023, fuel consumptions of Solid fuels for the year 2021 was recalculated. See the differences in table Tab. 3-23 below. Due to the change of activity data in CzSO 2023 for Natural Gas, Gaseous fuels were recalculated for the years 2018 and 2021, see the Tab. 3-24.

Tab. 3-23 Changes after recalculation in 1.A.2.c for Solid fuels

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	21599.45	Submission 2023	kt	0.22
Submission 2024	TJ	21560.54	Submission 2024	kt	0.22
Difference	TJ	-38.90	Difference	kt	0.00
Submission 2024	%	-0.18	Submission 2024	%	-0.18
CO_2 emission		2021	N_2O emission		2021
Submission 2023	kt	2107.54	Submission 2023	kt	0.03
Submission 2024	kt	2103.74	Submission 2024	kt	0.03
Difference	kt	-3.80	Difference	kt	0.00
Submission 2024	%	-0.18	Submission 2024	%	-0.18

Tab. 3-24 Changes after recalculation in 1.A.2.c for Gaseous fuels

Fuel consumption		2018	2021
Submission 2023	TJ	10264.27	14777.34
Submission 2024	TJ	10264.45	12905.71
Difference	TJ	0.18	-1871.62
Submission 2024	%	0.00	-14.50
CO_2 emission		2018	2021
Submission 2023	kt	569.15	819.22
Submission 2024	kt	569.28	719.82
Difference	kt	0.13	-99.40
Submission 2024	%	0.02	-13.81
CH_4 emission		2018	2021
Submission 2023	kt	0.01	0.01
Submission 2024	kt	0.01	0.01
Difference	kt	0.00	0.00
Submission 2024	%	0.00	-14.50
N_2O emission		2018	2021
Submission 2023	kt	0.00	0.00
Submission 2024	kt	0.00	0.00
Difference	kt	0.00	0.00
Submission 2024	%	0.00	-14.50

3.2.11.6 Category-specific planned improvements (CRF 1.A.2.c)

Currently there are no planned improvements in this category.

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

3.2.12.1 Category description (CRF 1.A.2.d)

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

1.A.2.d, 2022								
Structure of Fuels	Activity	CO₂			CH₄		N₂O	
	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	6.81	1	0.00010	0.1	0.00001
Fuel Oil - High Sulphur	118.50	77.40	1	9.17	3	0.00036	0.6	0.00007
Other Bitumenous Coal	4.25	94.08*)	0.9707*)	0.39	10	0.00004	1.5	0.00001
Brown Coal + Lignite	3 761.00	98.94*)	0.9846*)	366.38	10	0.03761	1.5	0.00564
Brown Coal Briquets	1.92	97.50	0.9846*)	0.18	10	0.00002	1.5	0.00000
Natural Gas	5 058.76	55.78*)	1	282.15	1	0.00506	0.1	0.00051
Wood/Wood Waste	21 232.15	112.00	1	2 378.00	30	0.63696	4.0	0.08493
Gaseous Biomass	12 571.12	54.60	1	686.38	1	0.01257	0.1	0.00126
Total year 2022	**9 047.81**			**665.08**		**0.69273**		**0.09242**
Total year 2021	11 189.57			778.05		0.70907		0.09456
Index 2022/2021	0.81			0.85		0.98		0.98
Total year 1990	25 900.78			2 285.33		0.18784		0.02890
Index 2022/1990	0.35			0.29		3.69		3.20

*) *Country specific data*

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

2022							
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
Fuel Oil - High 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 manufacturing processes related to the production of paper, cardboard and print in printing plants. There are two primary paper production factories in the Czech Republic (JIP - Papírny Větřní, a. s., Mondi Štětí a.s.) with a high consumption of waste wood from production processes. The other plants select the kind of fuel on the basis of the same criteria as the rest of the processing industry.

In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Paper, Pulp and Printing

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

Pulp, paper and print: NACE Divisions 17 and 18

The fraction of CO_2 emissions in subsector 1.A.2.d in CO_2 emissions in sector 1.A.2 equalled 6 % in 2022. It contributed 0.8 % to CO_2 emissions in the whole Energy sector.

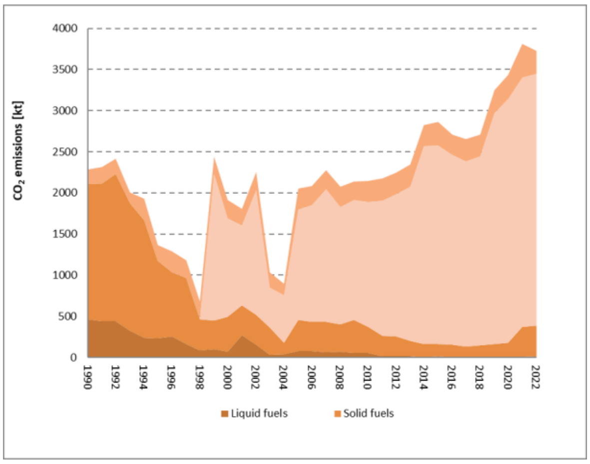

Fig. 3-15 Development of CO_2 emissions in source category 1.A.2.d

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

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

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

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

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

See chapter 3.2.5.

3.2.12.4 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.

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

Based on a changes of activity data in CzSO, 2023, fuel consumption of Solid fuels for the year 2021 was recalculated. See the differences in the Tab. 3-25. Due to the change of Net Calorific Value in CzSO 2023 for Natural Gas, Gaseous fuels were recalculated for the year 2018, 2021, see the Tab. 3-26.

Tab. 3-25 Changes after recalculation in 1.A.2.d for Solid fuels

Fuel consumption		**2021**	**CH_4 emission**		**2021**
Submission 2023	TJ	3696.97	**Submission 2023**	kt	0.04
Submission 2024	TJ	3689.37	**Submission 2024**	kt	0.04
Difference	TJ	-7.60	**Difference**	kt	0.00
Submission 2024	%	-0.21	**Submission 2024**	%	-0.21
CO_2 emission		**2021**	**N_2O emission**		**2021**
Submission 2023	kt	360.83	**Submission 2023**	kt	0.01
Submission 2024	kt	360.09	**Submission 2024**	kt	0.01
Difference	kt	-0.74	**Difference**	kt	0.00
Submission 2024	%	-0.21	**Submission 2024**	%	-0.21

Tab. 3-26 Changes after recalculation in 1.A.2.d for Gaseous fuels

Fuel consumption		**2018**	**2021**
Submission 2023	TJ	4775.923	7349.772
Submission 2024	TJ	4776.008	7350.536
Difference	TJ	0.085	0.764
Submission 2024	%	0.002	0.010
CO_2 emission		**2018**	**2021**

Submission 2023	kt	264.823	407.452
Submission 2024	kt	264.884	407.494
Difference	kt	0.061	0.042
Submission 2024	%	0.023	0.010
CH_4 emission		**2018**	**2021**
Submission 2023	kt	0.005	0.007
Submission 2024	kt	0.005	0.007
Difference	kt	0.000	0.000
Submission 2024	%	0.002	0.010
N_2O emission		**2018**	**2021**
Submission 2023	kt	0.000	0.001
Submission 2024	kt	0.000	0.001
Difference	kt	0.000	0.000
Submission 2024	%	0.002	0.010

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

Currently there are no planned improvements in this category.

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

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

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

1.A.2.e, 2022								
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	155.07	65.86*)	1	10.21	1	0.00016	0.1	0.00002
Heating and Other Gasoil	85.20	74.10	1	6.31	3	0.00026	0.6	0.00005
Fuel Oil - Low Sulphur	39.50	77.40	1	3.06	3	0.00012	0.6	0.00002
Fuel Oil - High Sulphur	118.50	77.40	1	9.17	3	0.00036	0.6	0.00007
Other Bituminous Coal	448.45	94.08*)	0.9707*)	40.95	10	0.00448	1.5	0.00067
Brown Coal + Lignite	3 103.37	98.94*)	0.9846*)	302.31	10	0.03103	1.5	0.00466
Coke	205.31	107.00	1	21.97	10	0.00205	1.5	0.00031
Natural Gas	12 024.45	55.78*)	1	670.67	1	0.01202	0.1	0.00120
Wood/Wood Waste	62.02	112.00	1	6.95	30	0.00186	4.0	0.00025
Gaseous Biomass	3 881.53	54.60	1	211.93	1	0.00388	0.1	0.00039
Total year 2022	**16 179.85**			**1 064.66**		**0.05622**		**0.00764**
Total year 2021	18 818.44			1 182.67		0.05799		0.00759
Index 2022/2021	0.86			0.90		0.97		1.01
Total year 1990	37 616.46			2 988.18		0.21342		0.03226
Index 2022/1990	0.43			0.36		0.26		0.24

[*)] Country specific data

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

2022							
Structure of Fuels	Source of	Emission factors			Method used		
	Activity data	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Heating and Other Gasoil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

Structure of Fuels	Source of Activity data	Emission factors CO_2	Emission factors CH_4	Emission factors N_2O	Method used CO_2	Method used CH_4	Method used N_2O
		2022					
Fuel Oil - Low Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Fuel Oil - High Sulphur	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Other Bituminous Coal	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Coke	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Wood/Wood Waste	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Gaseous Biomass	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

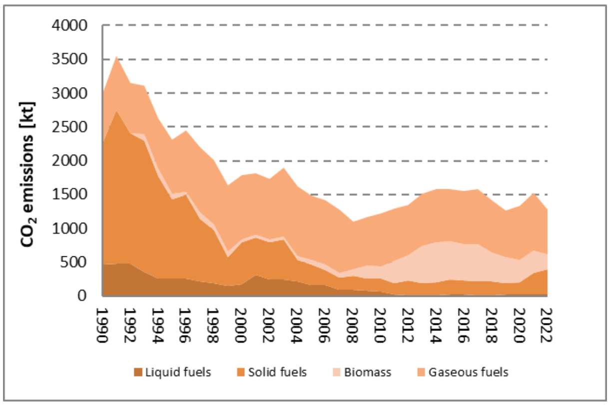

Fig. 3-16 Development of CO_2 emissions from fossil fuels combustion in source category 1.A.2.e

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

In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Food, Beverages and Tobacco

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

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

The fraction of CO_2 emissions in subsector 1.A.2.e in CO_2 emissions in sector 1.A.2 equalled 10% in 2022. 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.

It is obvious from the graph in Fig. 3-16 that natural gas is the dominant fuel over the entire time series with quite balanced consumption. The high share of fossil fuels at the beginning of the period reduced continuously and with replacement of fossil fuels by solid and gaseous biofuels towards the end of this period. The overall amount of fuel consumed decreased until 2008. Since 2008 there has been an increase in fuel consumption, which is covered by increasing consumption of biofuels, in response to the development of the financial crisis in the period at the end of the first decade of the 21st century. Since 2014 the consumption was stable, two years ago a slight decrease started.

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 and biomass only in sector 1.A.2.e.

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

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

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

See chapter 3.2.5.

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

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

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

Based on minor changes of activity data in CzSO, 2023, fuel consumption of Solid fuels for the year 2021 was recalculated. See the differences in the Tab. 3-27. Activity data were also changed for Liquid fuels for the year 2021, see the recalculation in the Tab. 3-28 Due to the change of activity data in CzSO 2023 for Natural Gas, Gaseous fuels were recalculated for the years 2018 and 2021, see the Tab. 3-29.

Tab. 3-27 Changes after recalculation in 1.A.2.e for Solid fuels

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	3190.50	Submission 2023	kt	0.03
Submission 2024	TJ	3186.73	Submission 2024	kt	0.03
Difference	TJ	-3.77	Difference	kt	0.00
Submission 2024	%	-0.12	Submission 2024	%	0.00
CO_2 emission		**2021**	**N_2O emission**		**2021**
Submission 2023	kt	310.23	Submission 2023	kt	0.00
Submission 2024	kt	309.88	Submission 2024	kt	0.00
Difference	kt	-0.35	Difference	kt	0.00
Submission 2024	%	-0.01	Submission 2024	%	-0.02

Tab. 3-28 Changes after recalculation in 1.A.2.e for Liquid fuels

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	376.392	Submission 2023	kt	0.001
Submission 2024	TJ	397.692	Submission 2024	kt	0.001
Difference	TJ	21.300	Difference	kt	0.000
Submission 2024	%	5.356	Submission 2024	%	0.000
CO_2 emission		**2021**	**N_2O emission**		**2021**
Submission 2023	kt	26.683	Submission 2023	kt	0.000
Submission 2024	kt	28.261	Submission 2024	kt	0.000
Difference	kt	1.578	Difference	kt	0.000
Submission 2024	%	0.397	Submission 2024	%	1.587

Tab. 3-29 Changes after recalculation in 1.A.2.e for Gasous fuels

Fuel consumption		2018	2021
Submission 2023	TJ	13817.700	15232.439
Submission 2024	TJ	13817.947	15234.022
Difference	TJ	0.247	1.584
Submission 2024	%	0.002	0.010
CO_2 emission		**2018**	**2021**
Submission 2023	kt	766.185	844.446
Submission 2024	kt	766.361	844.533
Difference	kt	0.177	0.088
Submission 2024	%	0.023	0.010
CH_4 emission		**2018**	**2021**
Submission 2023	kt	0.014	0.015
Submission 2024	kt	0.014	0.015
Difference	kt	0.000	0.000
Submission 2024	%	0.002	0.010

N_2O emission		2018	2021
Submission 2023	kt	0.001	0.002
Submission 2024	kt	0.001	0.002
Difference	kt	0.000	0.000
Submission 2024	%	0.002	0.010

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

Currently there are no planned improvements in this category.

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

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

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

1.A.2.f, 2022								
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
Heating and Other Gasoil	85.20	74.10	1	6.3	3	0.00026	0.6	0.00005
Fuel Oil - Low Sulphur	39.50	77.40	1	3.1	3	0.00012	0.6	0.00002
Fuel Oil - High Sulphur	118.50	77.40	1	9.2	3	0.00036	0.6	0.00007
Anthracite	19.04	98.30	1	1.9	10	0.00019	1.5	0.00003
Other Bituminous Coal	3 432.49	94.08*)	0.9707*)	313.5	10	0.03432	1.5	0.00515
Brown Coal + Lignite	373.80	98.94*)	0.9846*)	36.4	10	0.00374	1.5	0.00056
Coke	1 510.77	107.00	1	161.7	10	0.01511	1.5	0.00227
Coal Tars	111.11	80.70	1	9.0	10	0.00111	1.5	0.00017
Brown Coal Briquets	1 420.12	97.50	0.9846*)	136.3	10	0.01420	1.5	0.00213
Coke Oven Gas	82.21	44.40	1	3.6	1	0.00008	0.1	0.00001
Natural Gas	21 550.42	55.78*)	1	1 202.0	1	0.02155	0.1	0.00216
Other fuels - liquid	582.29	71.93*)	1	41.9	30	0.01747	4	0.00233
Other fuels - solid	5 944.65	84.33*)	1	501.3	30	0.17834	4	0.02378
Wood/Wood Waste	4 311.92	112.00	1	482.9	30	0.12936	4	0.01725
Total year 2022	**35 373.47**			**2 432.90**		**0.41630**		**0.05598**
Total year 2021	41 313.09			2 760.30		0.42203		0.05653
Index 2022/2021	0.86			0.88		0.99		0.99
Total year 1990	59 962.36			4 527.12		0.29373		0.04487
Index 2022/1990	0.59			0.54		1.42		1.25

*) *Country specific data*

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

2022							
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

Structure of Fuels	Source of Activity data	2022 Emission factors CO_2	CH_4	N_2O	Method used CO_2	CH_4	N_2O
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, CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Other fuels - solid	ETS, CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Wood/Wood Waste	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

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

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

In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

Non-Metallic Minerals

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

NACE Divisions 23

23 Manufacture of other non-metallic mineral products

23.1 Manufacture of glass and glass products

23.2 Manufacture of refractory products

23.4 Manufacture of other porcelain and ceramic products

23.5 Manufacture of cement, lime and plaster

The fraction of CO_2 emissions in subsector 1.A.2.f in CO_2 emissions in sector 1.A.2 equalled 22% in 2022. It contributed 3 % to CO_2 emissions in the whole Energy sector.

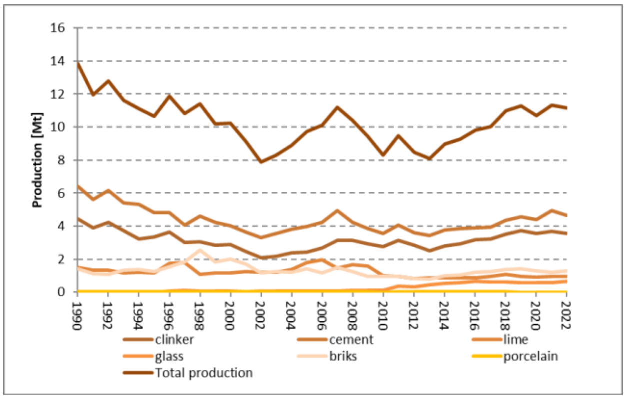

Fig. 3-17 Production of the most important mineral products

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

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

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

The graph shows the evolution of CO_2 emissions, that has the same pattern as the fuel consumption. The high consumption of fossil fuel at the beginning of the period decreased gradually, and it is evident that the most important fuel in this sector is natural gas. The high consumption of fossil fuels gradually was declining and liquid fuels, from 2002 gradually were replaced by alternative fuels (Other fuels). The increase in fuel consumption between 2005 and 2008, was interrupted by the crisis development of the economy and after some recovery in 2010-2011, followed by another decline. From 2014 was recorded slight increase and from 2016 slight decrease. Slight increase since 2017 can be observed for biomass.

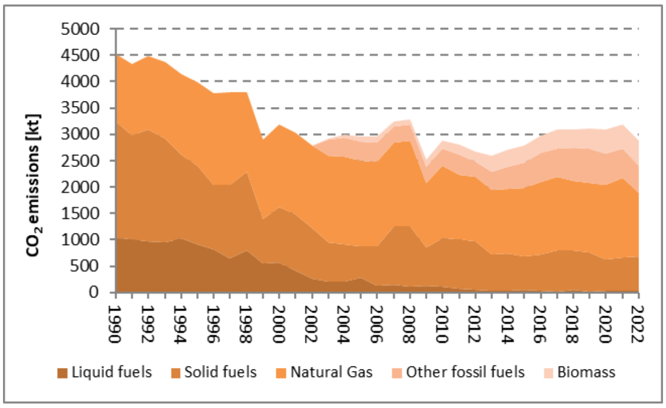

Fig. 3-18 Development of CO_2 emissions in source category 1.A.2.f

3.2.14.2 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 EU ETS database, where the emission factors for different types of alternative fuels are available. 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). Quite extense recalculation were done for the year 2020, based on the change of the methodology. Biocomponent was separately added to the 1.A.2.f category since 2003. It was found out that in the CzSO questionnaire “CZECH_RENEWABLE” is sheet “IndWaste”, which actually contain a mixture of fossil and bioparticles, although these data are marked as non-ren (information from the Ministry of Industry and Trade). The proportion of the biocomponent was calculated as a linear decrease from 50% to zero. This procedure must be used, as there was a very low proportion of solid biofuels in this subcategory, which is gradually growing. The linear decrease between 2003 and 2012 must be chosen because today there is no longer any basis for determining the share of the bio-component in alternative fuels. Due to the refinement of solid and liquid other fossil fuels calculations quite steady consumption in years were achieved. Alternative fuel consumption is shown in Tab. 3-30.

Tab. 3-30 Consumption of alternative fuels in sector 1.A.2.f

[TJ/year]	2003	2004	2005	2006	2007	2008	2009	2010	2011
Solid fuels	2 424	3 200	3 517	3 398	3 726	3 222	3 236	3 224	3 885
Liquid fuels	1 266	1 156	589	1 014	240	557	682	708	661
Total	3 690	4 356	4 105	4 412	3 966	3 779	3 918	3 932	4 546
[TJ/year]	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Solid fuels	2 279	2 904	3 739	4 640	5 512	5 448	6 182	6 769	6 435
Liquid fuels	1 029	1 138	1 153	1 022	1 091	978	1 257	1 118	687
Total	3 309	4 042	4 893	5 662	6 603	6 426	7 438	7 887	7 122
[TJ/year]	**2021**	**2022**							
Solid fuels	6 192	5 945							
Liquid fuels	582	582							
Total	6 773	6 527							

Emission factors for calculating CO_2 emissions is based on the consumption of fuel (solid, liquid fuels). The resulting emission factor corresponds to the relative representation of individual types of fuels. In Tab. 3-31 is shown an overview of emission factors used for solid and liquid alternative fuels in different years. It can be seen that the EF is quite stable.

Tab. 3-31 CO_2 emission factors used in the consumption of alternative fuels in sector 1.A.2.f

[t CO_2/TJ]	2003	2004	2005	2006	2007	2008	2009	2010	2011
Solid fuels	87.55	87.46	88.54	84.54	78.26	80.98	79.14	85.23	85.78
Liquid fuels	75.42	75.80	75.09	76.16	73.00	71.93	70.42	81.21	77.40
[t CO_2/TJ]	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Solid fuels	92.61	87.46	87.52	84.98	85.20	84.83	85.43	83.31	82.26
Liquid fuels	80.08	78.75	78.78	79.30	77.91	76.79	78.86	77.81	75.64
[t CO_2/TJ]	**2021**	**2022**							
Solid fuels	86.58	84.33							
Liquid fuels	75.21	71.93							

For the calculation of CH_4 and N_2O emissions were used default emission factors in line with the IPCC 2006 Gl. (IPCC 2006), for the entire time series 2003-2022 (Tab. 3-32).

Tab. 3-32 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

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

See chapter 3.2.5.

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

As a basic indicator for verification of fuel consumption in the sector of production of pig iron and steel, should be regarded indicators of the overall production of basic goods such as cement, lime, clay tiles and roof tiling or glass and fine ceramics. This is a relatively large mass flows, which also exhibit high energy demands (Fig. 3-18). Comparison of total production and total fuel consumption in the sub sector 1.A.2.f is shown in Fig. 3-19.

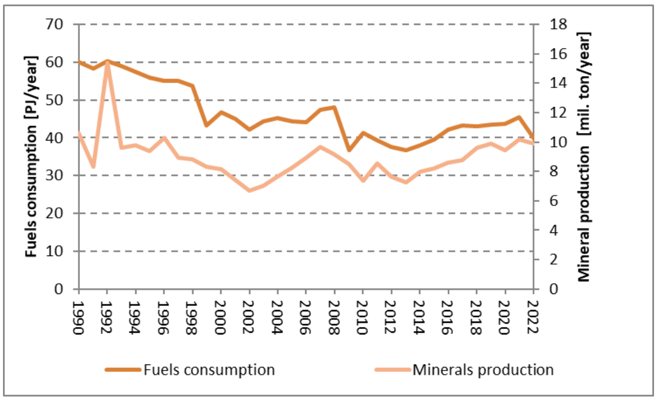

Fig. 3-19 Trends in production of mineral products compared with the development of fuel consumption in the sector 1.A.2.f

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

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

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

Based on minor changes of activity data in CzSO, 2023, fuel consumption of Solid fuels for the year 2021 was recalculated. See the differences in the Tab. 3-33. Based on the minor changes in activity data CzSO, 2023, fuel consumption of Liquid fuels was recalculated for the year 2021, see the Tab. 3-34. Due to the change of activity data in CzSO 2023 for Natural Gas, Gaseous fuels were recalculated for the year 2018 and 2021, see the Tab. 3-35. In the subcategory 1.A.2.f was found out wrong emission factor for CO_2 in 2021. The emission factors were updated and recalculation of CO_2 emissions was performed, see the Tab. 3-36.

Tab. 3-33 Changes after recalculation in 1.A.2.f for Solid Fuels

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	6121.10	Submission 2023	kt	0.06
Submission 2024	TJ	6628.51	Submission 2024	kt	0.07
Difference	TJ	507.42	Difference	kt	0.01
Submission 2024	%	7.66	Submission 2024	%	7.74
CO_2 emission		2021	N_2O emission		2021
Submission 2023	kt	568.97	Submission 2023	kt	0.01
Submission 2024	kt	622.72	Submission 2024	kt	0.01
Difference	kt	53.75	Difference	kt	0.00
Submission 2024	%	8.63	Submission 2024	%	7.74

Tab. 3-34 Changes after recalculation in 1.A.2.f for Liquid Fuels

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	516.40	Submission 2023	kt	0.00
Submission 2024	TJ	537.70	Submission 2024	kt	0.00
Difference	TJ	21.30	Difference	kt	0.00
Submission 2024	%	3.96	Submission 2024	%	4.55
CO_2 emission		2021	N_2O emission		2021
Submission 2023	kt	38.64	Submission 2023	kt	0.00
Submission 2024	kt	40.22	Submission 2024	kt	0.00
Difference	kt	1.58	Difference	kt	0.00
Submission 2024	%	3.92	Submission 2024	%	4.66

Tab. 3-35 Changes after recalculation in 1.A.2.f for Gaseous Fuels

Fuel consumption		2018	2021
Submission 2023	TJ	23867.17	27370.69
Submission 2024	TJ	23867.60	27373.53
Difference	TJ	0.43	2.85
Submission 2024	%	0.00	0.01
CO_2 emission		2018	2021
Submission 2023	kt	1323.42	1517.36
Submission 2024	kt	1323.73	1517.52
Difference	kt	0.31	0.16
Submission 2024	%	0.02	0.01
CH_4 emission		2018	2021
Submission 2023	kt	0.02	0.03
Submission 2024	kt	0.02	0.03
Difference	kt	0.00	0.00
Submission 2024	%	0.00	0.01
N_2O emission		2018	2021
Submission 2023	kt	0.00	0.00
Submission 2024	kt	0.00	0.00
Difference	kt	0.00	0.00
Submission 2024	%	0.00	0.01

Tab. 3-36 Changes after recalculation in 1.A.2.f for CO_2 emissions.

CO2 emissions		2021
Submission 2023	TJ	2670.50
Submission 2024	TJ	2725.99
Difference	TJ	55.49
Submission 2024	%	2.04

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

Currently there are no planned improvements in this category.

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

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

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

1.A.2.g, 2022								
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	723.64	65.86*)	1	47.66	1	0.00072	0.1	0.00007
Fuel Oil - Low Sulphur	39.50	77.40	1	3.06	3	0.00012	0.6	0.00002
Fuel Oil - high Sulphur	592.50	77.40	1	45.86	3	0.00178	0.6	0.00036
Anthracite	1.94	98.30	1	0.19	10	0.00002	1.5	0.00000
Other Bitumenous Coal	23.62	94.08*)	0.9707*)	2.16	10	0.00024	1.5	0.00004
Brown Coal + Lignite	883.68	98.94*)	0.9846*)	86.08	10	0.00884	1.5	0.00133
Coke	33.20	107.00	1	3.55	10	0.00033	1.5	0.00005
Brown Coal Briquets	307.86	97.50	0.9846*)	29.55	10	0.00308	1.5	0.00046
Natural Gas	32 140.33	55.78*)	1	1 792.64	1	0.03214	0.1	0.00321
Wood/Wood Waste	8 598.60	112.00	1	963.04	30	0.25796	4	0.03439
Total year 2022	**34 746.26**			**2 010.75**		**0.30522**		**0.03994**
Total year 2021	44 919.30			2 579.20		0.33995		0.04432
Index 2022/2021	0.77			0.78		0.90		0.90
Total year 1990	232 304.69			19 063.89		1.80697		0.26619
Index 2022/1990	0.15			0.11		0.17		0.15

*) *Country specific data*

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

2022							
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
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 an energy-demanding branch with fuel consumption, such as the textile and leather industry, wood processing and subsequent production processes, the entire machine industry, incl. production of means of transport and the construction industry.

In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported in the section Industry Sector under the item:

- Transport Equipment

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

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

The fraction of CO_2 emissions in subsector 1.A.2.g in CO_2 emissions in sector 1.A.2 equalled 18 % in 2022. 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 has constantly decreased until 2020. Liquid fuels have also constantly decreased in importance since 1990. Natural Gas is also important fuel in this category. This importance of NG can be seen as a slight increase for the year 2021.

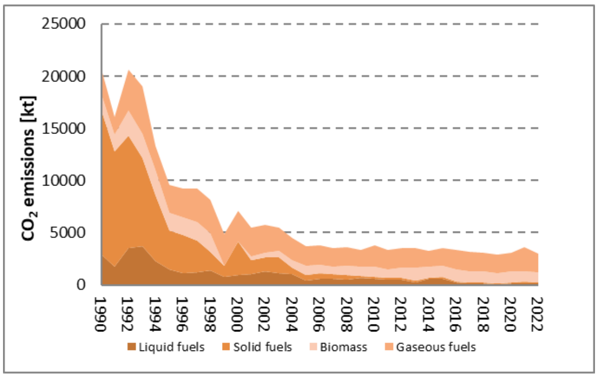

Fig. 3-20 Development of CO_2 emissions in source category 1.A.2.g

The graph in Fig. 3-20 shows that the beginning of the period was characterised by highly energy-intensive types of industrial processes in this category. Social changes occurring in the Czech Republic in the early 90s resulted in energy-saving measures being introduced by newly privatized enterprises. Together, these influences led to an end to inefficient production and suppression of consumption, particularly of fossil fuels, which were the dominant fuels at the beginning of the period and virtually disappeared by 2005, when they were replaced by biomass. At the same time, the importance of liquid fuels decreased. All this was reflected very significantly by a decline in the CO_2 emissions (and other greenhouse gases). This is the category with the largest relative decrease in CO_2 emissions from 1990 to 2022 (89% decrease).

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

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

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

See chapter 3.2.5.

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

See chapter 3.2.6.

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

Based on minor changes of activity data in CzSO, 2023, fuel consumptions of Solid fuels, respectively for Liquid fuels for the year 2021 were recalculated. See the differences in the

Tab. 3-37, resp. Tab. 3-38. Due to the change of activity data in CzSO 2023 for Natural Gas, Gaseous fuels were recalculated for the years 2018 and 2021, see the Tab. 3-39.

Tab. 3-37 Changes after recalculation in 1.A.2.g for Solid Fuels.

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	1335.52	Submission 2023	kt	0.01
Submission 2024	TJ	1332.75	Submission 2024	kt	0.01
Difference	TJ	-2.77	Difference	kt	0.01
Submission 2024	%	-0.21	Submission 2024	%	-0.21
CO_2 emission		2021	N_2O emission		2021
Submission 2023	kt	130.12	Submission 2023	kt	0.00
Submission 2024	kt	129.85	Submission 2024	kt	0.00
Difference	kt	-0.27	Difference	kt	0.00
Submission 2024	%	-0.21	Submission 2024	%	-0.21

Tab. 3-38 Changes after recalculation in 1.A.2.g for Liquid Fuels.

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	2217.59	Submission 2023	kt	0.00
Submission 2024	TJ	2089.79	Submission 2024	kt	0.00
Difference	TJ	-127.80	Difference	kt	0.00
Submission 2024	%	-6.12	Submission 2024	%	-9.49
CO_2 emission		2021	N_2O emission		2021
Submission 2023	kt	158.34	Submission 2023	kt	0.00
Submission 2024	kt	148.87	Submission 2024	kt	0.00
Difference	kt	-9.47	Difference	kt	0.00
Submission 2024	%	-6.36	Submission 2024	%	-11.01

Tab. 3-39 Changes after recalculation in 1.A.2.g for Gaseous Fuels.

Fuel consumption		2018	2021
Submission 2023	TJ	31033.86	39827.34
Submission 2024	TJ	31034.41	41496.76
Difference	TJ	0.55	1669.42
Submission 2024	%	0.00	4.02
CO_2 emission		2018	2021
Submission 2023	kt	1720.81	2207.92
Submission 2024	kt	1721.21	2300.47
Difference	kt	0.4c0	92.55
Submission 2024	%	0.02	4.02
CH_4 emission		2018	2021
Submission 2023	kt	0.03	0.04
Submission 2024	kt	0.03	0.04
Difference	kt	0.00	0.00
Submission 2024	%	0.00	4.02
N_2O emission		2018	2021
Submission 2023	kt	0.00	0.00
Submission 2024	kt	0.00	0.00
Difference	kt	0.00	0.00
Submission 2024	%	0.00	4.02

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

Currently there are no planned improvements in this category.

3.2.16 Transport (1.A.3)

For the purposes of greenhouse gas emissions calculations, the type of transport modes and vehicle categories are differed according to a vehicle type. A particular category consists of the transport mode, the fuel used and the type of emission standard that the vehicle must meet (in the road transport). The categories of vehicles are not so detailed for non-road transport.

Activity data (AD) for road transport are calculated with the help of combining Czech Car Registry (CCR) and Database of Technical Control Stations (TCS). The result is average traffic performance for each category in vehicle kilometres per year. These data are entered into COPERT 5.7 calculation program (see chapter 3.2.16.3).

The data required for calculations in other categories (aviation, railways, navigation) are fuel consumption statistics provided by Czech Statistical Office (CzSO). Activity data are further obtained from EUROCONTROL database for aviation and from Czech Railway Administration and České dráhy for railways.

The categories of mobile sources are the following:

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

- airplanes fuelled by aviation gasoline,
- airplanes fuelled by jet kerosene.

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

- motorcycles, mopeds, micro-cars, quad & ATVs (L-category):
    - conventional, Euro 1 – Euro 5,
    - petrol, diesel,
- passenger cars (PCs):
    - PRE ECE, ECE 15/00-01, ECE 15/02, ECE 15/03, ECE 15/04, conventional, improved conventional, open loop, Euro 1 – Euro 6,
    - petrol, petrol hybrid, petrol PHEV, diesel, diesel PHEV, LPG bifuel, CNG bifuel, battery electric,
- light duty vehicles (LDVs):
    - conventional, Euro 1 – Euro 6,
    - petrol, diesel,
- heavy duty vehicles (HDVs):
    - conventional, Euro I – Euro VI,
    - petrol, diesel,
- buses:
    - conventional, Euro I – Euro VI,
    - diesel, diesel hybrid, biodiesel, CNG.

Railways (CRF 1.A.3.c)

- diesel locomotives: line-haul, shunting, rail cars,
- steam locomotives: bituminous coal, lignite.

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

- ships with diesel engines.

3.2.16.1 Methodological issues

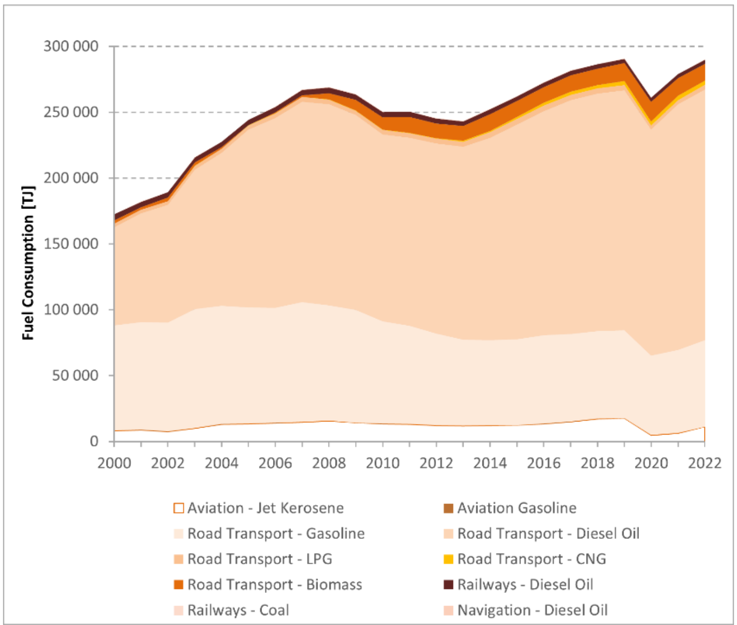

Fig. 3-21 Annual fuel consumption by mode of transport

The methodology for road transport in the Czech Republic is based on COPERT 5 methodology from 2018 (see chapter 3.2.16.3). Other sectors operate with emission factors in [$g.kg^{-1}$] of fuel instead of [$g.TJ^{-1}$] of energy because the country-specific measured data of every greenhouse gas are in the weight units in the internal database. The AD calculated for the CRF Reporter in TJ are affected by CS calorific value (which is variable in different years) of a particular fuel. The fuel consumption entered to the CRF Reporter must be converted from weight to energy units (using the calorific value). Therefore, the time series of IEF depends partially on the trend of calorific values and mostly on EF in [$g.kg^{-1}$]. In case of road transport, all is done automatically in COPERT 5.7. Emission factors of transport subsectors are always given for the current submission year. All calorific values used for calculations in the transport sector are presented in the chapter 3 (Energy).

In the table below, activity data by mode of transport are displayed, a graphical comparison is shown in Fig. 3-21.

Tab. 3-40 Fuel consumption by mode 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	131	8 256	79 855	74 322	2 852	97	2 480	4 440	NO	213
2001	88	8 774	81 712	82 493	2 792	97	1 842	4 066	NO	335
2002	131	7 576	82 574	89 452	2 838	97	2 586	3 942	NO	168
2003	131	10 186	90 191	105 862	2 884	146	2 480	3 857	NO	168
2004	131	13 097	89 883	116 057	3 015	146	1 275	3 810	NO	251
2005	88	13 610	88 234	135 003	3 104	146	106	3 848	14	209
2006	88	14 116	87 332	144 135	3 298	146	727	4 107	15	257
2007	88	14 809	91 070	152 072	3 527	195	1 204	4 061	13	214
2008	88	15 675	87 701	152 639	3 506	244	4 469	4 501	14	171
2009	88	14 332	85 499	148 039	3 242	293	7 913	4 083	14	215
2010	88	13 423	77 631	142 060	3 374	343	9 374	3 959	15	172
2011	44	13 293	74 618	142 631	3 417	392	12 140	3 869	15	129
2012	88	12 384	69 510	144 170	3 767	489	11 136	3 737	15	215
2013	88	11 951	65 316	146 332	3 898	736	11 205	3 652	16	86
2014	88	12 341	64 662	153 487	4 292	1 032	12 817	3 697	43	129
2015	131	12 427	65 178	162 927	4 336	1 528	12 000	3 607	43	129

2016	131	13 380	67 180	170 197	4 336	2 076	11 875	3 308	41	172
2017	131	15 025	66 425	177 508	4 205	2 320	12 440	3 436	41	172
2018	131	17 320	66 471	180 111	4 030	2 615	12 273	3 435	28	129
2019	131	17 710	66 450	182 483	3 854	3 106	13 602	3 308	13	215
2020	88	4 850	60 380	171 429	3 241	3 157	14 872	2 927	8	172
2021	88	6 495	62 798	186 581	3 285	3 205	13 624	2 852	11	173
2022	88	11 171	65 692	190 184	3 723	3 174	12 850	3 109	13	130

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

Burning processes in air transport are quite different from those in land and water transport. This is caused by its operation in a wider range of atmospheric conditions (namely by substantial changes in atmospheric pressure, air temperature, and humidity). These variables are changing vertically with an altitude and horizontally with air masses. The categories 1.A.3.a (domestic aviation) and 1.D.1.a (international aviation) are reported with respect to distinctive flight phases: LTO (Landing/Take-off up to 3 000 feet) and CRUISE (above 3 000 feet). Emissions from helicopters used for public and private purposes are included in this category. Emissions from military aircrafts and helicopters are not included and are reported in the category 1.A.5.b Military: Mobile Combustion.

3.2.16.2.1 Methodological issues

For IFR flights, bottom-up data from EUROCONTROL were used in time series 2005 to present year. Time series 1990–2004 was estimated by extrapolation of EUROCONTROL fuel consumption with the help of fuel consumption from Czech Oil questionnaire provided by CzSO. Emissions were calculated with EUROCONTROL implied emission factors. LTO/CRUISE ratios were calculated from EUROCONTROL data (Tab. 3-41). In 2024 submission, the entire time series 1990–2022 was recalculated based on the latest EUROCONTROL data (see chapter 10.1.1.2).

For VFR flights, ratio between LTO a CRUISE was obtained from ÚCL as their expert judgement because there is no database for VFR flight characteristics in CZ. The LTO/CRUISE ratio and EFs according to 2006 IPCC Guidelines were applied on fuel consumption obtained from CzSO in Czech Oil questionnaire. Fuel consumption for helicopters was also obtained from CzSO. Ratio between LTO and CRUISE was obtained from ÚCL. EFs according to 2006 IPCC Guidelines were applied on fuel consumption. LTO and CRUISE ratios are presented in the Tab. 3-41.

To ensure comparability of statistics, fuel consumption for aviation is fuel balanced on fuel consumption stated in Czech Oil questionnaire for jet kerosene and aviation gasoline on national level.

Tab. 3-41 Ratio of fuel usage between LTO and CRUISE flight mode in 2022

Subsector	Flight Mode	Ratio
1.A.3.a (IFR)	LTO	0.264
	CRUISE	0.763
1.A.3.a (VFR, Helicopters)	LTO	0.900
	CRUISE	0.100

1.D.1.a	LTO	0.130
	CRUISE	0.870

Activity data

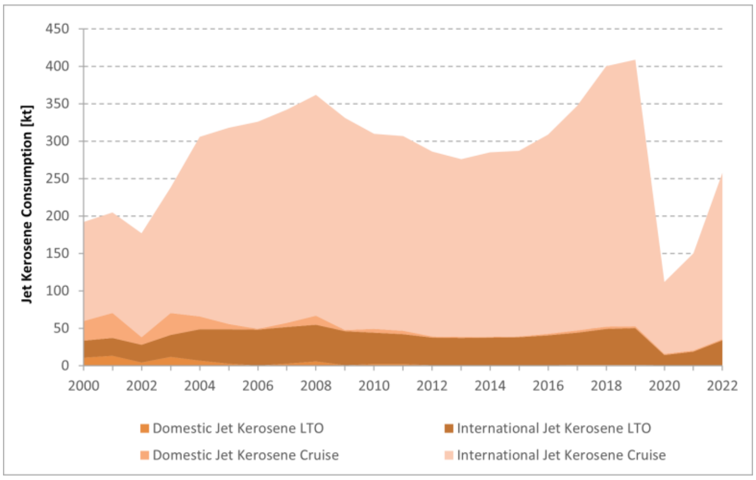

Fig. 3-22 Annual jet kerosene consumption in aviation according to flight mode

Activity data are gained from CzSO and EUROCONTROL. Data are divided between LTO and CRUISE flight mode according to ratio which is stated in the Tab. 3-41. The total consumption of jet kerosene in the Czech Republic is divided into five categories (Domestic Aviation, International Aviation, Army, Industry and Commercial and Public Services). The jet kerosene consumption as well as relevant emissions from categories Army, Industry, Commercial and Public Services are not reported in CRF tables in Transport sector 1.A.3, but in sectors 1.A.5.b, 1.A.2.g and 1.A.4.a respectively. Data for domestic aviation and international aviation are gained from EUROCONTROL (IFR flights) and from CzSO (VFR flights and helicopters). Fig. 3-22 displays jet kerosene consumption according to flight mode.

Emission factors

The emission factors for IFR flights are on Tier 2 level for CO_2 and on Tier 3 level for N_2O. Those EFs are based on EUROCONTROL database. EFs for VFR flights and helicopters and for CH_4 for IFR flights are Tier 1. They are based on calorific value of fuel (updated every year by Czech Oil Questionnaire for EEA) and EF (kg/TJ) stated in 2006 IPCC Guidelines for aviation.

Tab. 3-42 Emission factors for CO_2, CH_4 and N_2O for aviation in [g.kg^{-1}] of fuel in 2022

Subsector	Fuel Type	EF CO_2	EF CH_4	EF N_2O
		[g.kg^{-1}]	[g.kg^{-1}]	[g.kg^{-1}]
Aviation - LTO	Aviation Gasoline	3050	0.022	0.086
Aviation - CRUISE	Aviation Gasoline	3050	0.022	0.086
Aviation - LTO	Jet Kerosene	3150	0.022	0.086
Aviation - CRUISE	Jet Kerosene	3150	0.022	0.086

Emissions

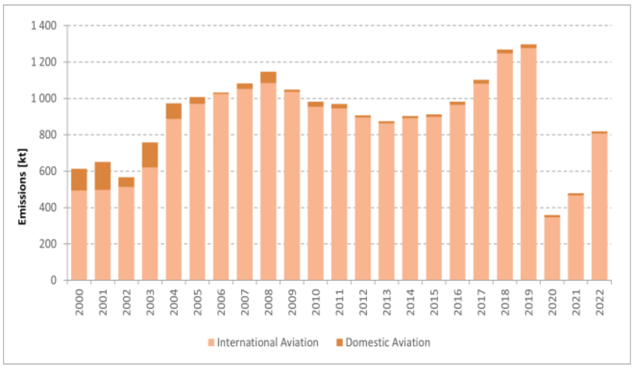

Fig. 3-23 Emissions of CO_2, CH_4 and N_2O from aviation

CO_2 emissions from domestic air transport make a very small contribution to overall emissions from aviation (2% in average for years 2005–2022) as they are mainly limited to flights between the five largest airports in the Czech Republic (Prague, Brno, Karlovy Vary, Pardubice and Ostrava). Similarly to road transport, the consumption of aircraft fuels is not monitored centrally by the Czech Statistical Office. Aircrafts are mainly fuelled by jet kerosene while the consumption of aviation gasoline and CO_2 emissions from aviation gasoline are limited to small aircrafts used in agriculture, sports and for recreational activities. Small aircrafts fuelled by aviation gasoline include VFR flights. There are no small aircrafts fuelled by jet kerosene for VFR flights in the Czech Republic.

Fig. 3-23 shows GHG emissions from aviation in the Czech Republic. The emissions were decreasing from 2008 to 2013 as a result of the economic crisis. From 2014, the emissions were increasing until a huge drop in 2020 and 2021 caused by COVID-19 pandemic situation. In 2022, the emissions grew sharply, but didn't reach the level of years before pandemic.

3.2.16.3 Road Transport (CRF 1.A.3.b)

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

3.2.16.3.1 Methodological issues

The appropriate distribution is necessary to assign a relevant emission factor. Sector 1.A.3.b Road Transport 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.

For estimation of road transport emissions, COPERT 5.7 model was used. COPERT is based on the 2023 Emission Inventory Guidebook and 2016 IPCC Guidelines and also incorporates results of several technology, research and police assessment projects. Model is being regularly updated (usually new version each year). The basis for emission calculations in COPERT 5 are number of vehicles, average annual mileage, and average total mileage for COPERT categories. Other important variables are:

- CS meteorological information,
- EU average information about driver behaviour (trip length, trip duration, average speed on different roads etc.),
- technical parameters of vehicles (technologies for emissions reduction, 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,
- share of fossil fraction in biodiesel,
- ETBE content in biogasoline.

This is only a brief summary. Full description of COPERT 5 program is possible to find in COPERT Documentation. Full methodology of application of COPERT 5 in Czechia is described in Pelikán and Brich, 2017 and Pelikán and Brich, 2018.

Activity data

AD for COPERT program are gained from two large databases – Czech Car Registry (CCR) and Database of Technical Control Stations (TCS). CCR contains information about numbers and technical details of vehicles registered in particular categories in CZ. TCS defines annual 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 COPERT categories which are relevant in CZ. Results are in full accuracy four years before the actual reported year. The reason is that new cars in CZ must undertake a technical control after four years after signing in CCR. To have precise average annual mileage and emissions estimates, it is necessary to recalculate results 4 years backward repeatedly. This calculation procedure for average annual mileage in Czech conditions was developed by Brich in 2014 and improved in 2019. Methodology was certified by Czech MoT. COPERT uses these AD to calculate fuel consumption in all categories. Fuel consumption in categories is normalized with the help of total fuel consumption provided by CzSO for national level.

Fig. 3-24 shows trends of fuel consumption after 2000. General rising trend of fuel consumption by PCs and LDVs is in line with general trend in the whole Europe. There is an obvious influence of economic crisis between 2008 and 2013 to fossil fuels consumption (Tab. 3-43). From 2014, there is a significant increase of fuel consumption of main fossil fuels. In 2017, almost 10% lower prices of diesel and gasoline influenced increase of fossil fuels consumption. The consumption of gasoline fluctuated around 90 000 TJ from 2003 to 2009, but it started to decline significantly since 2010. This decline was especially caused by the downward trend in an average fuel consumption of modern passenger cars. In 2013, the gasoline consumption decreased to 65 320 TJ. Since then, it has been fluctuating around this value. Exception is year 2020 influenced by COVID situation, when gasoline consumption was 60 378 TJ. In 2021, it rose to almost 63 000 TJ and in 2022 it again reached the pre-pandemic level. Diesel fuel consumption was steadily growing from 2000 until 2008 when economic crisis started. After the crisis, steep increase began in 2014 and was related to economic growth and growing popularity of diesel PCs. Due to COVID pandemic, diesel consumption dropped to 171 416 TJ in 2020. In 2021, it sharply increased to 186 576 TJ and the growth was continuing in 2022.

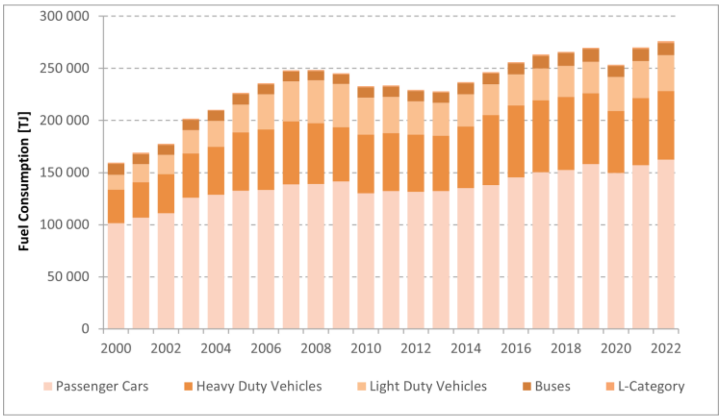

Fig. 3-24 Trend of fuel consumption according to vehicle categories

Bioethanol was almost not used, and biodiesel was only used in a small share in Czech Republic until 2008. The consumption of gasoline also includes the consumption of bioethanol, which started to be added to all gasoline in the amount of 2% since 1 January 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 have not changed since then. Share of biofuels in fossil fuels increased too (6.8% in 2010 and 8.5% in 2015). These facts (the reduction in a consumption and an increasing share of bio-components) have a favourable impact on CO_2 emissions. In 2015, lower taxes for blends with high percentage of biodiesel were implemented, but customers slowly accepted this change. Since 2016, the consumption of biodiesel has been steadily increasing and it reached more than 12 500 TJ in 2020. Since 2021, it has been slightly decreasing. Bioethanol shows no specific long-term trend. The highest consumption of bioethanol was before COVID pandemic in 2019 (3 078 TJ).

Tab. 3-43 Fuel consumption in road transport in the Czech Republic

Year	Gasoline	Diesel Oil	LPG	CNG	Biodiesel	Bioethanol
	[TJ]	[TJ]	[TJ]	[TJ]	[TJ]	[TJ]
2000	79 889	74 325	2 852	97	2 590	0
2001	81 750	82 499	2 792	97	1 924	0
2002	82 616	89 458	2 838	97	2 701	0
2003	90 237	105 871	2 884	146	2 590	0
2004	89 934	116 072	3 015	146	1 332	0
2005	88 289	135 024	3 104	146	111	0
2006	87 371	144 165	3 298	146	703	54
2007	91 148	152 101	3 527	195	1 258	0
2008	87 722	152 660	3 506	244	3 145	1 458
2009	85 503	148 052	3 242	293	5 698	2 457
2010	77 632	142 065	3 374	343	7 252	2 430
2011	74 615	142 624	3 417	392	10 027	2 538
2012	69 510	144 167	3 767	489	9 176	2 349
2013	65 320	146 329	3 898	736	9 361	2 241
2014	64 650	153 478	4 292	1 032	10 508	2 754
2015	65 173	162 926	4 336	1 528	9 768	2 646
2016	67 189	170 196	4 336	2 076	10 286	2 025
2017	66 422	177 508	4 205	2 320	10 397	2 484
2018	66 470	180 112	4 030	2 615	10 138	2 565
2019	66 432	182 481	3 854	3 106	10 989	3 078
2020	60 378	171 416	3 241	3 157	12 654	2 754
2021	62 808	186 576	3 285	3 205	11 803	2 322
2022	65 695	190 186	3 723	3 174	10 656	2 646

CNG buses have been used in the Czech Republic from 1994 and CNG PCs from 2006. The steep increase of the CNG consumption in 2012 was caused by subsidies from public resources in order to encourage the use of CNG buses. Other subsidies were determined to CNG LDVs and PCs which were used by local authorities what resulted in steady increase of CNG consumption and is continuing in the present. LPG consumption was continuously growing until 2016. After 2016, it began to decrease what was probably caused by low prices of diesel and gasoline, and in the last years also thanks to the introduction of new alternative fuels.

Emission factors

Emission factors are COPERT based. EFs for CO_2 are on Tier 2 level and for CH_4 and N_2O on Tier 3 level. Generally, EFs for all GHGs are composed from hot EFs, cold EFs and they are additionally dependent on vehicle category and driving mode (share of urban, rural, highway driving).

Tab. 3-44 Implied EFs for CO_2 for road transport

Year	Gasoline	Diesel Oil	LPG	CNG	Biomass
	[t/TJ]	[t/TJ]	[t/TJ]	[t/TJ]	[t/TJ]
2010	70.41	73.11	68.95	56.23	74.75
2011	70.27	73.20	68.96	56.25	75.03
2012	70.28	73.24	68.98	56.38	75.02
2013	70.26	73.24	68.98	56.18	75.08
2014	70.06	73.19	68.98	56.09	74.99
2015	69.96	73.27	68.98	55.95	74.95
2016	70.44	73.25	68.98	55.79	75.25
2017	70.11	73.26	68.98	55.86	75.08
2018	70.04	73.28	68.98	55.89	75.02
2019	69.72	73.25	68.98	55.93	74.92
2020	69.74	73.11	68.98	55.89	75.16
2021	70.14	72.80	68.98	55.91	75.25
2022	69.99	72.88	68.98	52.89	75.04

EFs for CO_2 count with using A/C, SCR, and lubricant consumption. Implied EFs are additionally dependent on calorific value of fuel (kg/TJ) because input data about primary fuel consumption provided by CzSO are only available in ‘kt’ units. Therefore, the primary fuel consumption must be recalculated to ‘TJ’ units with the help of the fuel energy content (calorific value) which is updated based on the Czech Oil Questionnaire for EEA every year. CO_2 IEF also depends on country-specific H:C and O:C ratios which were calculated based on the laboratory analysis (Černý, 2018). The rest of the parameters (A/C usage, SCR, and lubricant consumption) are influencing how CO_2 production is distributed between fuel combustion and other processes. This is implemented in COPERT methodology which is in line with EMEP/EEA Emission Inventory Guidebook (EIG) 2023. Implied EFs for CO_2 after year 2010 are shown in the Tab. 3-44.

Tab. 3-45 Implied EFs for CH_4 for road transport

Year	Gasoline	Diesel Oil	LPG	CNG	Biomass
	[kg/TJ]	[kg/TJ]	[kg/TJ]	[kg/TJ]	[kg/TJ]
2010	16.15	2.29	10.79	48.81	8.83
2011	15.03	1.85	10.64	48.83	6.85
2012	14.08	1.58	10.47	42.94	6.32
2013	13.54	1.35	10.40	39.77	5.69
2014	12.63	1.20	10.08	35.88	5.56
2015	12.28	1.03	10.00	34.05	5.39
2016	11.72	0.85	10.01	31.82	4.08
2017	11.31	0.86	9.92	32.30	4.51
2018	11.49	0.79	9.76	29.52	4.68
2019	10.20	0.62	9.61	29.51	4.37
2020	10.01	0.57	9.68	31.50	3.61
2021	9.82	0.53	9.73	29.93	3.26
2022	9.38	0.51	9.55	27.49	3.66

In the Tab. 3-45 and Tab. 3-46, there are shown implied EFs for CH_4 and N_2O for road transport after year 2010.

Tab. 3-46 Implied EFs for N_2O for road transport

Year	Gasoline	Diesel Oil	LPG	CNG	Biomass
	[kg/TJ]	[kg/TJ]	[kg/TJ]	[kg/TJ]	[kg/TJ]
2010	1.90	2.09	2.35	4.09	2.60
2011	1.80	2.23	2.26	3.97	2.66
2012	1.68	2.39	2.12	3.59	2.77
2013	1.58	2.51	2.01	3.41	2.85
2014	1.48	2.64	1.93	3.21	2.93
2015	1.39	2.59	1.84	3.04	2.84
2016	1.27	2.67	1.79	2.81	2.92
2017	1.17	2.68	1.73	2.88	2.87
2018	1.10	2.73	1.64	2.70	2.88
2019	0.94	2.75	1.54	2.80	2.81
2020	0.88	2.88	1.49	3.06	2.99
2021	0.82	2.89	1.41	2.93	3.02
2022	0.76	2.92	1.32	2.72	2.96

CO_2 emissions

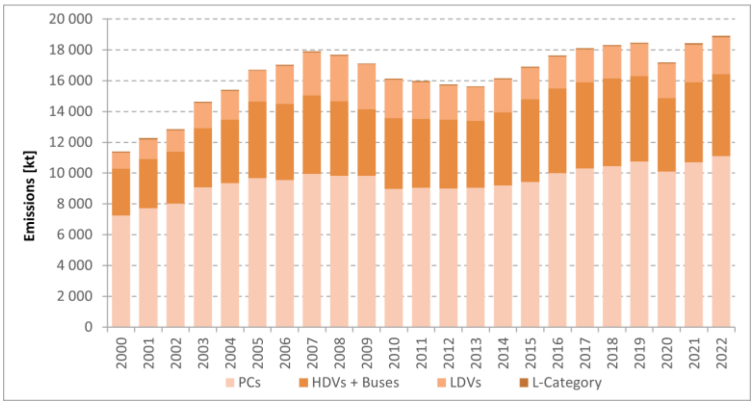

Fig. 3-25 Emissions of CO_2 from road transport according to subcategories

Carbon dioxide emissions were calculated on the basis of the total consumption in all COPERT vehicle categories which are relevant in CZ. COPERT separately calculates emissions from hot engines, cold engines, emissions originated from A/C and SCR usage (diesel cars) and emissions caused by lubricant consumption during burning processes. Emissions from lubricants combusted in 2-stroke moped and motorcycle engines are reported within 1.A.3.b.iv subcategory according to 2006 IPCC Guidelines and based on EIG 2023 and COPERT methodology.

A gradually increasing share of transport in total CO_2 emissions in the Czech Republic became evident during the 90´s 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). It is obvious, according to the methodology of calculation of CO_2 emissions described above, that trend in CO_2 emissions copies trend in fuel consumption (see Fig. 3-26). A decrease in emissions of carbon dioxide from road transport was recorded in 2008 for the first time. In the same year, a downward trend started which continued until 2014 (Jedlička et al., 2014). From 2014 till 2019, emissions from road transport were growing and reached almost 18 500 kt of CO_2 in 2019. The next year, there was a decrease to around 17 000 kt due to COVID situation. It was the first drop in CO_2 emissions after the economic crisis. The emissions jumped back to the value before COVID in 2021 and reached almost 19 000 kt in 2022. The carbon dioxide emissions trend is primarily a result of the changes in the traffic performance by gasoline and diesel cars. According to the Fig. 3-26, the CO_2 emissions from road transport are following the trend of energy consumption. There are no disproportions. Small fluctuation can be caused by the fact that EFs are calculated based on a slightly variable calorific value of a particular fuel. These values are given by CzSO every year. Other factor is that CO_2 emissions are dependent on the ratio of energy consumption of a particular type of fuel.

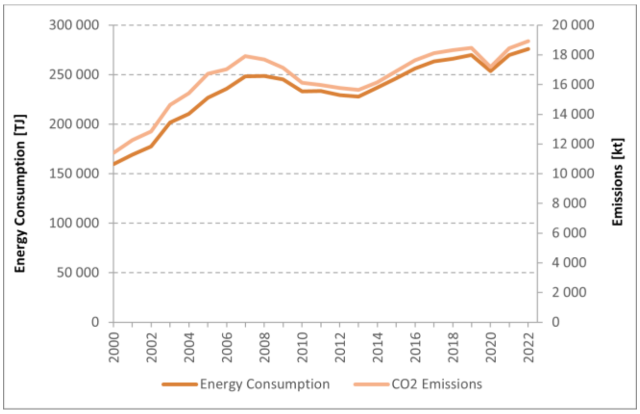

Fig. 3-26 Comparison of energy consumption and CO_2 emissions from road transport

CH_4 emissions

Methane emissions derived from road transport-related greenhouse gas emissions have being successfully mitigated in Czech Republic. Trend in CH_4 emission production according to subcategories are shown in Fig. 3-27. The annual trend in these emissions is constantly decreasing and is very similar to other hydrocarbon emissions which are limited in accordance with Euro regulations. New vehicles must substantially fulfil 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 a slow renewal of the car fleet. Average age of personal cars was 15.93 years and average age of trucks was 18.22 years in 2022 (SDA, 2023). Car park renewal in CZ is still in progress and older vehicles are frequently used in the construction and food industries. The potential problem in CH_4 emissions could be growing share of CNG vehicles (especially buses from 2012). CNG is composed of approx. 98% of CH_4. On the other hand, CNG is beneficial for other GHGs and pollutants.

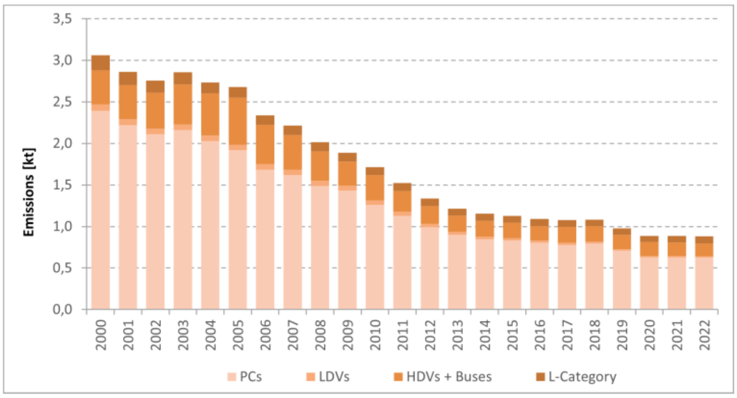

Fig. 3-27 Emissions of CH_4 from road transport according to subcategories

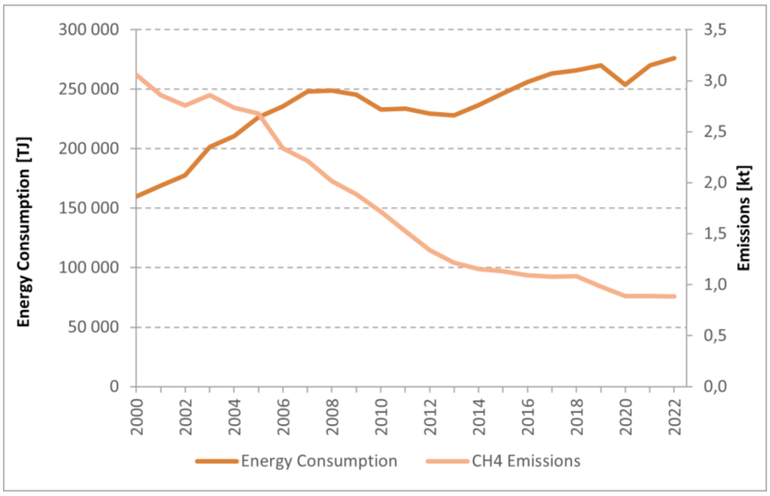

Fig. 3-28 Comparison of energy consumption and CH_4 emissions from road transport

Fig. 3-28 shows the opposite trend in emission production of CH_4 and energy consumption in road transport The continuous decrease started in 1996 when the Euro 2 (II) standard was implemented. The decrease in the following years was intensified by toughening the THC limits in 2005 by the Euro 4 standard. Another cause of the downward trend is an increasing ratio of diesel passenger cars within the car fleet over the past few years, which produce less CH_4. In 2018 and 2019, increase of energy consumption continued (not so intensively compared to the last years) but CH_4 emissions have still been decreasing. In 2019, emissions even fell under 1 kt thanks to car fleet renewal.

N_2O emissions

Trend in N_2O emissions production according to subcategories is shown in Fig. 3-30. There is a huge drop in emissions after 2000 which was probably related to Euro 3 standard implementation. Similarly to carbon dioxide emissions, the next decrease of nitrous oxide emissions started in 2009 as a consequence of reduced consumption of gasoline and diesel oil. New vehicles exhibit higher emissions compared to older models because they are equipped with 3-way catalytic converters which reduce only NO_X emissions but not N_2O emissions. However, this effect is suppressed in new vehicles because of a lower fuel consumption. Between 2008 and 2010, the N_2O emissions were decreasing because of economic crisis and lower traffic performance. From 2013 to 2019, N_2O emissions were more significantly increasing. This fact is caused by a higher consumption of a diesel oil which is influenced by progress in the national economy and by increase in a transport of goods and material. In 2018, increase of fuel consumption continued but not so intensively as in the last years. There was a decrease to 0.61 kt due to COVID situation in 2020. In 2022, N_2O emissions reached 0.66 kt what is the highest value since 2001. This increase is mitigated by modernization of car fleet in the Czech Republic.

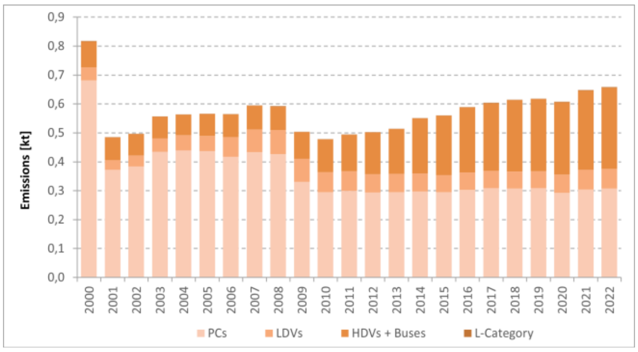

Fig. 3-30 Emissions of N_2O from road transport according to subcategories

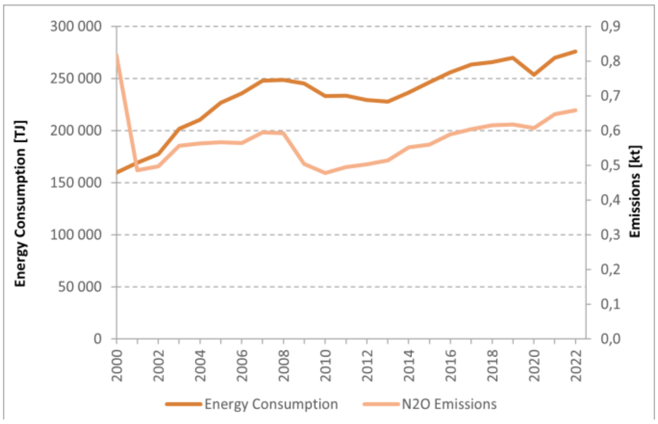

Fig. 3-29 Comparison of energy consumption and N_2O emissions from road transport

Over the past years, except for 2020 influenced by COVID, N_2O emissions have been increasing. The main reason is growing share of vehicles with high N_2O emissions. Consequently, N_2O emissions from mobile sources represent higher contribution than CH_4 emissions. In N_2O emissions from mobile sources, the most important source seems to be passenger automobile transport, especially gasoline-fuelled passenger cars with catalysts. Fig. 3-29 shows a similar trend in N_2O emissions from road transport compared to the energy consumption trend. Between years 2009 and 2013, there was more significant decreasing trend in N_2O emissions compared to fuel consumption. This effect could be related to introduction of more advanced emission control technologies.

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

3.2.16.4.1 Methodological issues

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

In 2023 submission, new methodology for calculation of railway emissions from diesel oil was introduced which increased detail and accuracy of calculation from Tier 1 to Tier 2 level as per EIG 2023. Based on the new activity data obtained from Czech Railway Administration (Správa železnic), České dráhy (ČD) and CzSO, national diesel fuel consumption statistics were broken down by locomotive type in order to apply three different sets of emission factors (EIG, 2023). There are three diesel locomotive categories:

- line-haul locomotives,
- shunting locomotives,
- rail-cars.

Calculation of railway emissions from diesel consists of three main steps:

1) Rail traffic performance calculation – Average traffic performance of line-haul locomotives and rail-cars is calculated based on the latest available data from Správa železnic for profile weeks in the given year. In each category, five the most frequent locomotives and their share on rail traffic performance in brtkm is defined. Final value is weighted traffic performance of these locomotives. Shunting locomotive traffic performance is based on the study Perůtka et al., 2020.
2) Calculation of traction diesel consumption – Specific traction diesel consumption is calculated for each locomotive category. Final traction diesel consumption is a product of activity data and specific traction diesel consumption. Based on this value, share of each locomotive category on the total rail diesel fuel consumption given by CzSO is set.
3) EFs application – Tier 2 EFs are applied on final diesel consumption calculated for each category.

Steam locomotives are operated in the Czech Republic as well. However, their contribution to emissions is very small as they only serve as tourist attractions. EFs used for calculation of railway emissions from coal are on Tier 1 level according to 2006 IPCC Guidelines.

Activity data

Activity data about rail traffic performance were obtained from Czech Railway Administration (Správa železnic) and from the major Czech railway operators ČD and ČD Cargo. Data about national fuel consumption were provided by CzSO. Regular railway operation uses diesel oil. Coal is only used within historical rides and the percentage of its consumption is very small. In general, fuel consumption by railways has a slightly decreasing trend from 2000. The only exception were years 2005–2008. After this period, the fuel consumption fell to 84 kt in 2015 and then oscillated around 80 kt because of the economic crisis and replacement of diesel-powered locomotives by electric ones. Since 2016, biodiesel has been used as well. It's share on the total railway diesel consumption has been around 8%. In 2020, non-bio diesel consumption dropped to 68 kt due to restrictions during COVID pandemic which still continued in 2021. Coal (lignite) started to be used at Czech railways for purposes of historical rides in 2005. From 2014, bituminous coal was used too. Total coal consumption has been decreasing since 2018. The reason is no consumption of lignite from 2018. Both diesel and coal consumption increased in 2022 as the result of general return to pre-pandemic traffic performance.

Tab. 3-47 Fuel consumption by railways

Year	Non-bio Diesel Oil [kt]	Biodiesel [kt]	Coal [kt]
2000	104.0	0.0	0.0
2001	97.0	0.0	0.0
2002	94.0	0.0	0.0
2003	92.0	0.0	0.0
2004	91.0	0.0	0.0
2005	92.0	0.0	1.0
2006	96.0	0.0	1.0
2007	95.0	0.0	1.0
2008	105.0	0.0	1.0
2009	95.0	0.0	1.0
2010	92.0	0.0	1.0
2011	90.0	0.0	1.0
2012	87.0	0.0	1.0
2013	85.0	0.0	1.0
2014	86.0	0.0	2.0
2015	84.0	0.0	2.0
2016	77.0	8.0	2.0
2017	80.0	7.0	2.0
2018	80.0	6.0	1.0
2019	77.0	5.0	0.5
2020	68.0	5.0	0.3
2021	66.0	6.0	0.4
2022	72.0	6.0	0.5

Emission factors

The emission factors for diesel oil are Tier 2 for all GHGs. CO_2 EF is country-specific, CH_4 and N_2O EFs are applied according to EIG 2023. EFs for coal for CO_2, CH_4 and N_2O are Tier 1. They are based on calorific value of fuel (updated every year by Czech Oil Questionnaire for EEA) and EF [$kg.TJ^{-1}$] stated in 2006 IPCC Guidelines for railways see Tab. 3-48.

Tab. 3-48 Emission factors for CO_2, CH_4 and N_2O for railways in [$g.kg^{-1}$] of fuel in 2022

Locomotive type	Fuel Type	EF CO_2 [$g.kg^{-1}$]	EF CH_4 [$g.kg^{-1}$]	EF N_2O [$g.kg^{-1}$]
Line-haul	Diesel Oil	3 146	0.182	0.024
Shunting	Diesel Oil	3 146	0.176	0.024
Rail-cars	Diesel Oil	3 146	0.179	0.024
Steam	Coal	2 553	0.053	0.040

Emissions

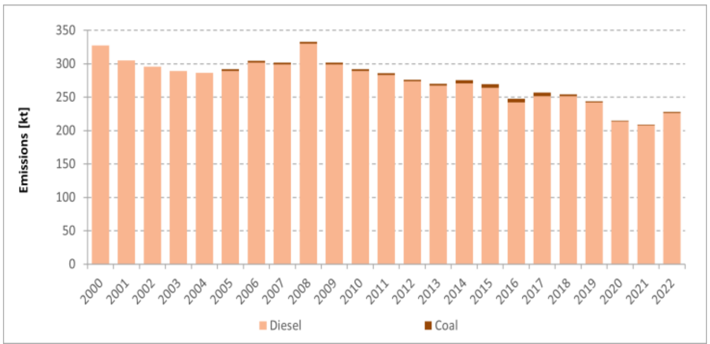

Fig. 3-31 Trend in emissions of CO_2, CH_4 and N_2O from railways

Emissions from railways are strongly dependent on fuel consumption due to the methodology. GHG emissions are given in the Fig. 3-31. The sharpest decrease in emissions was happening until 1994. This was related to the decrease of freight transport because of significantly lowest coal mining intensity compared to period before 1989. Next factor was electrification of core network and modernization of rolling stock during these years. In the following years, GHG emissions were slightly decreasing except for period 2005-2008 when an increase connected with economic growth was recorded. After 2008, the emissions were decreasing again due to economic crisis. Since 2012, GHG emissions were oscillating around 250 kt depending on traffic performance on railways in the particular year. In 2020 and 2021, they dropped to 210 kt due to COVID pandemic. In 2022, GHG emissions from diesel oil rose to 227 kt and from coal to 1.3 kt what was related to post-pandemic traffic performance increase. Emissions from burning coal have been produced by usage for historical rides since 2005 but they have only minor share (1%) on overall railway emissions.

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

3.2.16.5.1 Methodological issues

Primary data on fuels available via the CzSO or other statistics do not allow a proper differentiation into national and international navigation on inland waterways in the Czech Republic. Therefore, all activity data are allocated to CRF 1.A.3.d Domestic Navigation for the time being.

Activity data

Fuel consumption by domestic navigation is very low (see Tab. 3-49). The CzSO have been providing data about diesel oil consumption since 1997. The data before 1997 are based on the CzSO expert judgement. All data are related to diesel oil consumption within recreational fleet which basically represents most of the fuel consumption by domestic navigation in the Czech Republic. There is no Czech merchant fleet.

Tab. 3-49 Fuel consumption by domestic navigation

Diesel Oil [kt]			
2000	5	**2011**	3
2001	8	**2012**	5
2002	4	**2013**	2
2003	4	**2014**	3
2004	6	**2015**	3
2005	5	**2016**	4
2006	6	**2017**	4
2007	5	**2018**	3
2008	4	**2019**	5
2009	5	**2020**	4
2010	4	**2021**	4
		2022	3

Emission factors

The emission factors for CO_2, CH_4 and N_2O are Tier 1 based on calorific value of fuel (updated every year by Czech Oil Questionnaire for EEA) and EF (kg/TJ) stated in 2006 IPCC Guidelines for navigation.

Tab. 3-50 Emission factors of CO_2, CH_4 and N_2O for domestic navigation in [g.kg^{-1}] of fuel in 2022

Subsector	Fuel Type	EF CO_2	EF CH_4	EF N_2O
		[g.kg^{-1}]	[g.kg^{-1}]	[g.kg^{-1}]
Domestic Navigation	Diesel Oil	3 199	0.302	0.086

Emissions

Emissions from domestic navigation are strongly dependent on fuel consumption. Values are quite fluctuating because of irregularities in traffic performance on Czech inland waterways. Overall GHG emissions are given in the Fig. 3-32.

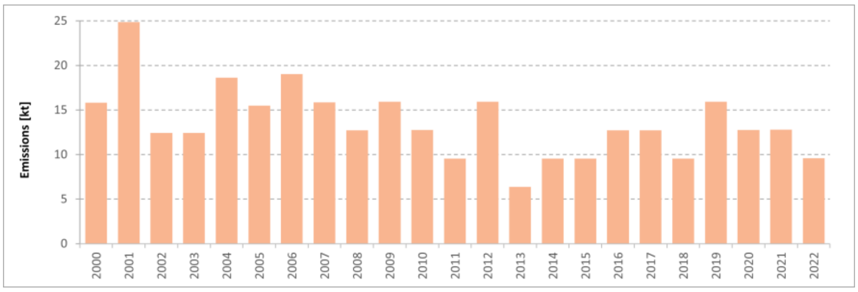

Fig. 3-32 Trend in emissions of CO_2, CH_4 and N_2O from domestic navigation

3.2.16.6 Other Transport (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, 2022) Questionnaire in the Transport Sector section under the item:

Pipeline Transport

There are embodied the fuels of economic part according to NACE Rev. 2 Pipeline Transport: NACE Divisions 35.22, 49.50.

3.2.16.7 Uncertainties in Transport (CRF 1.A.3.)

Uncertainties were calculated according to chapter A.5 EIG 2023. The uncertainties given here were evaluated for the entire time series (1990–2022) and for all reported categories (see Annex 2). Uncertainties of national emissions within transport sector for particular GHG are given in Tab. 3-51.

Tab. 3-51 Uncertainty data for transport from uncertainty analysis

IPCC Source Category	GHG	Base Year Emissions (1990)	Year 2022 Emissions	Contribution to Variance by Category in Year 2022
		[kt]	[kt]	[%]
1A3 Transport	CO_2	11 742	20 902	0.79
	CH_4	87.34	26.03	58.72
	N_2O	89.48	180.47	39.00

3.2.16.8 Source-specific QA/QC and verification

QC carried out in the Transport Research Centre (CDV) is based on routine and consistent checks to ensure data integrity, correctness, completeness and to identify and address errors. Documentation and archiving of all QC activities is carried out. QC activities include methods such as accuracy checks on data acquisition and calculations, and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimated parameters and methods. QA and verification of activity data is guaranteed in the CDV by comparing activity data with world and European databases and third person checks.

An inventory compiler is responsible for coordinating the institutional and procedural arrangements of inventory activities. These cover data collection from the CzSO, deciding of usage of emissions factors (according to CS or EIG) and estimation of emissions from mobile sources. The uncertainty assessment is carried out by the inventory compiler too. The last step is a documentation and archiving of data. The inventory compiler designs responsibilities for implementation QA/QC procedures among persons not directly involved in the compilation of 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 the CDV is based on the inner quality control procedure system, which is harmonised with the QA/QC system of Czech Hydrometeorological Institute (CHMI). Since the transport sector belongs to the energy sector, there has been a 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. The CHMI in close cooperation with CzSO ensure 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 categories, all years, all subcategories and confirm that entire category of mobile sources is being covered).
- Trend checks (checking value of implied emission factors and unusual, unexplained trends noticed for activity data or other parameters across the time series).
- Checking of internal documentation and archiving.

b. Responsibilities in CDV

The sectoral guarantor of QA/QC procedures for mobile sources:

- is responsible for the sectoral QA/QC plan and the compliance of all QA/QC procedures,
- provides plan for the QC procedure and is responsible for its implementation.

Inventory compiler of inventory from mobile sources:

- performs the emission calculations from transport in the emission model,
- provides for data import in the CRF table,
- is responsible for 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 Dědina (Research Institute of Agricultural Technology)

c. QA/QC procedure in CDV

During every submission, in the beginning of summer, the inventory compiler first receives preliminary activity data from CzSO and makes first calculations which are compared with previous years regarding to a trend in data from last years. If there are some discrepancies, activity data will be consulted with CzSO and inaccuracies will be corrected. During autumn, CzSO provides final activity data. Then final calculations are made. Also, the QC is made by the inventory compiler, afterwards by a person responsible for compilation of Transport yearbook in CDV and Mr. Jiri Dufek from MOTRAN RESEARCH. Every error is described, documented and saved. The next quality control is made by an expert in CHMI. Last step of QC are European reviews. The QA is made on activity data by comparing it with databases like Eurostat and IEA. Main discrepancies are consulted with CzSO and explained during reviews. Emission estimates are prepared for a submission until 5 February and send to an inventory coordinator. The Stage 1 review questions are processed during the second half of March. The Stage 2 review questions are processed during May and June.

3.2.16.9 Recalculations and improvements

All recalculations and improvements are in detail described in chapter 10.1.1.2. In this chapter, there are only mentioned changes due to review process and improvement plan and also improvements planned in the future.

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

3.2.16.9.1.1 Recalculations due to methodology changes

1.A.3.b – Road Transport

New version of COPERT programme (update from the version 5.5.1 to 5.7.2) was used to calculate emissions from road transport. Due to this update, entire time series 1990-2022 were recalculated. The methodological changes include, inter alia, revision and update of emission factors for Euro 6 passenger cars and Euro VI buses or addition of battery electric passenger cars category.

1.A.3.c – Railways

Recalculation of CO_2 emissions due to the methodology update – separation of non-bio and biodiesel consumption. Emissions were recalculated in time series 2016-2022.

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

Planned improvement is to update the process of calculation of emissions from navigation to Tier 2. This should be finished by the end of 2024.

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

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

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

1.A.4.a, 2022								
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
Fuel Oil - Low Sulphur	79.00	77.40	1	6.11	10	0.00079	0.6	0.00005

Fuel Oil - High Sulphur	118.50	77.40	1	9.17	10	0.00119	0.6	0.00007
Other Bituminous Coal	25.98	94.14*)	0.9707*)	2.37	10	0.00026	1.5	0.00004
Brown Coal + Lignite	756.00	97.83*)	0.9846*)	72.82	10	0.00756	1.5	0.00113
Coke	10.92	107.00	1	1.17	10	0.00011	1.5	0.00002
Brown Coal Briquets	380.95	97.50	0.9846*)	36.57	10	0.00381	1.5	0.00057
Natural Gas	38 853.83	55.78*)	1	2 167.08	5	0.19427	0.1	0.00389
Wood/Wood Waste	472.77	112.00	1	52.95	300	0.14183	4	0.00189
Gaseous Biomass	896.44	54.60	1	48.95	5	0.00448	0.1	0.00009
Total year 2022	**40 586.46**			**2 319.61**		**0.35653**		**0.00782**
Total year 2021	45 197.38			2 559.02		0.39922		0.00836
Index 2022/2021	0.90			0.91		0.89		0.94
Total year 1990	119 864.09			9 907.15		1.00085		0.10113
Index 2022/1990	0.34			0.23		0.36		0.08

*) *Country specific data*

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

2022							
Structure of Fuels	**Source of Activity data**	**Emission factors**			**Method used**		
		CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Other kerosene	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
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
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

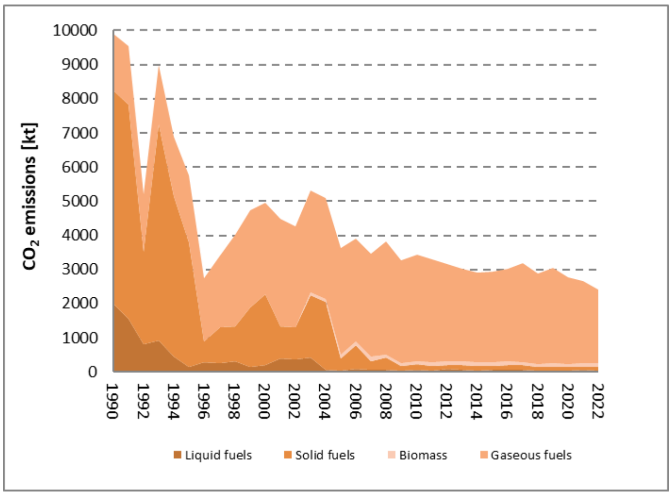

Fig. 3-33 Development of CO_2 emissions in source category 1.A.4.a

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

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

CO_2 emissions produced in category 1.A.4.a represent in 2022 22% of whole 1.A.4, which is 3% of CO_2 emissions from the Energy sector 1.A.

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

In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported in capture Other sectors under the item:

- Commercial and Public Services
- Non-specified (Other)

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

Fig. 3-33 shows that at the beginning of the period in the subsector 1.A.4.a predominated the consumption of fossil fuels, which was coupled with liquid fuels, and gradually substituted primarily with natural gas. The share of biofuels in this subsector is a minority. The overall decrease in fuel consumption is about 65%, which resulted in a decrease in CO_2 emissions by about 77%. Higher decrease in emissions than the one in the fuel consumption is determined by the changes in the structure of fuels in favour of natural gas. Estimates of CO_2, CH_4 and N_2O emissions from gaseous fuels for 1992-1994 in the subcategory 1.A.4.a were revised using interpolation as is described in 2006 IPCC Guidelines (vol. 1, chap. 5, section 5.3.3).

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

During processing data for the subsector 1.A.4.a among the used fuels are also included fuels, which are in the questionnaires of CzSO, listed in section "Transport sector". The amount of these fossil fuels is given in Tab. 3-52 in TJ.

Tab. 3-52 Quantities of fuels used in the sector transport in stationary sources

Year	2005	2006	2007	2008	2009	2010	2011	2012
TJ/year	12.7	35.2	33.7	35.9	12.4	12.5	12.1	12.2
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
TJ/year	12.0	40.2	38.9	36.9	38.7	27.5	13.2	8.3
Year	**2021**	**2022**						
TJ/year	11.0	13.2						

According to the communication to CzSO, this is a fuel for heating the buildings of the state-owned company Czech Railways and that is why its combustion was situated in the subsector 1.A.4.a. This is the consumption of bituminous coal and lignite worth 1-2 kt per year. The amount of these fuels in the total balance of 1.A.4.a virtually has no effect.

No other sector-specific methodological issues are applied, the general issues are given in chapter 3.2.4.

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

See chapter 3.2.5.

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

See chapter 3.2.6.

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

Based on minor changes of activity data in CzSO, 2023, fuel consumptions of Solid fuels for the year 2021 were recalculated. See the differences in the Tab. 3-53. Due to the change of activity data in CzSO, 2023, for Natural Gas, Gaseous fuels were recalculated for the years 2018 and 2021, see the Tab. 3-54.

Tab. 3-53 Changes after recalculations for Solid fuels in 1.A.4.a.

Fuel consumption		2021	CH_4 emission		2021
Submission 2022	TJ	1067.67	Submission 2022	kt	0.01
Submission 2023	TJ	996.98	Submission 2023	kt	0.01
Difference	TJ	-70.70	Difference	kt	0.00
Submission 2023	%	-7.09	Submission 2023	%	-7.09
CO_2 emission		**2021**	**N_2O emission**		**2021**
Submission 2022	kt	102.23	Submission 2022	kt	0.00
Submission 2023	kt	96.08	Submission 2023	kt	0.00
Difference	kt	-6.15	Difference	kt	0.00
Submission 2023	%	-6.40	Submission 2023	%	-7.09

Tab. 3-54 Changes after recalculations for Gaseous fuels in 1.A.4.a.

Fuel consumption		2018	2021
Submission 2023	TJ	47678.76	43338.42
Submission 2024	TJ	47679.61	43382.19
Difference	TJ	0.851	43.775
Submission 2024	%	0.002	0.101
CO_2 emission		**2018**	**2021**
Submission 2023	kt	2643.76	2402.57
Submission 2024	kt	2644.37	2404.99
Difference	kt	0.609	2.427
Submission 2024	%	0.023	0.101
CH_4 emission		**2018**	**2021**
Submission 2023	kt	0.238	0.217
Submission 2024	kt	0.238	0.217
Difference	kt	0.000	0.000
Submission 2024	%	0.002	0.101
N_2O emission		**2018**	**2021**
Submission 2023	kt	0.005	0.004
Submission 2024	kt	0.005	0.004
Difference	kt	0.000	0.000
Submission 2024	%	0.002	0.101

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

Currently there are no planned improvements in this category.

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

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

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

1.A.4.b, 2022									
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	0.01	0.1	0.0002
Other Bituminous Coal	5 326.41	94.14*)	0.9707*)	483.56	300	1.60	1.5	0.0080
Brown Coal + Lignite	22 757.00	97.83*)	0.9846*)	2158.69	300	6.83	1.5	0.0341
Coke	462.33	107.00	1	49.47	300	0.14	1.5	0.0007
Brown Coal Briquets	3 438.29	97.50	0.9846*)	330.07	300	1.03	1.5	0.0052
Natural Gas	69 780.08	55.78*)	1	3892.00	5	0.35	0.1	0.0070
Wood/Wood Waste	90 014.15	112.00	1	10081.58	300	27.00	4	0.3601
Charcoal	522.77	112.00	1	58.55	200	0.10	1	0.0005
Total year 2022	**103 739.76**			**7 043.89**		**37.06**		**0.4157**
Total year 2021	119 821.56			7 847.61		38.45		0.4389
Index 2022/2021	0.87			0.90		0.96		0.95
Total year 1990	208 699.35			18 374.86		60.62		0.4149
Index 2022/1990	0.50			0.38		0.61		1.00

[*)] Country specific data

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

2022							
Structure of Fuels	**Source for**	**Emission factors**			**Method used**		
	Activity data	**CO_2**	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
LPG	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Other Bituminous Coal	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Brown Coal + Lignite	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Coke	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Brown Coal Briquets	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Natural Gas	CzSO	CS	D	D	Tier 2	Tier 1	Tier 1
Wood/Wood Waste	CzSO	D	D	D	Tier 1	Tier 1	Tier 1
Charcoal	FAOSTAT	D	D	D	Tier 1	Tier 1	Tier 1

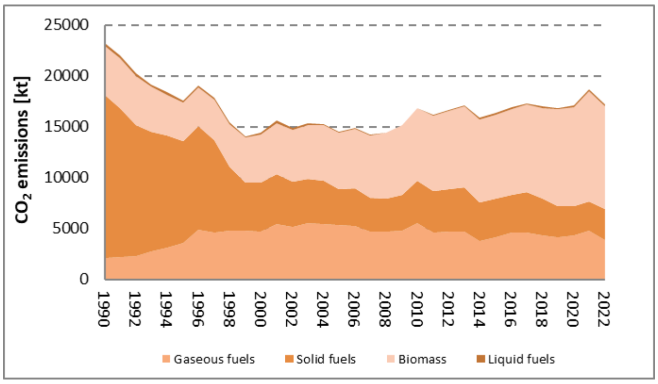

Fig. 3-34 Development of CO_2 emissions in source category 1.A.4.b

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, 2023), the consumption of the individual kinds of fuels in this sector is reported in capture Other Sector under the item: Residential

The fraction of CO_2 emissions in subsector 1.A.4.b in CO_2 emissions in sector 1.A.4 equalled 67% in 2022. It contributed 8% to CO_2 emissions in the whole Energy sector 1.A.

At the beginning of the period, a majority of households in the Czech Republic used coal as a heating fuel (mainly brown coal + lignite). This habit has changed over time and Natural Gas began to be used more than Solid Fuels. The same trend appears in the institutional sphere. The number of households using biomass for heating (biomass boilers) in the Czech Republic has increased in the last few years. This trend is also apparent in the Fig. 3-34.

The graph shows that at the beginning of the period in the subsector 1.A.4.b dominated consumption of fossil fuels, which have been gradually substituted primarily by natural gas, but also biofuels (in the case of households, it is mainly firewood). The share of liquid fuels (LPG) is negligible. Small annual fluctuations in fuel consumption are to be attributed to the average annual temperatures. Throughout the sector Residential, a slight decrease can be observed in fuel consumption, which was affected by the replacement of old boilers with more modern with higher efficiency and most importantly building insulations, which is controlled by the national programs "Green Savings". Increasing share of biomass has a positive effect on reducing CO_2 emissions, which are included in total greenhouse gas emissions. The total fuel consumption declines in this subsector about 23%, CO_2 emissions from the combustion of fossil fuels decreased by about 62%.

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

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

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

See chapter 3.2.5.

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

See chapter 3.2.6.

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

Due to the change of activity data in CzSO 2023 for Natural Gas, Gaseous fuels were recalculated for the year 2018, see the Tab. 3-55.

Tab. 3-55 Changes after recalculation in 1.A.4.b for Gaseous fuels

Fuel consumption		2018	CH_4 emission		2018
Submission 2023	TJ	78843.94	Submission 2023	kt	0.39
Submission 2024	TJ	78845.35	Submission 2024	kt	0.39
Difference	TJ	1.41	Difference	kt	0.00
Submission 2024	%	0.00	Submission 2024	%	0.00
CO_2 emission		2018	N_2O emission		2018
Submission 2023	kt	4371.86	Submission 2023	kt	0.01
Submission 2024	kt	4372.87	Submission 2024	kt	0.01
Difference	kt	1.01	Difference	kt	0.00
Submission 2024	%	0.02	Submission 2024	%	0.00

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

Currently there are no planned improvements in this category.

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

The subsector is further divided into:

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

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

1.A.4.c, 2022								
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	137.84	65.86*)	1	9.08	5	0.00069	0.10	0.00001
Gasoline	311.35	69.30	1	21.58	15.93	0.00496	0.84	0.00026
Diesel Oil	13 600.13	74.10	1	1 007.77	1.48	0.02013	3.07	0.04171
Fuel Oil - Low Sulphur	39.50	77.40	1	3.06	10	0.00040	0.60	0.00002
Fuel Oil - High Sulphur	158.00	77.40	1	12.23	10	0.00158	0.60	0.00009
Other Bituminous Coal	16.00	94.14*)	0.9707*)	1.46	300	0.00480	1.50	0.00002
Brown Coal + Lignite	214.27	97.83*)	0.9846*)	20.64	300	0.06428	1.50	0.00032
Coke	4.91	107.00	1	0.53	300	0.00147	1.50	0.00001
Brown Coal Briquets	8.44	97.50	0.9846*)	0.81	300	0.00253	1.50	0.00001
Natural Gas	1 718.45	55.78*)	1	95.85	5	0.00859	0.10	0.00017
Wood/Wood Waste	425.79	112.00	1	47.69	300	0.12774	4.00	0.00170
Gaseous Biomass	5 303.17	54.60	1	289.55	5	0.02652	0.10	0.00053
Total year 2022	**16 208.88**			**1 172.99**		**0.26368**		**0.04488**
Total year 2021	16 874.80			1 211.22		0.25919		0.04464
Index 2022/2021	0.96			0.97		1.02		1.01
Total year 1990	46 022.87			3 671.66		5.47293		0.07847
Index 2022/1990	0.35			0.32		0.05		0.57

*) *Country specific data*

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

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

2022							
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
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
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

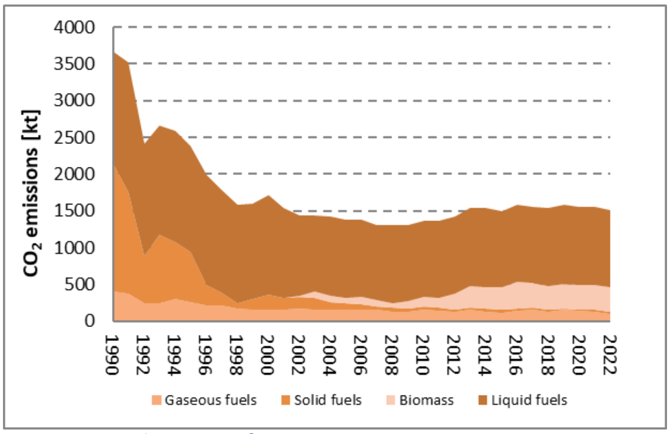

Fig. 3-35 Development of CO_2 emissions in source category 1.A.4.c

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

In accordance with the IPCC 2006 Gl., data on fuel consumption and emission data are divided into two subcategories, as mentioned above. In rural areas is mainly about fuel consumption for land cultivation and harvesting mechanisms, in forestry are mainly mining mechanisms. The fishing area has minor importance in the Czech Republic and is concentrated almost exclusively on fish farming.

In the CzSO Questionnaire (CzSO, 2023), the consumption of the individual kinds of fuels in this sector is reported in capture Industry Sector under the item:

- Agriculture/Forestry
- Fishing

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

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

The fraction of CO_2 emissions in subsector 1.A.4.c in CO_2 emissions in sector 1.A.4 equalled 11% in 2022. It contributed 1% to CO_2 emissions in the whole Energy sector.

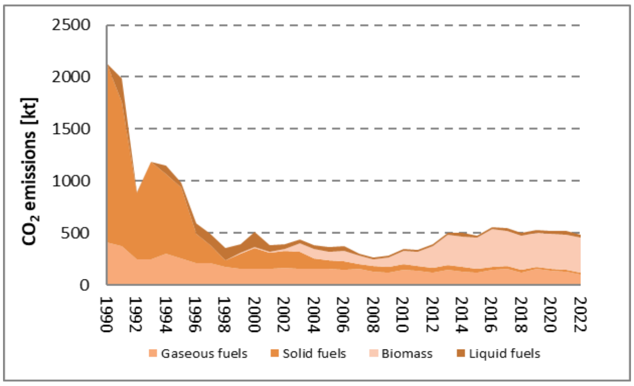

Fig. 3-36 Development of CO_2 emissions in source category 1.A.4.c.i

Development of fuel consumption and the corresponding CO_2 emissions throughout the subcategory 1.A.4.c are visible on Fig. 3-35.

From the graph on Fig. 3-35 is evident, that the stake in the entire subsector and in the overall period is for the liquid fuel (as it will be shown later, it is mainly about propellant fuel). At the beginning of the period a significant share is for the fossil fuels, but their consumption during the entire period declines due to the cancelation of the inefficient ways of heating of buildings and process plants. Biofuels are increasingly used until the end of the period.

In chart on Fig. 3-36 is shown the fuel consumption and the corresponding CO_2 emissions of only stationary sources and in the following graph (Fig. 3-37) are represented the consumption of fuels and the corresponding CO_2 emissions in off-road transportation and other mechanisms in the agriculture, forestry and fisheries.

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

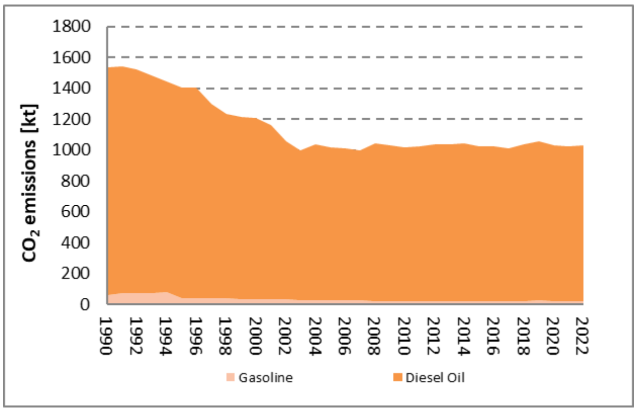

Fig. 3-37 Development of CO_2 emissions in source category 1.A.4.c.ii

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

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

The basic requirement for processing fuel consumption from mobile sources is their division between subsectors 1.A.3 Transport, 1.A.4.c.ii Off-road vehicles and other machinery and 1.A.5 Other. This distribution is done in coordination with CDV. The aim is that no fuel is included in the balance twice, nor that any fuel is omitted. Therefore, the following distribution is performed:

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

Motor fuels, which are consumed in the subsector 1.A.5 are allocated to 1.A.3. This is the fuel consumption of the army (transport on and off road, kerosene jet fuel consumption for air transport), and consumption in the fields of construction, extraction of fuels and minerals, industry (only areal transport). Furthermore, the consumption of motor fuels for mobile sources in the public sector (ambulance, fire brigade, etc.), both on and off roads as well as the consumption of aviation fuel are included here.

Based on our improvements CH_4 and N_2O emission for the categories 1.A.4.c.ii were recalculated. This need arised because the emission factors has not been updated for many years, which thus cause inaccurate reporting of emissions. The aim was to unify the emission factors with the emission factors use in 1.A.3 for this type of fuels. However, taking over the EFs determined always for the year in which the inventory is taken is currently, due to the time available for calculating the produced emissions, unfeasible. Time series analysis have been performed, which show that the three-year moving average will replicate the emission factors used well.

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

See chapter 3.2.5.

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

QA/QC procedures in this subsector must be coordinated with CDV. KONEKO, as the company responsible for processing the entire sector 1.A, performs before each submission distribution of motor fuels between the various subsectors 1.A.3, 1.A.5 and 1.A.4.c.ii. Simultaneously, after processing the data part of the submission, checks whether the predetermined distribution of fuel was properly applied and if it is necessary proposes corrections in order to avoid double counting of fuels, or their omission.

Other QA/QC and verification - see section 3.2.6.

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

Based on changes of Activity data in CzSO, 2023, fuel consumptions of Solid fuels for the year 2021 were recalculated. See the differences in table Tab. 3-56 below. Based on changes of Activity data in CzSO, 2023, fuel consumptions of Liquid fuels was recalculated for the year 2021, see the Tab. 3-57. Due to the change of activity data in CzSO, 2023 for Natural Gas, Gaseous fuels were recalculated for the year 2018, see the Tab. 3-58.

Tab. 3-56 Changes after recalculation in 1.A.4.c for Solid fuels

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	283.55	Submission 2023	kt	0.09
Submission 2024	TJ	254.13	Submission 2024	kt	0.08
Difference	TJ	-29.42	Difference	kt	-0.01
Submission 2024	%	-11.58	Submission 2024	%	-11.58
CO_2 emission		2021	N_2O emission		2021
Submission 2023	kt	27.06	Submission 2023	kt	0.00
Submission 2024	kt	24.49	Submission 2024	kt	0.00
Difference	kt	-2.57	Difference	kt	0.00
Submission 2024	%	-10.47	Submission 2024	%	-11.58

Tab. 3-57 Changes after recalculation in 1.A.4.c for Liquid fuels

Fuel consumption		2021	CH_4 emission		2021
Submission 2023	TJ	14324.99	Submission 2023	kt	0.03
Submission 2024	TJ	14396.87	Submission 2024	kt	0.03
Difference	TJ	71.89	Difference	kt	0.00
Submission 2024	%	0.50	Submission 2024	%	-0.41
CO_2 emission		2021	N_2O emission		2021
Submission 2023	kt	1058.05	Submission 2023	kt	0.04
Submission 2024	kt	1063.45	Submission 2024	kt	0.04
Difference	kt	5.40	Difference	kt	0.00
Submission 2024	%	0.51	Submission 2024	%	0.60

Tab. 3-58 Changes after recalculation in 1.A.4.c for Gaseous fuels

Fuel consumption		2018	CH_4 emission		2018
Submission 2023	TJ	2211.69	Submission 2023	kt	0.01
Submission 2024	TJ	2211.73	Submission 2024	kt	0.01
Difference	TJ	0.04	Difference	kt	0.00
Submission 2024	%	0.00	Submission 2024	%	0.00
CO_2 emission		2018	N_2O emission		2018
Submission 2023	kt	122.64	Submission 2023	kt	0.00
Submission 2024	kt	122.67	Submission 2024	kt	0.00
Difference	kt	0.03	Difference	kt	0.00
Submission 2024	%	0.02	Submission 2024	%	0.00

3.2.19.5 Category-specific planned improvements (CRF 1.A.4.c)

Currently there are no planned improvements in this category.

3.2.20 Other (1.A.5)

The subsector is further divided into:

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

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

1.A.5.b, 2022								
Structure of Fuels	Activity	CO_2			CH_4		N_2O	
	data	EF	OxF	Emission	EF	Emission	EF	Emission
	[TJ]	[t CO_2/TJ]		[kt]	[kg CH_4/TJ]	[kt]	[kg N_2O TJ]	[kt]
Gasoline	311.35	69.30	1	21.58	15.93*)	0.00496	0.84*)	0.00026
Kerosene Jet Fuel	692.80	71.50	1	49.54	4.94*)	0.00342	1.98*)	0.00137
Diesel Oil	2 633.68	74.10	1	195.16	1.48*)	0.00305	3.03*)	0.00799
Total year 2022	**3 637.83**			**266.27**		**0.01143**		**0.00962**
Total year 2021	4982.01			362.61		0.01802		0.01237
Index 2022/2021	0.73			0.73		0.63		0.78
Total year 1990	2 591.59			192.04		0.02274		0.00658
Index 2022/1990	1.40			1.39		0.50		1.46

*) *Country specific data*

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

2022							
Structure of Fuels	Source of	Emission factors			Method used		
	Activity data	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Gasoline	CzSO	D	CS	CS	Tier 1	Tier 2	Tier 2
Kerosene Jet Fuel	CzSO	D	CS	CS	Tier 1	Tier 2	Tier 2
Diesel Oil	CzSO	D	CS	CS	Tier 1	Tier 2	Tier 2

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

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

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

In the subsector 1.A.5.b.i is reported fuel consumption and corresponding emissions of greenhouse gases from aviation, besides the public air transport. This is primarily the consumption of aviation fuels in the army, in state institutions (aerial vehicles from Integrated Rescue System) or private air transport.

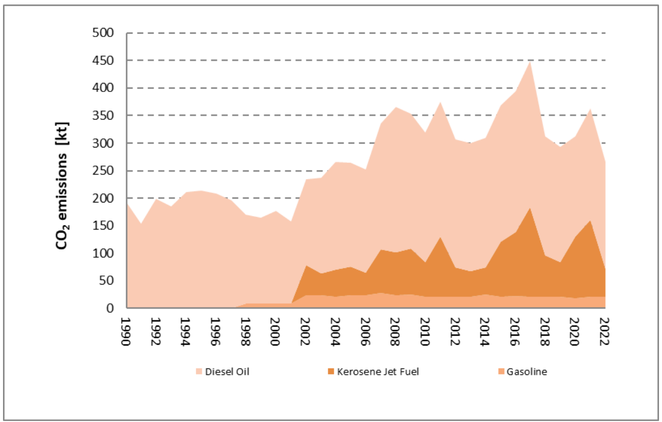

Fig. 3-38 Development of CO_2 emissions in source category 1.A.5.b.

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

Subsector 1.A.5.b.iii is used for the reporting of all remaining fuels (and greenhouse gases) that have not been reported elsewhere; it is mainly the consumption of motor fuels for ground vehicles in the military and in governmental institutions (Integrated Rescue System). Furthermore, it includes the consumption in the fields of construction, mining of fuels and minerals, industry (only areal transport).

The fraction of CO_2 emissions in subsector 1.A.5 in 2022 contributed 0.3% to CO_2 emissions in the whole Energy sector 1.A.

Development of fuel consumption and the corresponding CO_2 emissions throughout the subcategory 1.A.5.b. are seen in Fig. 3-38. Data of Kerosene Jet Fuel and Gasoline before 1998 are not available in sufficient details. Shares of fuels and corresponding emissions before 1998 are reported in the sector 1.A.3. Transport.

The graph on Fig. 3-38shows that a decisive proportion has diesel oil, another significant share is appertain to kerosene jet fuel (mainly army), the proportion of gasoline is minor.

3.2.20.1Methodological issues (CRF 1.A.5.b)

The basic requirement for processing fuel consumption by mobile sources is their division between subsectors 1.A.3 Transport and 1.A.4.c.ii and 1.A.5. This distribution is carried out in coordination with CDV. The aim is to ensure that no fuel is included in the balance twice and that no fuel is omitted. Therefore, the following distribution was performed:

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

Subsector 1.A.5.b.i reports fuels from aviation, which have been reallocated from consumption in 1.A.3 since 1998. This corresponds to the consumption of kerosene jet fuel by the army and aviation in state organizations (aerial rescue equipment). Subsector 1.A.5.b.iii reports motor fuels for ground transport systems, which have been reallocated from consumption in 1.A.3 since 1990. This corresponds to the consumption of motor fuels for mobile sources by the army and the public sector (ambulance, fire brigade, etc.), both on and off road.

Based on our improvements CH_4 and N_2O emission for the categories 1.A.5 were recalculated. This need arised because the emission factors has not been updated for many years, which thus cause inaccurate reporting of emissions. The aim was to unify the emission factors with the emission factors use in 1.A.3 for this type of fuels. However, taking over the EFs determined always for the year in which the inventory is taken is currently, due to the time available for calculating the produced emissions, unfeasible. Time series analyzes have been performed, which show that the three-year moving average will replicate the emission factors used well.

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

See chapter 3.2.5.

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

QA/QC procedures in this subsector must be coordinated with CDV. KONEKO, as the company responsible for processing the entire sector 1.A, evaluates the distribution of motor fuels among the various subsectors 1.A.3, 1.A.5 and 1.A.4.c.ii before each submission. Simultaneously, after processing the data portion of the submission, it checks whether the predetermined distribution of fuels was properly applied and, if necessary, proposes corrections in order to avoid double counting of fuels or their omission.

Other QA/QC and verification - see section 3.2.6.

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

Based on the change of activity data in CzSO 2023 for the year 2021, Liquid fuels were recalculated, see the Tab. 3-59.

Tab. 3-59 Changes after recalculation in 1.A.5.b for CH_4 and N_2O emission.

Fuel consumption		**2021**	**CH_4 emission**		**2021**
Submission 2023	TJ	4348.27	**Submission 2023**	kt	0.02
Submission 2024	TJ	4982.01	**Submission 2024**	kt	0.02
Difference	TJ	633.73	**Difference**	kt	0.00
Submission 2024	%	12.72	**Submission 2024**	%	3.53
CO_2 emission		**2021**	**N_2O emission**		**2021**
Submission 2023	kt	315.58	**Submission 2023**	kt	0.01
Submission 2024	kt	362.61	**Submission 2024**	kt	0.01
Difference	kt	47.03	**Difference**	kt	0.00
Submission 2024	%	12.97	**Submission 2024**	%	15.80

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

Currently there are no planned improvements in this category.

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

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

The current inventory includes CH_4 emissions for the following categories:

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

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

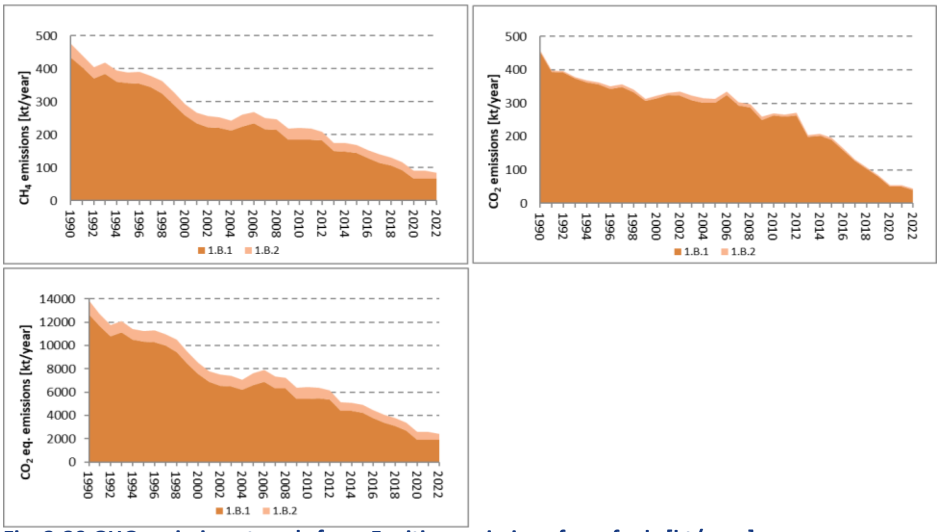

Fig. 3-39 GHG emissions trends from Fugitive emissions from fuels [kt/year]

Development of individual emissions of greenhouse gases in sector 1.B is shown on the graphs in Fig. 3-39. N_2O emissions for category 1.B.1 are NA,NO and for the category 1.B.2 the difference is visible on the fourth decimal number. Therefore, graph showing this trend was not added because it would be unclear. Development of N_2O emission can be described with the increasing values till 2005 (maximum emissions was between 2003-2005) and then decreasing trend can be observed.

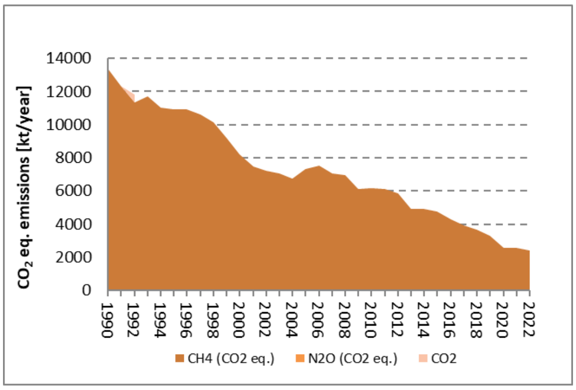

Fig. 3-40 The share of individual GHG emissions from the total emissions, expressed as CO_2 eq. (1.B.)

Sector 1.B is dominated by methane emissions from subcategory 1.B.1. - Solid fuels, while emissions from sector 1.B.2. - Oil and Natural gas represents on average 20% of the total emissions. CO_2 emissions arise primarily in subcategory 1.B.1 - Solid fuels. N_2O emissions originate only from the subsector 1.B.2.a - Oil and there are insignificant.

The importance of individual greenhouse gases from the total emissions, expressed as CO_2 equivalent, is visible from Fig. 3-40.

From the graphs on Fig. 3-39 and Fig. 3-40 is also clear that during the period occurred a significant decrease in GHG emissions across category 1.B. As it is shown below, the decrease was mainly due to a decrease in subcategory 1.B.1. - Solid fuels, in which vital source of emissions is underground mining of hard coal. For 2022, the decrease of total GHG emissions is 82% compared to the 1990 level.

3.3.1 Solid Fuels (CRF 1.B.1)

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

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

  - 1.B.1.a.2.i Mining
  - 1.B.1.a.2.ii Post-mining seam gas emissions
- 1.B.1.b Solid fuel transformation
- 1.B.1.c Other

3.3.1.1 Category description (CRF 1.B.1)

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

1.B.1, 2022								
Structure of sector		**Activity**	**CH_4**		**CO_2**		**N_2O**	
		data	**EF**	**Emission**	**EF**	**Emission**	**EF**	**Emission**
		[Gg]	**[kg CH_4/t]**	**[kt]**	**[t CO_2/t]**	**[kt]**	**[kg N_2O/t]**	**[kt]**
1.B.1.a	Coal mining/handl.	35.12		67.18	22.7	39.32		NO
1.B.1.a.1	Underground mines	1.73		20.20	22.7	39.32		NA
1.B.1.a.1.i	Mining		8.122	14.08	22.7	39.32	NA	NA
1.B.1.a.1.ii	Post-mining activ.		1.675	2.90	NA	NE	NA	NA
1.B.1.a.1.iii	Abandoned mines	+)			3.21		NE	NA
1.B.1.a.2	Surface mines	33.39		46.98		NE		NA
1.B.1.a.2.i	Mining		1.340	44.74	NA	NE	NA	NA
1.B.1.a.2.ii	Post-mining activ.		0.067	2.24	NA	NE	NA	NA
1.B.1.b	Solid fuel transformation	0.01	30	0.18	NA	NE	NA	NA
Total year 2022				**67.18**		**39.32**		**NA**
Total year 2021				66.49		51.25		NA
Index 2022/2021				1.01		0.77		NA
Total year 1990				435.02		456.24		NA
Index 2022/1990				0.15		0.09		NA

+) Methodology and emission factors are explained in 3.3.1.2.

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

2022								
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 activity	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 activity	CzSO	D	D	NA	Tier 1	Tier 1	-
1.B.1.b	Solid fuel transformation	FAOSTAT	D	D	NA	Tier 1	Tier 1	-

+) Methodology and emission factors are explained in 3.3.1.2.

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

The main process coal mining and handling emits 99 % of methane emissions from the category 1.B.1 Solid Fuels category is underground mining of Hard Coal in the Ostrava-Karviná area. A lesser source consists in Brown Coal mining by surface methods and post-mining treatment of Hard and Brown Coal. Coal mining (especially Hard Coal mining) is accompanied by an occurrence of methane. Methane, as a product of the coal-formation process, is physically bonded to the coal mass or is present as the free gas in pores and cracks in the coal and in the surrounding rocks.

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

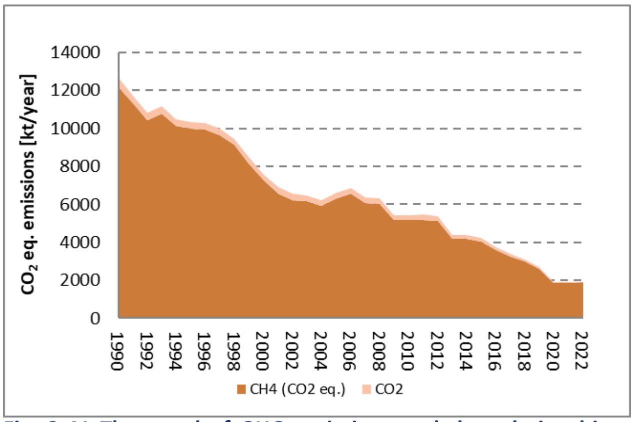

Fig. 3-41 The trend of GHG emissions and the relationship between emissions of CO_2 and CH_4 (1.B.1)

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

The graph on Fig. 3-41 shows the time trend of total emissions of greenhouse gases in the entire subsector 1.B.1. The chart also demonstrates the share of CO_2 emissions in the total GHG emissions, which on average makes about 2%. 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.

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 9 % of the total volume, is accompanied by considerably more significant CH_4 emissions than mining of lignite.

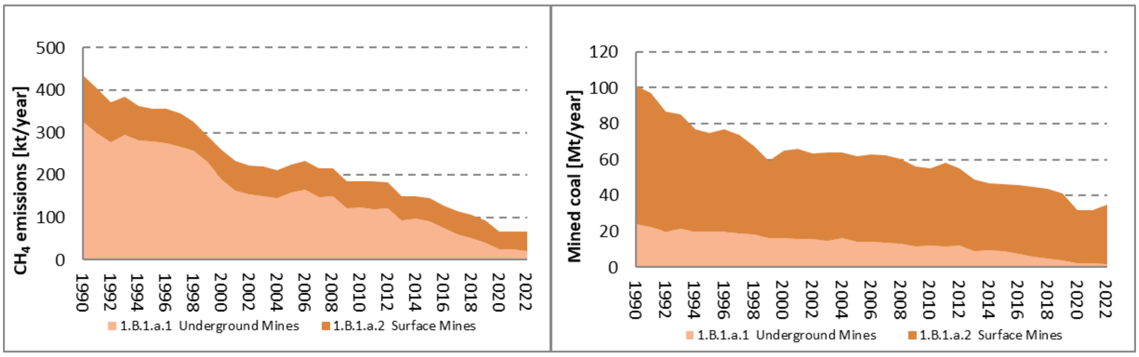

Fig. 3-42 The ratio of methane emissions from Underground mines and Surface mines and the corresponding development of mining of Hard Coal and Lignite (1.B.1)

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

In the Czech Republic, mainly Hard Coal is mined in underground mines (i.e. Hard Coal: Coking Coal and Bituminous Coal). Currently, underground mines are in operation in the Ostrava-Karviná coalmining area. In the end of year 2016, the part of Ostrava-Karvinná coalmining area was closed, which results in decreasing 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 was mined in only one underground mine in the Northern Bohemia. This mine was closed in 2016. Emissions from this mine used to be reported together with surface mining of Brown Coal – Lignite in subcategory 1.B.1.a.2 Surface Mines until the last submission. However, a recalculation was made and the data from underground mining of brown coal in the Northern Bohemia were added to the 1.B.1.a.1 Underground Mines. The amount of CH_4 emissions from brown coal underground mine in the Northern Bohemia contributed about 6 % of average to the CH_4 emissions of hard coal underground mines.

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

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

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

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

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

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

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

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

Abandoned underground mines in the Czech Republic are located in Kladno Basin (near Kladno, 30 km northwest of Prague), in the Ostrava-Karvina coalfield - OKR (North Moravia) and mine Koh-i-noor (Centrum) close to Dolní Jiříkov in North Bohemia (closed 2016). In terms of methane emissions are relevant only abandoned mines in OKR. Coal mining in the Kladno Basin was terminated in 2002. In these mines methane was absent, so the methane emissions estimate is made only from OKR mines.

To get more information about abandoned mines in Kladno basin, the head od Kladenské doly was contacted. Based on our request we received an official answer about this issue. Mining of coal was shut down in 2002 and within the mining period the mines were liquidated. Currently the major of all abandoned underground mines are disposed of in accordance with mining legislation. Basically it means that mines were filled with backfill material and the mine is closed by a special mining cover. This method reliably eliminates CO_2 and CH_4 emissions, which is also controlled by portable detection device. More information are stated in the official letter, which can be provided upon request.

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

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

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

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

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

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

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

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

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

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

Production of Coke from Coking Coal

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

Production of briquettes from Brown Coal

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

Production of charcoal

CH_4 emissions from charcoal production were estimated by using EF provided by the Revised 1996 Guidelines (IPCC, 1997); the value of 1 000 kg CH_4/TJ of charcoal produced was used. Since there are no available official activity data about charcoal production in the Czech Republic, the un-official data from FAOSTAT statistics were used. The missing data were extrapolated. The default net calorific value 30 MJ/kg (Table 1-13 in Revised 1996 Guidelines) was used to convert activity data to the energy units. Resulting CH_4 emissions please see in the Tab. 3-60. Unfortunately IPCC 2006 Gl. (IPCC, 2006) don't provide default emissions factors for fugitive emissions from charcoal production. From this reason the emission factor provided in Revised 1996 Guidelines (IPCC, 1997) is still used. Since these emissions are very low national inventory team consider this approach to be relevant in this case.

Tab. 3-60 CH_4 emissions from charcoal production

1.B.1.b Solid Fuel Transformation			
	Production [kt/year]	Production [TJ/year]	CH_4 emissions [kt/year]
1990	1.00	30.00	0.03
1991	1.00	30.00	0.03
1992	1.00	30.00	0.03
1993	1.00	30.00	0.03
1994	1.00	30.00	0.03
1995	1.00	30.00	0.03
1996	1.00	30.00	0.03
1997	1.00	30.00	0.03
1998	1.80	54.00	0.05
1999	2.60	78.00	0.08
2000	3.40	102.00	0.10
2001	4.20	126.00	0.13
2002	5.00	150.00	0.15
2003	6.00	180.00	0.18
2004	6.00	180.00	0.18
2005	6.00	180.00	0.18
2006	6.00	180.00	0.18
2007	6.00	180.00	0.18
2008	6.00	180.00	0.18
2009	6.00	180.00	0.18
2010	6.60	198.00	0.20
2011	6.40	192.00	0.19
2012	6.00	180.00	0.18
2013	6.00	180.00	0.18
2014	6.00	180.00	0.18
2015	6.00	180.00	0.18
2016	6.00	180.00	0.18
2017	7.98	239.49	0.24
2018	5.60	168.03	0.17
2019	6.07	182.13	0.18
2020	6.07	182.13	0.18
2021	6.07	182.13	0.18
2022	6.07	182.13	0.18

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

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

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

3.3.1.2 Methodological issues

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

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

Country specific emission factors were determined for calculation of fugitive methane emissions in underground mines in the second half of the 1990's: the ratio between mining and the volume of methane emissions is given in Tab. 3-61, see (Takla and Nováček, 1997).

Tab. 3-61 Coal mining and CH_4 emissions in the Ostrava - Karvina coal-mining area

	Coal mining	CH_4 emissions	Emission factors
	[mil. t/year]	[mil. m³/year]	[m³/t]
1960	20.90	348.9	16.7
1970	23.80	589.5	24.7
1975	24.11	523.8	21.7
1980	24.69	505.3	20.5
1985	22.95	479.9	20.9
1990	20.60	381.1	19.0
1995	15.60	270.7	17.4
1996	15.10	276.0	18.3
Total	**167.31**	**3 375.3**	**20.2**
1990 till 1996	50.76	927.8	18.3

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

The average value of the emission factor of 18.3 m^3/t was recalculated to 12.261 kg/t using a density of methane of 0.7 m^3/kg. This emission factor is used for coal mined in the Ostrava-Karviná coalmining area for years 1990 - 1999. The emission factor set by estimation at 50% of this value was used for the remaining Hard Coal from underground mines in other areas. This is valid for coal with minimum coal gas capacity (coal from the Kladno area to 2002 and coal from the Žacléř area from 1998).

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

The management of OKD, a.s. (Ostrava-Karviná mines, joint share company) was contacted since this company monitors in very detail the issues about methane production. In response to a request from the reporting team, the company provided a document in which the total amount of gas released by OKD mines was determined, together with the amount of methane withdrawn by degassing, the amounts of methane used for industrial purposes, venting of methane from degassing and the total amount of methane released into the atmosphere. A summary of the information provided is given in Tab. 3-62.

Tab. 3-62 Methane production from gas absorption of mines and its use

	mil.m³ 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. 3-63 are used for 2000 – 2008. After 2008, the emission factor calculated as the average value from the values for 2000-2008, i.e. 8.12 t/kt, is used. Research with aim to develop this emission factor was performed in 2011.

Tab. 3-63 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

Tab. 3-61 shows the average emission factor used for the years 1990-1999 for calculation of CH_4 emissions from OKD mines. For the time period 2000 to 2008 were used emission factors determined from the mining and emissions given by OKD mines (see Tab. 3-63). Based on these values an average emission factor, from the period 2000-2008 was set up, which was 8.12 tCH_4/kt. This average value has been used since 2009 (Takla and Nováček, 1997).

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

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

Country specific emission factors were determined for calculation of fugitive carbon dioxide emissions. An extra study was performed to determine the CO_2 emission factor for underground hard coal mining. Monthly data on the concentrations and amounts of CO_2 were processed for all the exhaust air shafts in the OKD area for 2009, 2010 and for part of 2011. These data yielded an average value of the emission factor, which is related to the volume of mining. The emission factor is equal to 22.75 t CO_2/kt of mined coal and this emission factor is country specific – Tier II level. This value is valid for the OKD area. The author of the study recommended that the determined emission factor for 1990 – 2009 be used. He determined an emission factor 22.68 t CO_2/kt of mined coal for 2010 and it was recommended that this value also be used for the subsequent years. These emission factors were used to extend the data for CO_2 emissions for underground hard coal mining; the values are given in the Tab. 3-64.

Tab. 3-64 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	22 415	22.75	456.24
1991	20 201	22.75	395.10
1992	18 637	22.75	392.83
1993	18 355	22.75	373.45
1994	17 376	22.75	362.60
1995	17 738	22.75	356.21
1996	17 453	22.75	343.65
1997	16 570	22.75	349.18
1998	16 112	22.75	332.53
1999	14 343	22.75	306.33
2000	14 855	22.75	315.13
2001	15 138	22.75	324.03
2002	14 467	22.75	322.98

Year	Production OKD	Emission factor	Emission of CO_2
2003	13 645	22.75	309.65
2004	15 579	22.75	301.87
2005	13 254	22.75	300.85
2006	13 385	22.75	324.80
2007	12 894	22.75	293.09
2008	12 663	22.75	288.00
2009	11 001	22.75	250.22
2010	11 593	22.68	262.88
2011	11 441	22.68	259.44
2012	11 652	22.68	264.22
2013	8 746	22.68	198.32
2014	8 900	22.68	201.82
2015	8 426	22.68	191.07
2016	7 015	22.68	159.07
2017	5 601	22.68	127.00
2018	4 562	22.68	103.45
2019	3 540	22.68	80.28
2020	2 200	22.68	49.89
2021	2 260	22.68	51.25
2022	1 734	22.68	39.32

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. 3-65 Used emissions factors and calculation of CH_4 emissions from underground coal mining – post mines operations in period 1990 - 2022

Year	Production OKD [kt/year]	Emission factor [t CH_4/kt]	Emission of CH_4 [kt CH_4/year]
1990	22 415	1.68	39.98
1991	20 201	1.68	36.71
1992	18 637	1.68	33.12
1993	18 355	1.68	34.77
1994	17 376	1.68	32.64
1995	17 738	1.68	32.75
1996	17 453	1.68	32.35
1997	16 570	1.68	30.76
1998	16 112	1.68	29.61
1999	14 343	1.68	26.49
2000	14 855	1.68	26.73
2001	15 138	1.68	26.04
2002	14 467	1.68	25.74
2003	13 645	1.68	24.10
2004	15 579	1.68	23.51
2005	13 254	1.68	23.48
2006	13 385	1.68	25.18
2007	12 894	1.68	22.82
2008	12 663	1.68	22.16
2009	11 001	1.68	19.22
2010	11 593	1.68	19.98
2011	11 441	1.68	19.65
2012	11 652	1.68	19.95
2013	8 746	1.68	15.13

Year	Production OKD [kt/year]	Emission factor [t CH_4/kt]	Emission of CH_4 [kt CH_4/year]
2014	8 900	1.68	15.54
2015	8 426	1.68	14.73
2016	7 015	1.68	12.02
2017	5 601	1.68	9.63
2018	4 562	1.68	8.04
2019	3 540	1.68	6.23
2020	2 200	1.68	3.77
2021	2 260	1.68	3.79
2022	1 734	1.68	2.90

The amount of brown coal mined from underground mine Kohinoor between 2002-2016 was added to the total amount of extracted hard coal. As the EF default value was used 18 m^3/t. To converted to t CH_4/kt, it was necessary to use conversion factor 0.67 kg/m^3. See the Tab. 3-66.

Tab. 3-66 Used emissions factors and calculation of CH_4 emissions from underground coal mining – in period 2002-2016.

Year	Production Kohinoor	Emission factor	Emission of CH_4
	[kt/year]	**[t CH_4/kt]**	**[kt CH_4/year]**
2002	380	0.012	4.58
2003	460	0.012	5.55
2004	458	0.012	5.52
2005	464	0.012	5.60
2006	466	0.012	5.62
2007	467	0.012	5.63
2008	298	0.012	3.59
2009	350	0.012	4.22
2010	425	0.012	5.13
2011	430	0.012	5.19
2012	455	0.012	5.49
2013	356	0.012	4.29
2014	480	0.012	5.79
2015	408	0.012	4.92
2016	55	0.012	0.66

Abandoned underground mines (CRF 1.B.1.a.1.ii)

Calculation of methane emissions from abandoned mines has been carried out in accordance with the methodology IPCC 2006 Gl. at the level Tier 1. For the purposes of this calculation, the number of closed mines in the Ostrava-Karvina coalfield was determined in prescribed intervals (intervals years 1901-1925, 1926-1950, 1951-1975, 1976 – 2000, 2001 to the present). Given that in the Ostrava-Karvina coalfield occur only mines with high amount of the gas, were used values for the percentage of coal mines that are gassy from the column High (IPCC 2006 Gl. (IPCC 2006): Tab. 4.1.5: TIER 1 – ABANDONED UNDERGROUND MINES, DEFAULT VALUES - PERCENTAGE OF COAL MINES THAT ARE GASSY, page 4.24.), the following:

1901 – 1925: 10%
1926 – 1950: 50%
1951 – 1975: 75%
1976 – 2022: 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 M^3 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. 3-67.

Tab. 3-67 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 - 2020	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
1996	0.43	2.17	10.43		13.04		13.04
1997	0.43	2.14	9.87		12.43		12.43
1998	0.43	2.11	9.38		11.92		11.92
1999	0.42	2.08	9.46		11.96		11.96
2000	0.42	2.05	9.55		12.03		12.03
2001	0.42	2.02	9.19	0.00	11.63		11.63
2002	0.41	1.99	8.86	0.00	11.27		11.27
2003	0.41	1.97	8.56	1.18	12.12		12.12
2004	0.41	1.94	8.31	0.97	11.63		11.63
2005	0.40	1.92	8.05	0.85	11.22	5.00	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	1.72	6.41	1.36	9.86	70.00	2.96
2016	0.37	1.71	6.28	1.75	10.11	70.00	3.03
2017	0.37	1.69	5.88	2.51	10.45	70.00	3.14
2018	0.37	1.67	5.79	2.43	10.26	70.00	3.08
2019	0.37	1.66	5.70	2.36	10.07	70.00	3.02
2020	0.36	1.64	5.61	3.05	10.67	70.00	3.20
2021	0.36	1.63	5.53	2.97	10.50	70.00	3.15
2022	0.36	1.62	5.47	3.27	10.71	70.00	3.21

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

Total emissions, used activity data and emission factors for proper extraction of lignite (Brown Coal) from surface mines and post-mining related adjustments are presented in the Tab. 3-68.

Tab. 3-68 Used activity data, emissions factors and calculation of CH_4 emissions from surface coal mining and post mines operations in period 1990 - 2022

year	Brown Coal production [kt/year]	Emission factors for activities		Emission of CH_4 [kt CH_4/year]
		mines [t CH_4/kt]	post-mines [t CH_4/kt]	
1990	77 169	1.34	0.067	108.58
1991	74 516	1.34	0.067	104.84
1992	66 665	1.34	0.067	93.80
1993	63 878	1.34	0.067	89.88
1994	56 929	1.34	0.067	80.10
1995	54 893	1.34	0.067	77.23
1996	57 365	1.34	0.067	80.71
1997	55 206	1.34	0.067	77.67

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]
1998	49 151	1.34	0.067	69.16
1999	43 047	1.34	0.067	60.57
2000	48 925	1.34	0.067	68.84
2001	50 461	1.34	0.067	71.00
2002	47 766	1.34	0.067	67.21
2003	49 326	1.34	0.067	69.40
2004	47 583	1.34	0.067	66.95
2005	47 816	1.34	0.067	67.28
2006	48 589	1.34	0.067	68.36
2007	48 824	1.34	0.067	68.70
2008	46 828	1.34	0.067	65.89
2009	44 824	1.34	0.067	63.07
2010	43 357	1.34	0.067	61.00
2011	46 273	1.34	0.067	65.11
2012	43 210	1.34	0.067	60.80
2013	40 027	1.34	0.067	56.32
2014	37 704	1.34	0.067	53.05
2015	37 643	1.34	0.067	52.96
2016	38 328	1.34	0.067	53.93
2017	39 121	1.34	0.067	55.04
2018	38 904	1.34	0.067	54.72
2019	37 261	1.34	0.067	52.41
2020	29 371	1.34	0.067	41.32
2021	29 279	1.34	0.067	41.20
2022	33 388	1.34	0.067	46.98

Determination of activity data and emission factors for mining and post-mining treatment is given in the description of the individual activities on surface mines.

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

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

Data from the source part of the questionnaire completed in the CzSO Questionnaire (CzSO, 2023), was employed to determine activity data on extraction of Brown Coal and Lignite. The mining yearbooks and other data sources continue to be used only for control purposes.

During surface mining, escaping methane is not related to specific flow of air and thus it is far more difficult to monitor the amount of methane escaping into the air. Consequently, default IPCC emission factors are employed to calculate methane emissions from surface mining and from post-mining treatment (IPCC 2006).

The emission factor for surface mining activities is used following due to the recommendation E.19 from FCCC/ARR/2016/CZE. The description of recommendation E.19 from FCCC/ARR/2016/CZE (2016 Centralised UNFCCC Review of Czech Republic), states that the upper limit of the proposed range of the Tier 1 EF from the 2006 IPCC GLs is applied by the Czech Republic because the average overburden depths of the surface mines varies from 120 to 200 m.

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

Emission calculation was performed for the production of wood charcoal at Tier I, using default emission factors - see chapter 3.3.1.1.2.

CH_4 emissions from charcoal production were estimated by using EF provided by the Revised 1996 Guidelines (IPCC 1997); the value of 1 000 kg CH_4/TJ of charcoal produced was used. Since there are no available official activity data about charcoal production in the Czech Republic, the un-official data from FAOSTAT statistics were used. The missing data were extrapolated. The default net calorific value 30 MJ/kg (Table 1-13 in Revised 1996 Guidelines) was used to convert activity data to the energy units. Unfortunately IPCC 2006 Gl. (IPCC 2006) don't provide default emissions factors for fugitive emissions from charcoal production. From this reason the emission factor provided in Revised 1996 Guidelines (IPCC 1997) is still used. Since these emissions are very low the team consider this approach to be relevant in this case.

3.3.1.3 Uncertainties and time-series consistency

The inventory methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2019.

In 2020 was carried out an extensive study aiming to update the uncertainties in the sector 1.B.1. From the study follows that in this category higher uncertainties should be expected than in 1.A. The uncertainties in the activity data result primarily from inaccuracies in weighing of extracted coal. Conversely, imports and exports of raw materials are sensitive economic data and low uncertainties should be expected.

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 should be quite low, while the uncertainty in the CO_2 emission factor should be expected higher.

The determination of uncertainties was carried out according the same methodology as in case of category 1.A, i.e. three independent experts estimate of 'basic' uncertainties, which were averaged (see chapter 3.2.5. or for details Veselá et al. 2020).

For specific uncertainties used for introduction into the trend in total national emissions see Annex 2.

3.3.1.4 Category-specific QA/QC and verification

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

QC activities at the level of Tier 1 were performed according to the QA/QC plan by the sector compiler. Routine control was performed in the framework of the following activities:

- activity data employed,
- emission factors employed,
- calculation procedures employed,
- transfer of numerical data from the working set to the CRF Reporter.

During control of the activity data, the CzSO data were compared with the data from the Mining Yearbook. Good agreement was found.

In control of the emission factors employed, the emission factors used in the Czech Republic methodology were compared with the emission factors of Slovakia, Poland and Germany in the context with the default emission factors. It was found that the emission factors employed for calculation of emissions in the Czech Republic methodology correspond, in their range, to the emission factors employed in the other countries.

Furthermore, the correct usage of the methodology at Tier I level for the calculation of CH_4 emissions from abandoned mines and the performance of own calculations were checked. The calculation procedure was consulted with an independent expert from the VSB-Technical University of Ostrava. It was concluded that the input data and the method of calculation are in line with the methodology.

Control that the transfer of numerical data from the working set to the CRF Reporter does not reveal any differences. The final working set in EXCEL format is locked to prevent intentional rewriting of values and archived at the coordination workplace. The protocols on the performed QA/QC procedures are stored too.

3.3.1.5 Category-specific recalculations

Based on our improvement the emission factor of Abonded mines were updated due to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This update covered years from 2017 till 2021 in a subcategory 1B1a1iii, but only for CH_4 emissions. See the Tab. 3-69.

Tab. 3-69 Changes after recalculation in 1.B.1.a.1 Underground mines

Extracted coal		2017	2018	2019	2020	2021
Submission 2023	kt	5.79	4.86	3.77	2.26	2.26
Submission 2024	kt	5.79	4.86	3.77	2.26	2.26
Difference	kt	0.00	0.00	0.00	0.00	0.00
Submission 2024	%	0.00	0.00	0.00	0.00	0.00
CH_4 emissions		2017	2018	2019	2020	2021
Submission 2023	kt	3.30	3.30	3.30	3.56	3.69
Submission 2024	kt	3.14	3.08	3.02	3.20	3.15
Difference	kt	-0.16	-0.22	-0.27	-0.36	-0.54
Submission 2024	%	-5.10	-7.11	-9.06	-11.15	-17.14

3.3.1.6 Category-specific planned improvements

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

In the other sub-sectors no improvements are planned at the present.

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

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

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

- 1.B.2.b.2 Production
- 1.B.2.b.3 Processing
- 1.B.2.b.4 Transmission and Storage
- 1.B.2.b.5 Distribution
- 1.B.2.b.6 Other

- 1.B.2.c Venting and Flaring
  - 1.B.2.c.1 Venting
  - 1.B.2.c.2 Flaring

3.3.2.1 Category description (CRF 1.B.2)

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

1.B.2, 2022								
Structure of sector		**Activity data**	**CH_4**		**CO_2**		**N_2O**	
			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.	3.23	4.735	0.015	7.576	0.0245	NA	-
1.B.2.a.3	Transport	316.92	0.146	0.046	0.013	0.0042	NA	-
1.B.2.a.4	Refining	316.92	0.585	0.185	NA	-	NA	-
1.B.2.a.5	Distrib. of Oil Prod.	316.92	NA	-	NA	-	NA	-
1.B.2.a.6	Other	NO						
1.B.2.b.1	Exploration	NE						
1.B.2.b.2	Production	7.75	37.68	0.292	+)	0.0001	NA	-
1.B.2.b.3	Processing	NO						
1.B.2.b.4	Transmission and	946.06	6.42	6.071	+)	0.0253	NA	-
	Storage	176.26	1.57	0.276	+)	0.0011	NA	-
1.B.2.b.5	Distribution	110.05	97.22	10.699	+)	0.0426	NA	-
1.B.2.b.6	Other	I.E.						
1.B.2.c.1	Venting - Oil	3.23	235.4	0.760	48.7	0.1573	NA	-
1.B.2.c.2	Flaring - Oil	3.23	0.568	0.002	919.9	2.9713	0.015	0.0001
Total year 2022				**18.348**		**3.225**		**0.0001**
Total year 2021				24.233		3.580		0.0001
Index 2022/2021				0.76		0.90		0.91
Total year 1990				42.695		2.202		0.00003
Index 2022/1990				0.43		1.46		1.74

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

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

2022								
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.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						

2022								
Structure of sector		Source of Activity data	Emission factors CH_4	CO_2	N_2O	Method used CH_4	CO_2	N_2O
1.B.2.b.4	Transmission and	CzSO	CS	CS	NA	Tier 2	Tier 2	-
	Storage	ERU	CS	CS	NA	Tier 2	Tier 2	-
1.B.2.b.5	Distribution	ERU	CS	CS	NA	Tier 2	Tier 2	-
1.B.2.b.6	Other	NO						
1.B.2.c.1	Venting - Oil	CzSO	D	D	NA	Tier 1	Tier 1	-
1.B.2.c.2	Flaring - Oil	CzSO	D	D	D	Tier 1	Tier 1	Tier 1

Approximately 96% of fugitive emissions are formed in the Czech Republic from gas industry in extraction, storage, transport and distribution of Natural Gas and in its final use. Crude Oil extraction and refining processes are very less important.

Determination of methane emissions from the processes of refining of Crude Oil is based on the recommended (default) emission factors according to the IPCC 2006 Gl. (IPCC 2006). For years prior to 2000, the maximum values of CH_4 EFs published in the Revised 1996 IPPC Guidelines (Workbook, table 1-6) were selected, this conservative approach attempts to replicate the poor condition of refineries during the 1990s. From 2002 to 2012, the maximum value of the EF CH_4 for developed countries was selected in the IPCC 2006 Guidelines (vol.2 chap.4, table 4.2.4). From 2013 to 2020, the average value of the EF CH_4 for developed countries was selected in the 2006 IPCC Guidelines was used, reflecting recent improvements in the fuel refining process taking place in Czechia.

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. 3-44 gives an overview of the trend in emissions in this category in the time series since 1990.

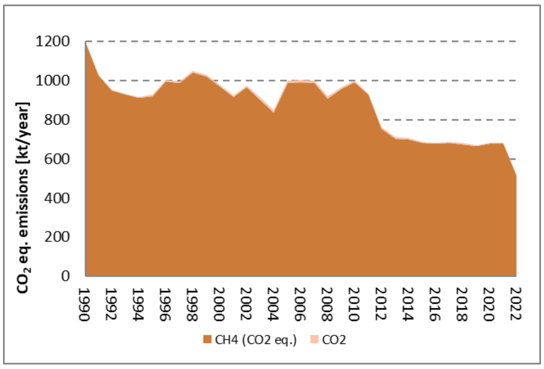

Fig. 3-44 The trend of GHG emissions and the relationship between CO_2 and CH_4 emissions (1.B.2)

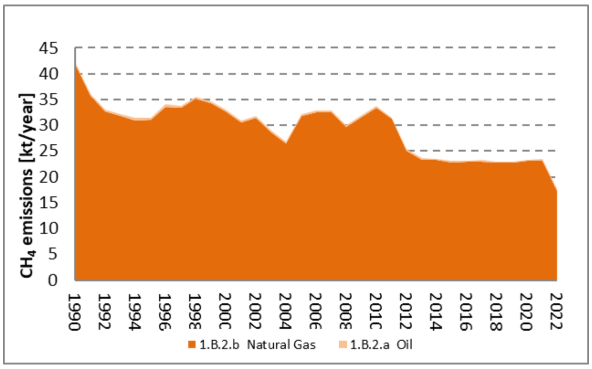

Fig. 3-44b The ratio of methane emissions from subsector Oil (1.B.2.a) and Natural Gas (1.B.2.b)

The graph on Fig. 3-44 shows that the proportion of total CO_2 emissions from the total GHG emissions is negligible (approximately 0.1%).

The contribution of the individual subsectors (Oil and Natural Gas) to the total CH_4 emissions throughout the period in the category 1.B.2 is shown on Fig. 3-44b.

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

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

In subcategory Oil are reported emissions from mining, processing of domestic crude oil and emissions from refining of imported crude oil. The share of domestic crude oil is very small - about 2.4% (from 0.4 to 4.9%). The time profile of domestic production and imports of crude oil in the Czech Republic is shown on Fig. 3-45.

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.

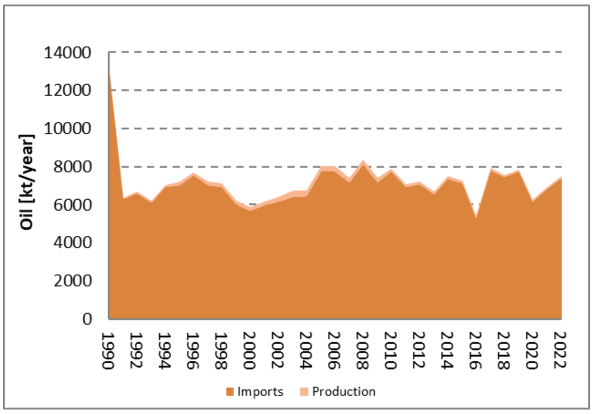

Fig. 3-45 Crude Oil production and import in the CZ in 1990 – 2022

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

Emissions from this subcategory are not estimated, since activity data are not available, which means that in CRF table notation key “NE” is used. Exploration is not regularly performed in the Czech Republic. The statement of MND a.s. (only company with licence for exploration in Czechia) is that they perform exploration but only very random and this activity do not release emissions at all.

Level of emissions in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines:

“Emissions should only be considered insignificant if the probable level of emissions is less than 0.05 % of total national greenhouse gas emissions and does not exceed 500 kt CO_2 equivalent. The total national estimated emissions for all gases and categories considered insignificant must remain below 0.1 % of total national greenhouse gas emissions."

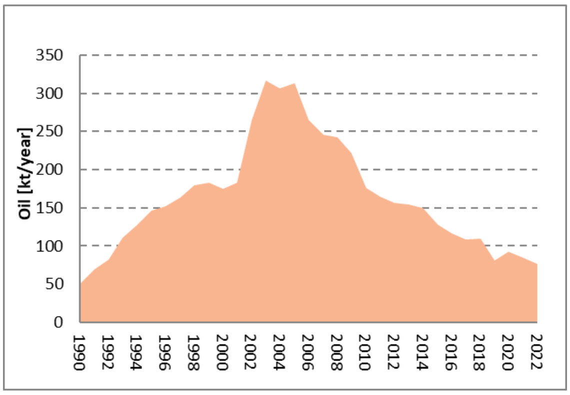

Fig. 3-46 Crude Oil production in the CZ in 1990 – 2022

The total greenhouse gas emissions of the Czech Republic are: 136.39 million tons of CO_2eq

Emissions from domestic oil production in the Czech Republic is 0.051 kt CO_2eq

If the survey represented a whole tenth of mining (exaggerated assumption), then there would be an emission of about 0.0051 kt, which is 0.00003% of the total annual emissions of the Czech Republic - that is 1 300 times lower than the recommended limit. These values are example from the inventory year 2021-2023.

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

Crude Oil is mined in the Czech Republic in Southern Moravia. The Fig. 3-46 gives the amount of mined Crude Oil in the territory of the Czech Republic.

The quantity of crude oil extracted in each year depends on the amount of recoverable reserves. From Fig. 3-44b is visible that the maximum extraction was in the period from 2003 to 2006. It is expected that the decline in production after 2022 will continue.

Transport (1.B.2.a.iii.3)

Transport of Crude Oil in the territory of the Czech Republic is performed only in closed systems (pipeline transport – Oil pipeline Družba from Russia and Ingolstat from Germany). Default emission factors were used to calculate fugitive CH_4 and CO_2 emissions in this subsector.

Refining (1.B.2.a.iii.4)

Crude Oil is processed in the territory of the Czech Republic in two main refinery facilities. The total volume of Crude Oil processed in the Czech Republic is presented in Fig. 3-45.

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)

In the subcategory Natural Gas are reported GHG emissions from domestic natural gas production and emissions related to the operation of individual parts of the gas system (import, transit, storage and distribution to end users). The share of the domestic natural gas production is very small - about 2.7% (from 1.7 to 4.9%). The time profile of domestic production and import of natural gas in the Czech Republic is shown on Fig. 3-47.

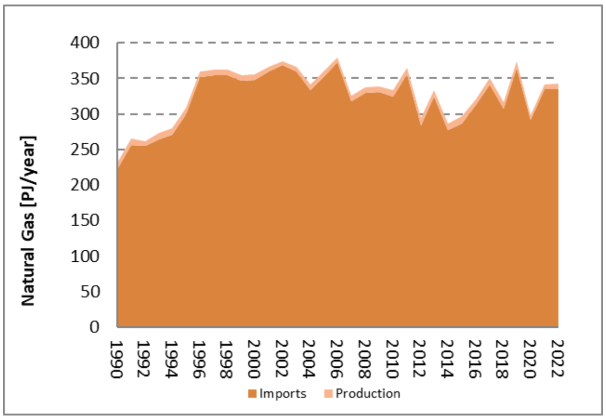

Fig. 3-47 Natural Gas production and import in the CZ in 1990 – 2022

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

Emissions formed in exploratory boreholes are not reported in this subcategory. This activity is not performed in the Czech Republic, or only completely random.

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

Natural Gas is extracted in the Czech Republic in the area of Southern Moravia, accompanying extraction of Crude Oil, and in Northern Moravia, where it is derived from degassing of hard coal deposits. The Fig. 3-48 gives the amount of production Natural Gas in the territory of the Czech Republic.

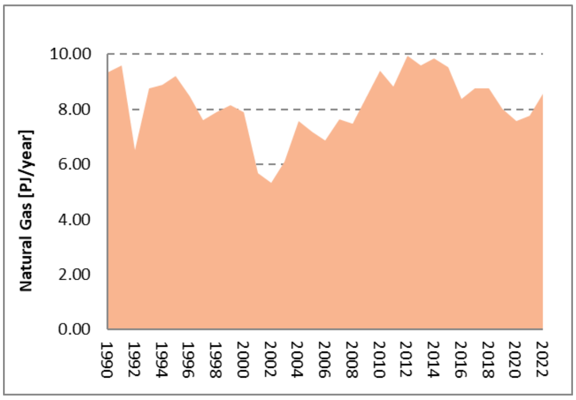

Fig. 3-48 Natural Gas production in the area of CZ in 1990 – 2022

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

Processing (1.B.2.b.iii.3)

Gas treatments, except for drying, are not performed in the Czech Republic. The drying process is not a source of GHG emissions.

Transmission and Storage (1.B.2.b.iii.4)

The calculation of GHG emissions in this subcategory is carried out in two steps; independently. In the first step is carried out an estimation of the emissions for the transit system and high-pressure gas pipelines. This estimate is based on calculation of a pipeline length and the corresponding emission factors. The second step emissions from underground gas storage facilities are taken directly from the operational records of company which provides natural gas storage in Czechia.

A transit gas pipeline runs through the territory of the Czech Republic, transporting Natural Gas from Russia to the countries of Western Europe, with a length of 4 059 km. Since 2022 this pipeline is gradually used for domestic Natural Gas transport. Until the conflict in Ukraine is resolved, emissions from this pipeline will be reported in 1.B.2.b.iii.2. In addition to this central gas pipeline, a system of high-pressure gas pipelines is in operation in the territory of the Czech Republic, providing supplies of Natural Gas from the transit gas pipeline and underground gas storage areas to centres of consumption. In 2022, the high-pressure gas pipelines had an overall length of 12 727 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. The control of calculated data are performed according to the Czech public databse IRZ (E-PRTR), where methane emissions are reported on each compression stations (from the reporting treshold 100 t/emissions site).

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 5 176 mil. m^3 in 2022.

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

Emissions from distribution gas pipelines, with an overall length in 2022 of 79 098 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. The large fluctuations in AD in the period 1990–2011 are because for that period AD were collected from individual gas companies. This data collection led to inaccuracies, which were addressed following the availability of updated official statistics from Energy Regulatory Office since 2012. In the beginning of the monitoring period (after 1990), it was necessary to increase technological level of gas facilities. Emissions were calculated from EF, which arise from the length of pipeline, number of customers and regulation stations, to the consumed amount of natural gas in individual years (from the CzSO questionnaire). For the year 2022 the number of gas pressure station control was 4 500 and number of gas use in household and small customers 2 773 120, medium and large costumers 8 164. These data are taken from the yearbook of Energy Regulatory Office.

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. 3-70 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. 3-70 further contains values of emissions CH_4, CO_2 and N_2O from Flaring in domestic production of Crude Oil. From the table it is clear that this is a minor proportion from the total emissions in whole subcategory Oil and Gas (1.B.2.a).

Tab. 3-70 Emissions of CH_4, CO_2 and N_2O from Venting and Flaring in 1990 – 2022

	Venting - emissions [t/year]		Flaring - emissions [t/year]		
	CH_4	CO_2	CH_4	CO_2	N_2O
1990	0.49	0.10	0.001	1.92	0.00003
1991	0.68	0.14	0.002	2.64	0.00004
1992	0.80	0.17	0.002	3.14	0.00005
1993	1.09	0.23	0.003	4.25	0.00007
1994	1.25	0.26	0.003	4.90	0.00008
1995	1.43	0.30	0.003	5.59	0.00009
1996	1.49	0.31	0.004	5.82	0.00009
1997	1.60	0.33	0.004	6.24	0.00010
1998	1.75	0.36	0.004	6.85	0.00011
1999	1.81	0.37	0.004	7.06	0.00011
2000	1.73	0.36	0.004	6.76	0.00011
2001	1.81	0.37	0.004	7.06	0.00011
2002	2.62	0.54	0.006	10.24	0.00016
2003	3.13	0.65	0.008	12.23	0.00019
2004	3.02	0.62	0.007	11.78	0.00019
2005	3.08	0.64	0.007	12.05	0.00019
2006	2.62	0.54	0.006	10.23	0.00016
2007	2.44	0.50	0.006	9.52	0.00015
2008	2.39	0.50	0.006	9.35	0.00015
2009	2.19	0.45	0.005	8.58	0.00014
2010	1.76	0.36	0.004	6.86	0.00011
2011	1.65	0.34	0.004	6.44	0.00010
2012	1.56	0.32	0.004	6.08	0.00010
2013	1.54	0.32	0.004	6.01	0.00010
2014	1.50	0.31	0.004	5.85	0.00009
2015	1.28	0.26	0.003	4.99	0.00008
2016	1.17	0.24	0.003	4.56	0.00007
2017	1.08	0.22	0.003	4.21	0.00007
2018	1.11	0.23	0.003	4.33	0.00007
2019	0.81	0.17	0.002	3.17	0.00005
2020	0.92	0.19	0.002	3.60	0.00006
2021	0.84	0.17	0.002	3.28	0.00005
2022	0.76	0.16	0.002	2.97	0.00005

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 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 couldn't be determined by direct measurements, as they are not connected with specific air outlets or chimneys. Thus, they can be determined only on the basis of professional estimates from balance losses or using emission factors. The resultant emissions of the individual substances were compared with the data in the national emission database and are of the same order of magnitude.

In general, it can be stated that fugitive greenhouse gas emissions occur in this subcategory only in operations in which Crude Oil saturated in carbon dioxide and methane is in contact with the atmosphere. All operations involving Crude Oil in the Czech Republic are hermetically sealed. Thus, fugitive emissions are formed only through leaks in the technical equipment. Following thermal treatment of Crude Oil, the resultant products no longer contain any dissolved gases and no fugitive emissions need be considered in subsequent operations.

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

CH_4 emissions from Crude Oil transport and refining and from Crude Oil mining, which is performed in the Czech Republic in combination with mining of Natural Gas, are reported in this category. CO_2 emissions from the refinery resulting from combustion processes (including flaring) are included in 1.A.1.b Crude Oil Refining.

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

Exploration is not systematically performed in the Czech Republic. For this reason, there are no known procedures for the determination of emissions in this subsector.

Activity data: number of mined boreholes – notation key 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 0.1771 kg CH_4/m^3 and was determined on the basis of published data in (Zanat et al.,1997). The emission factor was determined as the sum of the individual emission factors from pumping of raw Crude Oil and from storage of raw Crude Oil. These data were obtained by direct measurement. The resultant emission factor, which is used for the calculation of CH_4 emissions is based also on the net calorific values and density of crude oil.

CO_2 emissions are estimated based on the default emission factor (IPCC 2006 Gl. (IPCC 2006), Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52).

EF CO_2: 2.8E-04 Gg per 10^3 m^3 total oil production = 7 576 kg/PJ

For the estimation of N_2O emissions, no emission factor was available.

Transport (1.B.2.a.iii.3)

In this case, the activity data correspond to the total amount of petroleum transported through the territory of the Czech Republic by the pipeline system in the individual years. This amount corresponds to the Total Crude Oil input to refineries. The default emission factors from IPCC 2006 Gl. (IPCC 2006), Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52 are employed to calculate the CH_4 and CO_2 emissions.

EF CH_4: 5.4E-06 Gg per 10^3 m^3 oil transported by pipeline = 146 kg/PJ

EF CO_2: 4.9E-07 Gg per 10^3 m^3 oil transported by pipeline = 13 kg/PJ

These emission factors were used to calculate fugitive emissions for the years since 1990.

For the estimation of N_2O emissions, no emission factor was available.

Refining (1.B.2.a.iii.4)

Methane emissions from refining are calculated using IPCC Tier 1 methodology (Table 4.2.4 in IPCC 2006 Gl. (IPCC 2006)). Emissions are calculated by multiplying the amount of Crude Oil input to refinery by the emission factor. The emission factor value used was 585 kg/PJ.

This emission factor is based on the data from IPCC 2006 Gl. (IPCC 2006), Table 4.2.4, Tier 1 Emission factors for fugitive emissions from Oil and Gas operation in developed countries, page 4.52

EF CH_4: 2.6×10^{-6} to 41.0×10^{-6} Gg per 10^3 m^3 oil refined = 585 kg/PJ (average)

The value decreased during years and it was due to the improvements in technology of refining. For example for storage of crude oil, Czech companies use modern technologies contain double flootin roof and the bottom of the tank is double with a vacuum gap divided into four separate sections with separate pressure sensors that constantly monitor the tightness. Also during refining processes they follow BAT document for refining mineral oils.

Based on ERT recommendation (2022CZEQA28) recalculation of emission factor was done for the submission 2021-2023. For the period 1990 – 1999 the highest emission factor from Guidelines 2006 IPCC (1 148, respectively 1 150 kg/PJ) was used. This conservative approach attempts to replicate the poor condition of refineries during the 1990s. For 2002–2012, the maximum value of the CH4 EF for developed countries was taken from the 2006 IPCC Guidelines (vol.2 chap.4, table 4.2.4), which was a linear transition to an average value was applied and since 2013 the average value is used (585 kg/PJ). This average value comes from the minimum and maximum of default emission factor stated in Guidelines 2006 IPCC and reflecting recent improvements in the fuel refining process in Czechia.This recalculation was held in response to the ERT recommendation (2022CZEQA28) and eventhough the emission are higher, they are still under the threshold of significance for the Czech Republic.

The decrease in the IEF is based on the assumption that that there is ongoing “ecologization” of the refineries and oil storage facilities, whereby oil companies invest a significant amount of money to upgrade their equipment to minimize environmental damage. In the past, these investments were mainly aimed to reduce the usual pollutants, including non-methane volatile organic compounds (NMVOCs). The equipment upgrades aimed to reduce NMVOCs also led to a decrease in CH_4 emissions from 1.B.2.iv (refining/storage). The operators in Czechia are legally required to estimate and report NMVOC emissions in the integrated central system, which uses these data for national environmental policy decisions as well as for international reporting (e.g under European Monitoring and Evaluation Programme). For better expression of the situation a graph, which demonstrated the correlation between the EF for CH_4 emission from 1.B.2.iv (refining/storage) and that for NMVOCs, is shown in Fig. 3-49. The graph clearly showed that the decrease in EF for NMVOC, which is based on direct reporting by operators (i.e. tier 3), is even more significant than the decrease in CH_4 emission factor used for the GHG inventory.

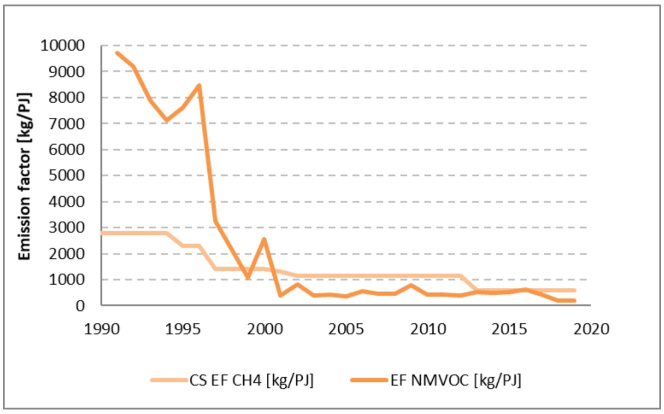

Fig. 3-49 Correlation between EF for NMVOC and CH_4 emissions.

The IPCC method does not give any EF for CO_2 or N_2O. Consequently, the notation key NA is used in CRF.

Distribution of Oil Products (1.B.2.a.iii.5)

The available IPCC methodology does not provide any EF for CO_2, CH_4 or N_2O – notation key – NA. The products which originate during oil processing cannot contain CO_2 or CH_4. There isn't known process by which could arise fugitive CO_2 or CH_4 emissions during the distribution of oil products.

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

Activity data: notation key: NO; CH_4, CO_2 and N_2O emissions – notation key NO.

3.3.2.2.2 Natural Gas (CRF 1.B.2.b)

Leakages in the distribution network and household distribution pipes can be considered to constitute the most serious source of emissions. In the 1990's, the distribution network was newly constructed almost entirely from welded plastics and the old pipeline was reconstructed to a major degree in the same manner. Household distribution pipes are subject to strict standards and any poor seals can be identified by the characteristic smell. In addition to safety aspects, all leakages also have an economic impact both for the distribution company and for the end user, so this aspect is carefully monitored and, as soon as possible, immediately remedied. As a whole, the gas distribution in the CZ is at a high technical level and it can be stated that all leakages are carefully sought out and eliminated.

As a method was developed in the last few years for determining methane emissions in the gas industry using specific emission factors, this sophisticated method of calculation continues to be used, although, from the standpoint of ref. (IPCC 2006), calculation using default values would probably suffice. Qualified estimation of methane emissions is thus carried out using specific emission factors for the individual parts of the gas industry system (Table 4.2.8. Classification of Gas losses as low, medium or high at selected types of Natural gas facilities, IPCC 2006 Gl. (IPCC 2006), page 4.71). Emission factors were determined by the International Gas Union (IGU) in 1998 in Study Group 8.1 Methane Emissions (Gas and the Environment, 2000). These EF were corrected on the basis of consultation with Czech Gas experts to the Czech conditions (technical conditions of the individual parts of the gas supply system).

Currently, companies from the gas industry are preparing on the fulfilling demands from Regulation of the European parliament and the council on methane emissions reduction in the energy sector and amending Regulation (EU) 2019/942. Partial results could already be used in the submission 2022/2024, as it can be seen from the Tab. 3-71. The total emissions are summarized in the Tab. 3-72.

The total emission value given corresponds to about 0.22% of the total consumption of Natural Gas in the Czech Republic. The detailed calculation given corresponds to Tier 2.

In general, it can be stated that the determined methane emissions in category 1.B.2 Gas are basically formed in several ways:

- through poor seals in the flanges and joints, fittings, probes in mining and storage fields and other parts of the pipeline system,
- through pipeline perforation,
- through technical discharge of gas into the air,

- through accidents.

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

Exploration of Natural gas is not carried out in the Czech republic regularly, but only very randomly. Therefore notation key NE was used in CRF Report tables for the emissions and activity data. The statement of MND a.s. (only company with licence for exploration in Czechia) is that they perform exploration but only very random and this activity do not release emissions at all, see chapter *Exploration (1.B.2.a.iii.1)* for more explanation.

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

Transmission and Storage (1.B.2.b.iii.4)

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

Other (1.B.2.b.iii.6)

1.B.2.b.6 is reserved for "others". We have used this "empty" category only to report the volume of stored gas, since separately stored gas cannot be reported anywhere else. Gas storage is reported according to the IPCC methodology in subcategory 1.B.2.b.4 (transit and storage) together with emissions from transit transport. The data in 1.B.2.6 should only be taken as additional information.

Fugitive methane emissions are calculated in these subcategories using an internal calculation model based on the methodology proposed in 1997 in IGU (Alfeld, 1998). Calculations of emissions are supplemented by data from the national Integrated Pollution Register (IPR) and investigations at individual distribution companies on registered units of Natural Gas and in this submission also from direct data on methane emissions from some gas companies.

Tab. 3-71 Model calculation of CH_4 emissions in the Natural Gas sector (2022)

	EF		Activity data		Losses of NG	Only methane*)
	value	units	value	units	[mil.m³/year]	
Production	0.2	% vol.	222	mil. m³	0.44	0.42
Total production						**0.42**
High pressure pipelines	600	m³/km.year	12 727	km	7.636	7.18
Transmission pipelines	200	m³/km.year	4 059	km	0.812	0.76
Compressors **)						0.733
Storage ***)						0.395
Total Transmission and storage						**9.07**
CNG filling to cars	0.47	% vol.	91.039	mil. m³	0.42	0.40
Technological leaks***)						0.709
Fugitive leaks***)						10.972
Regulation stations and measurement	1 000	m³/pc.year	940.5	pc	0.941	0.88
Distribution networks	300	m³/km.year	4 260	km	1.278	1.20
Number of customers	2	m³/consumer	595 137	pc	1.190	1.12
Total distribution						**15.28**
Total 1.B.2.b - Gas						**24.77**
Emissions in Gg (0.7 kg/m³)						**17.34**

*) *conversion to methane content in natural gas x 0.94*
**) *data from IRZ (Integrated Pollution Register of CZ version of E-PRTR)*
***) *data from operating register of leakage Natural Gas - Czech Gas Companies*

Emissions calculated in this model are then transformed to the structure of the sectors and subsectors according to the IPCC methodology.

Tab. 3-72 Recapitulation of methane emissions in 1.B.2.b – Gas.

Total production	**0.292**
Total Transmission and storage	6.348
Total Distribution	10.699
Total 1.B.2.b - Gas	17.339

3.3.2.2.3 Venting and Flaring (CRF 1.B.2.c)

The estimations of CO_2, CH_4 and N_2O emissions from venting and flaring in the course of oil production were obtained by using the default EFs provided by the IPCC 2006 Gl. (IPCC 2006) (see table 4.2.4, pages 4.48 – 4.54). In this case the following EFs were taken:

Venting (Default Weighted Total)

CH_4: 8.7E-03 Gg per 10^3 m^3 total oil production

CO_2: 1.8E-03 Gg per 10^3 m^3 total oil production

N_2O: NA

Flaring (Default Weighted Total)

CH_4: 2.1E-05 Gg per 10^3 m^3 total oil production

CO_2: 3.4E-02 Gg per 10^3 m^3 total oil production

N_2O: 5.4E-07 Gg per 10^3 m^3 total oil production

Owing to the fact that activity data are required in kg/PJ, the value was converted to kg/PJ by using the typical value of density for crude oil of 880 kg/t and value NCV was taken from CzSO questionnaires IAE as a simple average for domestic oil (42 MJ/kg):

Venting

CH_4: 235 390 kg/PJ

CO_2: 48 701 kg/PJ

Flaring

CH_4: 568.2 kg/PJ

CO_2: 919 913 kg/PJ

N_2O: 14.61 kg/PJ

3.3.2.3 Uncertainties and time-series consistency

The inventory methods used in this inventory were consistently employed across the whole reporting period from the base year of 1990 to 2022.

In 2020 was carried out an extensive study aiming to update the uncertainties in the sector 1.B.2. From the study follows that in this category higher uncertainties should be expected than in 1.A. During fuel mining/production is expected relatively high uncertainties due to used measuring instruments (for large quantities - millions of tonnes have relatively low accuracy) as well as the overall difficult operating conditions. Conversely, imports and exports of raw materials are sensitive economic data and low uncertainties should be expected. Venting and flaring is minor subcategory in inventories of Czechia, but this subcategory is less explored than others and thus the uncertainties are quite high.

The emission factors for determining emissions in extraction of Natural Gas and Crude Oil are based on specific measurements. 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. 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.

The determination of uncertainties was carried out according the same methodology as in case of category 1.A i.e. three independent experts estimate of 'basic' uncertainties, which were averaged (see chapter 3.2.5. or for details Veselá et al., 2020).

For specific uncertainties used for introduction into the trend in total national emissions see Annex 2.

3.3.2.4 Category-specific QA/QC and verification

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

QC activities at the level of Tier 1 were performed according to the QA/QC plan by the sector compiler. Routine control was performed in the framework of the following activities:

- activity data employed,
- emission factors employed,
- calculation procedures employed,
- transfer of numerical data from the working set to the CRF Reporter.

In control of the emission factors employed, the emission factors used in the Czech Republic methodology were compared with the emission factors of Slovakia, Poland and Germany in the context with the default emission factors. It was found that the emission factors employed for calculation of emissions in the Czech Republic methodology correspond, in their range, to the emission factors employed in the other countries. Comparison of the emission factors used in the Czech Republic with the emission factors of the surrounding countries corresponds to the level of Tier 2.

Control of the transfer of numerical data from the working set to the CRF Reporter did not reveal any differences.

The final working set in EXCEL format was locked to prevent intentional rewriting of values and archived at the coordination workplace.

The protocols on the performed QA/QC procedures are stored in the archive of the sector compiler.

3.3.2.5 Category-specific recalculations

There are no specific recalculations for this category.

3.3.2.6 Category-specific planned improvements

No specific improvements are planned for this category.

3.4 CO_2 transport and storage (CRF 1.C)

Not performed in the Czech Republic.

4 Industrial processes and product use (CRF Sector 2)

The sector of industrial processes of GHG emission inventory includes emissions from technological processes and not from fuel combustion used to supply energy for carrying out these processes. Consistent emphasis is put on the distinction between the emissions from fuel combustion in the Energy sector and the emissions from technological processes and production.

For example, in the production of cement, consideration is given only to emissions derived from the thermal decomposition of mineral raw materials (specifically CO_2 emissions from the decomposition of limestone) and not from fuel used to heat the rotary kiln (considered in category 1.A.2.f). However, the situation in iron and steel production is more complicated. Evaluation of the CO_2 emissions is based on consumption of metallurgical coke in blast furnaces, where coke is used dominantly as a reducing agent (iron is reduced from iron ores), even though the resulting blast furnace gas is also used for energy production, mainly in metallurgical plants.

In 2022, the total aggregate GHG emissions from industrial processes were 15045.20 kt of CO_2 equivalents, which represent decrease of 7% compared to the previous year. Emissions decreased by 12% 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 Black Production, Other Process Uses of Carbonates, Amonia Production, Lime Production and Nitric Acid 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 2022 and lists type of key category analysis for key categories.

Tab. 4-1 Overview of key categories in sector Industrial Processes (2022)

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	4.68	4.81
2.F.1 Refrigeration and Air conditioning	F-gases	LA, TA	LA, TA	Yes	Yes	Yes	Yes	2.97	3.05
2.A.1 Cement Production	CO_2	LA, TA		Yes	Yes			1.53	1.58
2.B.8 Petrochemical and Carbon Black Production	CO_2	LA, TA	LA, TA	Yes	Yes	Yes	Yes	0.84	0.87
2.A.4 Other Process Uses of Carbonates	CO_2	LA, TA		Yes	Yes			0.61	0.63
2.B.1 Ammonia Production	CO_2	LA		Yes	Yes			0.57	0.58
2.A.2 Lime Production	CO_2	LA		Yes	Yes			0.46	0.47
2.B.2 Nitric Acid Production	N_2O	TA		Yes	Yes			0.09	0.09

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

4.1.2 Emissions trends

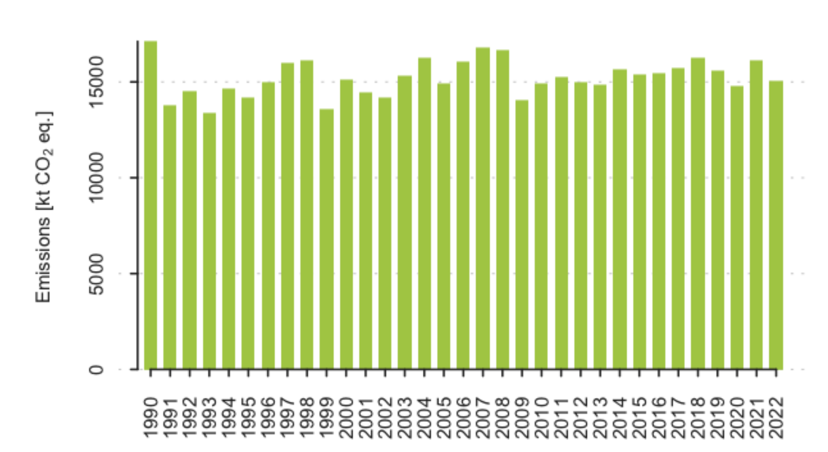

Fig. 4-1 Trend of emissions from IPPU [kt CO_2 eq.]

This chapter describes the emissions of greenhouse gases in more disaggregated way than chapter 2: Trends in Greenhouse Gas emissions.

GHG emissions in this category are driven mainly by economic development, supply and demand of products, where abatement technology is used only in specific cases (e.g. nitric acid production) or the driving force is different (e.g. substitutes to ozone depleting substances). GHG emission trend from Industrial Processes and Product Use from base year 1990 to 2022 is depicted in Fig. 4-1. CO_2 eq. emissions have shown stable trend since 2010 with slightly increasing fluctuations.

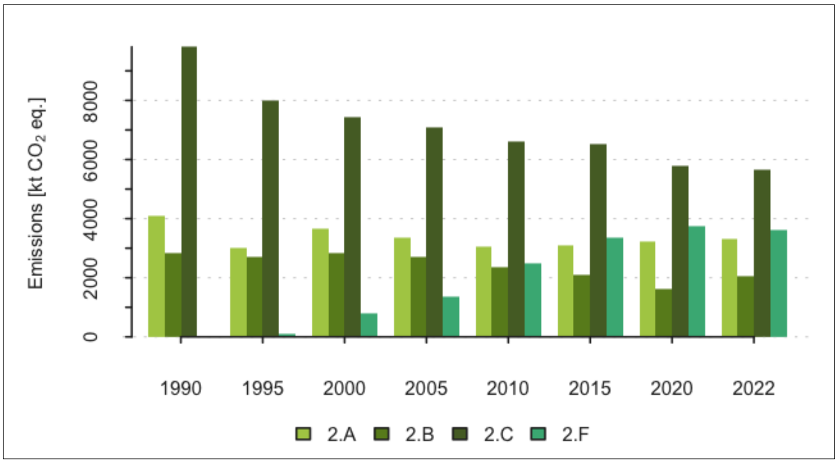

Fig. 4-2 Emissions from principal subcategories of IPPU [kt CO_2 eq.]

GHG emission trends for the principal categories of IPPU are depicted on Fig. 4-2 for years 1990, 1995, 2000, 2005, 2010, 2015, 2020 and 2022. Emissions in 2009 and 2010 were rather influenced by the economic crisis and in 2019 and 2020 by Covid-19 pandemic. Emissions from category 2.A decreased by 19% compared to 1990. Decreasing trend of emissions is observed also for categories 2.B and 2.C. Emissions decreased by 27% for 2.B and by 42% for 2.C compared to 1990. It can be seen that the emissions of fluorinated greenhouse gases from category 2.F are constantly increasing since 1995. 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 (2022)

IPCC Category	Emissions							
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	HFOs[1]
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	x	
2.F Product Uses as Substitutes for ODS				x	x			
2.G Other Product Manufacture and Use			x			x		
2.H Other	x							x

[1] *Hydrofluoroolefins (HFO-1234yf and HFO-1234ze)*

4.2 Mineral Industry (CRF 2.A)

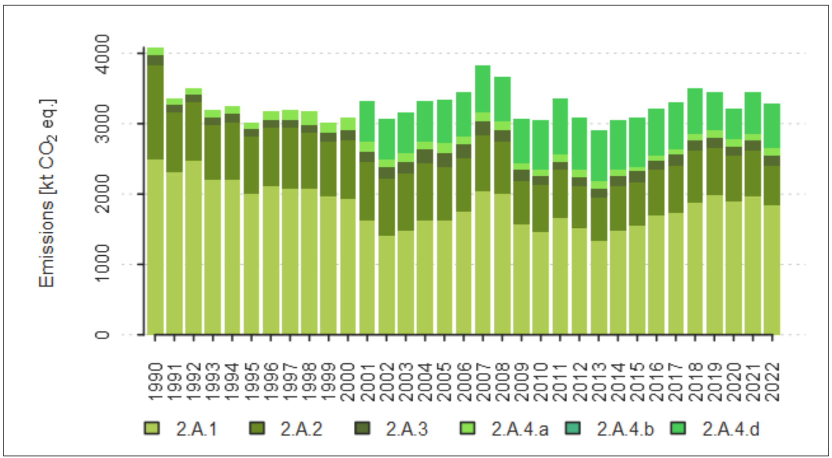

Fig. 4-3 Trend of emissions from 2.A Mineral Industry and share of specific subcategories [kt CO_2]

This category describes GHG emissions from the non-combustion processes from the following categories: 2.A.1 Cement Production, 2.A.2 Lime Production, 2.A.3 Glass Production, 2.A.4 Other Process Uses of Carbonates.

Emission trend for category 2.A Mineral Industry is depicted on Fig. 4-3. The major share 56% belongs to 2.A.1 Cement Production, 17% belongs to 2.A.2 Lime Production, 4% belongs to 2.A.3 Glass Production and 19% to 2.A.4 Other Process Uses of Carbonates. Tab. 4-3 lists the CO_2 emissions in the individual subcategories in 2.A Mineral Products in 2022.

Tab. 4-3 CO_2 emissions in individual subcategories in 2.A Mineral Products category in 1990 – 2022

	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	723.73
2014	1482.73	630.90	135.23	89.94	1.11	710.00
2015	1558.16	611.54	151.96	68.64	1.01	692.93
2016	1697.60	639.82	138.06	70.26	1.01	673.52
2017	1728.27	673.53	155.01	79.03	1.15	661.44
2018	1867.54	749.37	147.68	90.41	0.75	649.40
2019	1977.24	680.95	143.60	110.04	0.79	529.87
2020	1891.03	650.80	138.83	96.50	0.81	432.66

2021	1957.87	667.02	143.92	91.17	1.00	582.98
2022	1846.97	555.89	145.87	100.01	0.99	638.50

Tab. 4-4 gives an overview of the emission factors and methodology used for computations of emissions in category 2.A Mineral Products in 2022.

Tab. 4-4 CO_2 emission factors and methodology used for computations of 2022 emissions and removals 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	0.70	t CO_2/t CaO	CS	Tier 3
2.A.3 Glass Production	0.11	t CO_2/t Glass	EU ETS	Tier 3
2.A.4.a Ceramics	0.13	t CO_2/tiles thousand m^2	CS (EU ETS)	Tier 3
	0.05	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	PS	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	0.72	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 26%. Total CO_2 emissions equal to 1846.97 kt in 2022. 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 - 2022. 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 - 2022

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Clinker production	[kt]	4 726.0	4 368.0	4 653.0	4 122.0	4 134.0	3 740.0	3 934.0	3 829.0	3 758.0	3 547.0
EF CO_2	[t CO_2/ t clinker]	0.527	0.529	0.531	0.532	0.534	0.536	0.538	0.544	0.550	0.553
CO_2 emissions	[kt]	2 489.2	2 308.9	2 468.4	2 194.6	2 208.4	2 005.0	2 116.5	2 083.4	2 067.7	1 962.9
	Unit	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Clinker production	[kt]	3537.0	2954.0	2549.0	2725.0	3017.0	3045.1	3287.7	3837.0	3758.7	2923.2
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]	1936.9	1628.8	1403.5	1484.9	1626.8	1624.5	1748.5	2043.1	1996.1	1566.1
	Unit	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Clinker production	[kt]	2748.5	3132.3	2837.6	2472.2	2792.1	2919.2	3188.1	3236.0	3514.3	3722.2
EF CO_2	[t CO_2/ t clinker]	0.534	0.531	0.535	0.539	0.531	0.534	0.532	0.534	0.531	0.531
CO_2 emissions	[kt]	1469.0	1664.5	1517.1	1331.8	1482.7	1558.2	1697.6	1728.3	1867.5	1977.2

	Unit	2020	2021	2022
Clinker production	[kt]	3556.0	3673.0	3497.0
EF CO_2	[t CO_2/ t clinker]	0.532	0.533	0.528
CO_2 emissions	[kt]	1891.0	1957.9	1847.0

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 2022.

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 2022 obtained from CCA and other sources are as follows:

- Difference between the data from CCA and CzSO: 0.001%
- Difference between the data from CCA and ISPOP: 0.001%
- Difference between the data from CCA and EU ETS: 0.001%

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 58%. 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 longterm minimum of 758.07 kt. In 2022, production of lime decreased by 149.57 kt compared to previous year to a new minimum of 728.38 kt. The reason is higher import of lime. Local lime production is still identified as a key category in this year’s submission though.

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 - 2022 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 separately as pure CaO and additional carbonate additives. The ratio of their composition varies, and therefore IEF fluctuates between 0.788 and 0.758 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.

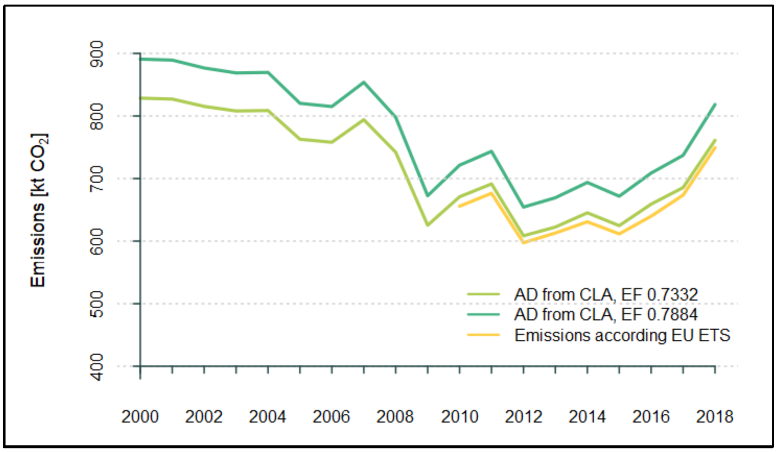

Fig. 4-4 Final emission values [kt CO_2] with applied EF 0.7332 and 0.7884 [t CO2/t lime] compared to EU ETS data

For the time period 1990 - 2009, the activity data is based on the data from CLA (the Czech Lime Association) and emissions were calculated by using the Tier 1 method. 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). This period's calculation is based on Vácha's research, which states: "According to provided information by CLA, the content of calcium oxide (CaO) in manufactured lime is 93%. Particle 0.93 is added to the computation formula in order to recalculate lime to pure 100% CaO. " The national EF, used for the time period 1990 - 2009, reflects the production of lime and quick lime (0.7884 t CO_2/t lime) (Vácha, 2004). The calculation in the period 1990 – 2009 is based on the following formula.

$$Emissions(CO_2) = Amount\ of\ Lime\ Produced * 0.7884\ t\ \ CO_2/t\ CaO * 0.93$$

Combination of the average purity (93%) and the national EF resuting emission factor is 0.733 t CO_2/t lime. The reason of lower IEF for the time period 1990 – 2009 than IEF for the time period 2010-2019 is in different source of activity data for each time series. On Fig. 4-4 is depicted that emissions would be overestimated if just national EF (without considering purity) was used.

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.

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 – 2022

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Lime production	[kt]	1 823.0	1 152.0	1 134.0	1 062.0	1 100.0	1 115.0	1 133.0	1 163.0	1 087.0	1 074.0
EF CO_2	[t CO_2/ t lime]	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
CO_2 emissions	[kt]	1,336.6	844.7	831.5	778.7	806.5	817.5	830.7	852.7	797.0	787.5
	Unit	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Lime production	[kt]	1 130.0	1 128.0	1 112.0	1 102.0	1 103.0	1 040.4	1 033.8	1 083.0	1 012.0	853.0
EF CO_2	[t CO_2/ t lime]	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
CO_2 emissions	[kt]	828.5	827.1	815.3	808.0	808.7	762.8	758.0	794.1	742.0	625.4
	Unit	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Lime production	[kt]	831.7	858.1	758.1	778.0	816.2	800.2	835.8	888.0	985.6	897.9
EF CO_2	[t CO_2/ t lime]	0.788	0.788	0.788	0.788	0.773	0.764	0.766	0.758	0.760	0.758
CO_2 emissions	[kt]	655.8	676.4	597.4	613.0	630.9	611.5	639.8	673.5	749.4	680.9
	Unit	**2020**	**2021**	**2022**							
Lime production	[kt]	855.7	878.0	948.2							
EF CO_2	[t CO_2/ t lime]	0.761	0.760	0.763							
CO_2 emissions	[kt]	650.8	667.0	555.9							

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 - 2022, 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 2022.

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 2022 obtained from EU ETS and other sources are as follows:

- Difference between the data from EU ETS and CLA: 7.4%
- Difference between the data from EU ETS and CzSO: 24.4%

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 increased by 5% 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 145.87 kt CO_2 in 2022.

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 - 2022 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 - 2022. 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 – 2022

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Glass production	[kt]	1 236.6	1 060.2	1 046.1	1 014.7	1 097.1	832.0	875.0	970.0	1 012.0	1 042.0
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]	142.8	122.4	120.8	117.1	126.7	96.0	101.0	112.0	116.8	120.3

	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Glass production	[kt]	1 197.0	1 203.0	1 349.0	1 416.0	1 662.0	1 654.0	1 750.0	1 688.0	1 519.2	1 329.3
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]	138.2	138.9	155.7	163.5	191.9	190.9	202.0	194.9	175.4	153.5

	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Glass production	[kt]	1 022.5	1 055.5	1 088.4	1 157.6	1 119.3	1 254.7	1 295.3	1 194.5	1 219.4	1 179.0
EF CO_2	[t CO_2/ t glass]	0.125	0.108	0.118	0.109	0.121	0.121	0.107	0.130	0.121	0.122
CO_2 emissions	[kt]	127.8	113.8	128.1	126.2	135.2	152.0	138.1	155.0	147.7	143.6

	Unit	2020	2021	2022
Glass production	[kt]	1 151.7	1 200.5	1 298.8
EF CO_2	[t CO_2/ t glass]	0.121	0.120	0.112
CO_2 emissions	[kt]	138.8	143.9	145.9

4.2.3.3 Uncertainties and time-series consistency

Since activity data are based on the EU ETS for time period 2010 - 2022, 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 2022.

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 category.

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 649%.

CO_2 emissions from 2.A.4.a Ceramics equalled to 100.01 kt in 2022. 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 0.99 kt CO_2 in 2022. CO_2 emissions from 2.A.4.d Other amounted to 638.50 kt CO_2 in 2022.

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 four categories by adding new nodes under 2.A.4.d Other category. Consequently, these four 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 2010-2022. 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, denitrification by using urea and removals from $CaCO_3$ production.

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 - 2022. 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 by using urea appeared in EU ETS for the first time in year 2017, at the same time when this technology was introduced in the Czech Republic, following new legislation based on the EU Industrial Emissions Directive 2010/75/EU. Data for year 2016 were due to the transitional period negligible and thus reported as "NE". Prior to 2016, urea was not used for denirification, so emissions from this source were reported using notation key "NO". Main purpose of denitrification by using urea is to reduce NO_x emissions which are produced during combustion processes. As a reducing agent in the denitrification process is used aqueous urea solution ($CO(NH_2)_2$). Denitrification process can by described using the following equation:

$$CO(NH_2)_2 + 2NO + {}^{1}\!/_{2}\, O_2 \rightarrow 2N_2 + CO_2 + 2H_2O$$

It is obvious that as a side effect of this process, CO_2 emissions are emitted. In 2022, 21 facilities (power plants, heating plants and chemical plants) reported CO_2 emissions from denitrification processes. Data (activity data, emission factors and CO_2 emissions) are obtained directly from users of this process and thus methodology used for emission estimates is Tier 3. CO_2 emissions from denitrification amounted to 6.99 kt in 2022; emissions are under the threshold of significance. The denitrification process is closely linked to heat and electricity production, and for clarity and consistency with EU ETS, it is reported in this category together with desulphurization.

Previously, production of $CaCO_3$ in one paper mill in the Czech Republic was included. During this process, CO_2 reacts with hydrated lime, forming $CaCO_3$. For each mole of $CaCO_3$ produced, one mole of CO_2 is absorbed, so the mass of CO_2 removal can be estimated from the produced amount of $CaCO_3$ and the stoichiometry of the chemical process. In reality, when lime and cement products are used in construction, the same reaction occurs, and these processes are not included in estimations. Therefore it was decided to remove the absorption of CO_2 in $CaCO_3$ production from the inventory.

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, denitrification and $CaCO_3$ production because activity data describe completely different type of inputs.

Tab. 4-8 lists the CO_2 emissions and removals in the individual subcategories in 2.A.4 Other Process Uses of Carbonates for time period 1990 - 2022.

Tab. 4-8 CO_2 emissions and removals in individual subcategories in 2.A.4 Other Process Uses of Carbonates category in 1990 – 2022

	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	680.90	NO
2014	89.94	1.11	46.89	663.11	NO
2015	68.64	1.01	47.62	645.31	NO
2016	70.26	1.01	46.00	627.52	NE
2017	79.03	1.15	48.99	609.72	2.72
2018	90.41	0.75	49.78	591.93	7.69
2019	110.04	0.79	46.63	478.63	4.62
2020	104.32	0.81	47.32	380.60	4.74
2021	91.17	1.00	47.60	529.07	6.30
2022	100.01	0.99	47.60	583.90	6.99

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 2022.

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 2022.

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 2022 and for flue-gas desulphurization from 1996 to 2022.

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

2.A.4.d Other

Process Uses of Carbonates - Ceramics - data of total production of tiles for the year 2021 were updated which resulted in minor change of emission factor.

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

The search for AD for mineral wool production is scheduled for the period 1990 - 1999. Since the Tier 3 method is used for emission calculations in this category (except for mineral wool production), no other significant improvements are planned.

4.3 Chemical Industry (CRF 2.B)

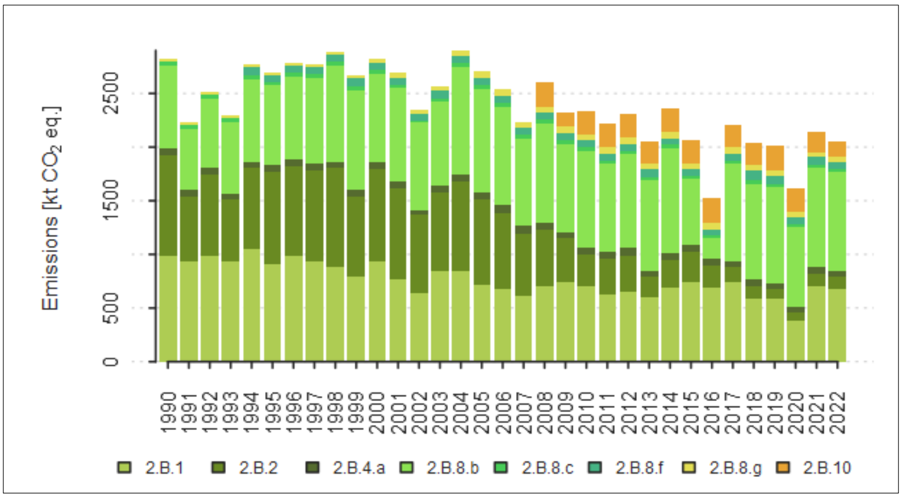

Fig. 4-5 Trend of emissions from 2.B Chemical Industry and share of specific subcategories [kt CO_2 eq.]

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 52% belongs to 2.B.8 Petrochemical and Carbon Black Production, 33% belongs to 2.B.1 Ammonia Production, 7% to 2.B.10 Other, 5% to 2.B.2 Nitric Acid Production and 3% to 2.B.4.a Caprolactam Production. The emission trend for the category 2.B Chemical Industry is depicted in Fig. 4-5.

Tab. 4-9 lists the exact amount of CO_2 eq. emissions from the individual subcategories in 2.B Chemical Industry for time period 1990 - 2022.

Tab. 4-9 CO_2 eq. emissions in individual subcategories in 2.B Chemical industry category in 1990 - 2022

	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	932.80	68.82	832.97	IE
1991	933.44	598.90	66.58	631.83	IE
1992	989.89	760.55	59.02	710.28	IE
1993	933.98	572.40	62.58	728.02	IE
1994	1055.82	749.95	53.71	907.97	IE
1995	903.19	863.90	65.88	861.78	IE
1996	989.20	829.45	63.67	906.57	IE
1997	931.15	855.95	64.24	924.33	IE
1998	886.50	922.20	55.85	1020.63	IE
1999	788.90	752.60	65.65	1061.64	IE
2000	936.02	861.25	67.68	963.80	IE
2001	761.75	850.65	63.90	1014.49	IE
2002	638.58	731.40	39.13	944.47	IE
2003	850.60	728.75	58.55	926.46	IE
2004	843.43	837.40	63.55	1156.16	IE
2005	721.70	789.70	71.10	1123.94	IE
2006	683.27	702.25	71.64	1078.24	IE
2007	617.11	575.05	71.87	971.42	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
2008	700.21	535.30	56.79	1084.11	222.76
2009	744.18	402.80	58.65	985.48	136.47
2010	705.45	288.85	65.66	1060.69	210.17
2011	628.05	328.60	70.13	968.83	220.22
2012	653.79	336.55	68.21	1032.19	224.54
2013	601.13	188.61	57.57	996.84	214.76
2014	689.05	255.52	61.42	1140.53	219.50
2015	741.66	280.18	65.60	756.39	223.06
2016	685.72	216.44	59.18	327.56	233.58
2017	743.75	134.32	61.44	1064.77	206.53
2018	585.60	112.24	64.36	1074.84	207.40
2019	582.93	91.88	58.08	1050.43	226.18
2020	381.79	72.10	60.47	884.01	221.53
2021	701.31	121.11	64.35	1067.84	191.45
2022	682,45	104.49	55.44	1072.18	139.01

Tab. 4-10 gives an overview of the emission factors used for computations of emissions in category 2.B Chemical Industry for year 2022.

Tab. 4-10 Emission factors used for computations of 2022 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 2
2.B.2 Nitric Acid Production	0.68	kg N_2O /t HNO_3	PS	Tier 3
2.B.4 Caprolactam, Glyoxal and Glyoxilic Acid Production	C	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.

Following table (Tab. 4-11) contains information about chemical production in the Czech Republic and number of manufactures. It can be seen, that except of nitric acid production, only one manufacturer for each product operates in the Czech Republic and thus due to confidentiality reasons is very difficult to obtain direct information about production and emissions related to the production from manufacturers. Each manufacturer (in the case of the Czech Republic – chemical plants) reports their emissions in EU ETS but only as bulk emissions which is not sufficient for emission estimates because emissions are related to the total emissions from all processes carried out in a plant (other production, combustion processes etc.). For those reasons, Tier 1 methodology is used for emission estimates, except of N_2O emissions from nitric acid production, CO_2 emissions from ammonia production and CO_2 emissions from carbon black production.

Tab. 4-11 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 2022 equalled to 682.45 kt of CO_2, emissions decreased by 26,9 % compared to 1990 (990.80 kt of CO_2 eq.). Emissions in period 2005 - 2022 fluctuate slightly every year with minimum in 2020 and maximum in 2009. The sharp decrease of emissions in 2020 was probably due to the Covid-19 pandemic and lockdown and ther impact on the production. Increase of emissions from 2014 was mainly caused by the end of urea production, which has not been produced since 2014.

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

Tier 2 approach is used to estimate the emissions from amonia production. As there is only one producer for amonia in Czech republic, all provided data (process type, fuel type, amonia production data, CO_2 recovered for urea production data) are plant specific.

The equation used for calculation of emissions differs from the equations in the IPCC 2006 Gl., Volume 3, Chapter 3 but is still consistent with the Tier 2 methodology in the 2006 IPCC guidelines. 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 42.5 GJ (NCV)/t NH_3 (IPCC 2006). Total CO_2 emissions from ammonia production were 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. Untill 2013, the urea-related emissions were allocated under the agriculture sector (please se chapter 5.8 for details, CRF 3.H). 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. 4-12. Related CO_2 emissions from ammonia production are reported in Table 1.A(d) under Other Oil, which is the feedstock used, as well (please see chapter 3.2.3. for details).

Tab. 4-12 Activity data and CO_2 emissions from ammonia production in 1990 – 2022

	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	2018	2019
Residual fuel oil used for NH_3 product	[TJ]	11 484	10 278	10 659	8 212	9 400	10 118	9 355	10 146	7 989	7 953
Ammonia produced	[kt]	257.19	230.18	238.72	183.91	210.53	226.60	209.51	227.24	178.92	178.10
CO_2 from 2.B.1	[kt]	705.45	628.05	653.79	601.13	689.05	741.66	685.72	743.75	585.60	582.93
CO_2 consumed in urea production	[kt]	136.34	125.34	127.54	0.81	NO	NO	NO	NO	NO	NO
	Unit	2020	2021	2022							
Residual fuel oil used for NH_3 product	[TJ]	5 209	9 568	9 310							
Ammonia produced	[kt]	116.65	214.27	208.51							
CO_2 from 2.B.1	[kt]	381.79	701.31	682.45							
CO_2 consumed in urea production	[kt]	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 2022.

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 category.

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

In this year, no source-specific improvements are planned.

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 2022 equalled to 0.39 kt N_2O, emissions have decreased by 82.6% compared to 1990; the substantial decrease in recent years has been a consequence of the gradual introduction of mitigation technology and improving its effectiveness.

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 (A – atmospheric pressure), slightly elevated pressure (MP – medium pressure) (approx. 0.4 MPa) and at elevated pressure (HP – high 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. 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.

All the nitric acid production processes in the Czech Republic are equipped with technologies for removal of nitrogen oxides (NO_X), based on selective (SCR) or non-selective catalytic reduction (NSCR). Non-selective catalytic reduction (NSCR) also makes a substantial contribution to removal of N_2O. Following table shows more detailed information about technology used for nitric acid production and technologies used for removal of NO_x by units.

Tab. 4-13 Pressure level and removal technology used by unit in the Czech Republic

Unit	Pressure level	Removal technology
1	MP	NSCR
2	HP	SCR
3	MP	NSCR
4	MP	SCR
5	A	SCR

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

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 - 2021, 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.

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
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
Effectiveness of mitigation [%]	-	10.00	23.85	43.97	38.21	63.46	83.46	83.33	81.41
	2013	2014	2015	2016	2017	2018	2019	2020	2021
EF [kg N_2O/t HNO_3 (100%)]	1.86	2.81	3.07	2.00	1.52	0.93	0.64	0.68	0.96
Effectiveness of mitigation [%]	76.18	64.02	60.60	74.31	80.56	88.02	91.78	91.25	87.73
	2022								
EF [kg N_2O/t HNO_3 (100%)]	0.83								
Effectiveness of mitigation [%]	89.33								

[a)] EF without N_2O mitigation.

Tier 1 approach was used for emission estimates in years 1990 to 2012. AD for these years were taken from CzSO. N_2O emissions for the years 1990-2012 were based on a mean value of the nitric acid production capacity with NSCR technology and compared with measured values of the outlet gas mixture. 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. 4-17 gives the N_2O emissions from production of nitric acid, including the production values.

Tab. 4-17 Emission trends for HNO_3 production and N_2O emissions in 1990 - 2022

	Production of HNO_3, [kt HNO_3 (100%)]	Emissions of N_2O from HNO_3 production [kt N_2O]	Implied Emission Factor IEF [kg N_2O/kt HNO_3]
1990	530.00	3.52	6.64
1991	349.56	2.26	6.46
1992	439.39	2.87	6.53
1993	335.95	2.16	6.43
1994	439.79	2.83	6.43
1995	505.32	3.26	6.45
1996	484.80	3.13	6.46
1997	483.10	3.23	6.69
1998	532.50	3.48	6.54
1999	455.00	2.84	6.24
2000	505.00	3.25	6.44

	Production of HNO_3, [kt HNO_3 (100%)]	Emissions of N_2O from HNO_3 production [kt N_2O]	Implied Emission Factor IEF [kg N_2O/kt HNO_3]
2001	505.08	3.21	6.36
2002	437.14	2.76	6.31
2003	500.58	2.75	5.49
2004	533.73	3.16	5.92
2005	532.21	2.98	5.60
2006	543.11	2.65	4.88
2007	554.22	2.17	3.92
2008	506.96	2.02	3.98
2009	505.17	1.52	3.01
2010	441.70	1.09	2.47
2011	561.82	1.24	2.21
2012	550.46	1.27	2.31
2013	514.94	0.71	1.38
2014	546.77	0.96	1.76
2015	532.15	1.06	1.99
2016	562.66	0.82	1.45
2017	533.95	0.51	0.95
2018	579.34	0.42	0.73
2019	566.99	0.35	0.61
2020	466.52	0.27	0.58
2021	601.57	0.46	0.76
2022	579.16	0.39	0.68

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, since 2005 the reduction in IEF has been caused mainly by the gradual increase in the effectiveness of the mitigation units employed for the dominant technology (see Tab. 4-17) to 2010. A further reduction in IEF in 2011 was then caused by an increasing contribution of this dominant technology (0.7 MPa) to 56% of the annual production of HNO_3.

The Institute of Physical Chemistry of the Czech Academy of Science together with the University of Chemistry and Technology Prague are studying the high temperature decomposition of N_2O from HNO_3 production by using a structured catalyst with focus on the possible use of the technology on an industrial scale. It follows that the development of technologies used in nitric acid production is still ongoing and possible improvements could be introduced in the future.

4.3.2.3 Uncertainties and time-series consistency

In 2014, the estimates of the uncertainty parameters were refined on the basis of in the study (Markvart and Bernauer, 2013), which takes into account the data in 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 2022.

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.

Verification is provided by comparison of the activity data obtained from CzSO, EU ETS and ISPOP. The nitric acid production data provided by CzSO are compared with data provided by EU ETS and ISPOP. The percentage differences between nitric acid production data for 2022 obtained from EU ETS and other sources are as follows:

- Difference between the data from ISPOP and CzSO: 3.68 %
- Difference between the data from EU ETS and ISPOP: 0.00 %

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 year 2013 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 the data were recalculated from AR4 to AR5 GWP values for the time series 2013-2021. Last year there were incorrectly used the AR4 GWP values. The change in emission is approximately 11 %.

The recalculation was done only for the time series 2013-2021 as those values are taken from EU ETS forms as CO_2 eq and recalculated to N_2O emission using GWP values. The values for years 1990-2012 are from CzSO in form of activity data (production of nitric acid/year) and from those the emission was calculated using PS emission factor.

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%, used emission factor for 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.

The emissions of N_2O was estimated using Tier 1 approach, equation 3.9 from IPCC 2006 Gl., Volume 3, Chapter 3. The activity data for time series 1990 - 2022 were provided by the producer. The plant-specific emission factor was used for calculation.

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.

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 category.

4.3.4.6 Category-specific planned improvements, including tracking of those identified in the review process

No improvement is planned for the next submission. Emissions are estimated according a series of studies (Markvart and Bernauer, 2004 – 2013) and (Bernauer and Markvart, 2014 - 2016) and activity data provided by the producer.

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., volume 3, chapter 3.7 this process does not give rise to process greenhouse gas emissions that are of significance.

This conclusion is supported by EU ETS data, where the only sources of emissions originate from neutralization process and from natural gas usage in the pigment thermal process. Those emissions are reported elsewhere. Emissions from neutralization process are reported in NIR chapter 4.2.4 (CRF 2.A.4). Emission from natural gas usage in thermal processes are reported in NIR chapter 3.2.11 (CRF 1.A.2c).

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 1072.18 kt CO_2 eq. in year 2022, emissions have increased by 28.7 % compared to 1990.

Sharp 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 and the production capacity returned to its normal value as before the accident.

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 – 2022, 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. 4-18.

Tab. 4-18 Emission trends from CO_2 and CH_4 emissions from production of ethylene in 1990 - 2022

	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	485.14	923.22	1.46
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
2018	451.55	859.29	1.35
2019	448.57	853.63	1.35
2020	375.13	713.87	1.13
2021	464.16	883.29	1.39
2022	464.28	883.52	1.39

CO_2 and CH_4 emissions from the production of ethylene dichloride and vinyl chloride monomer

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 - 2022 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 – 2022 between 0.001 and 0.003 kt CH_4, which is considered as insignificant value. In 2022, emissions of carbon dioxide equalled to 24.22 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).

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 and from the producer

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 and data from producer. 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 2022, emissions of carbon dioxide equalled to 39.76 kt and methane emissions equalled to 0.59 kt.

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 category.

Activity data for styren for years 2019-2022 were observed straight from producer as those years activity data (amount of product per year) were missing in the EU ETS forms, thus activity data for those years in previous submission were calculated from production capacity of the plant and number of working days per each year.

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 139.014 kt CO_2 in 2022.

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 10-16 kt of CO_2). Emissions from steam reforming of NG are somewhat more significant (about 130-220 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. 4-19 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 Table 1.A(d) under Natural Gas as well (please see chapter 3.2.3. for details).

Tab. 4-19 Emission trends for category 2.B.10 Other in 2008 - 2022

	Unit	2008	2009	2010	2011	2012	2013	2014
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
Non selective catalytic reduction	CO_2 emissions [kt]	14.42	13.39	14.42	13.49	14.52	13.43	14.77
	Unit	2015	2016	2017	2018	2019	2020	2021
Other non-energy use in chemical industry	CO_2 emissions [kt]	208.02	220.49	190.15	191.76	211.09	205.56	176.81
Non selective catalytic reduction	CO_2 emissions [kt]	15.04	13.09	16.37	15.64	15.10	15.96	14.64
	Unit	2022						
Other non-energy use in chemical industry	CO_2 emissions [kt]	129.03						
Non selective catalytic reduction	CO_2 emissions [kt]	9.98						

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 2022.

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 category.

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; 99.6% 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 major 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). Several small companies produce specialized steel products. Their emissions account for less than 1% of overall emissions.

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

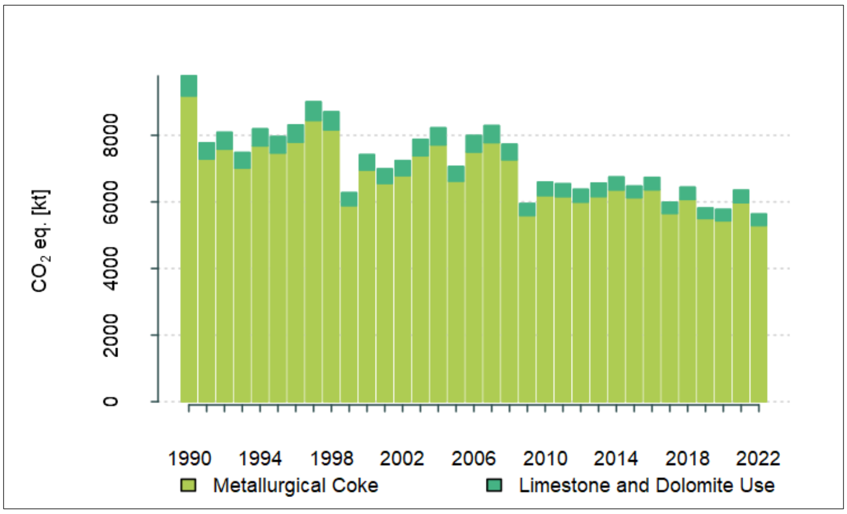

Fig. 4-6 Trend of CO_2 emissions in 2.C.1, 1990 – 2022 [kt CO2]

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 2014–2022 was also used as reducing agent in the blast furnace, as well as Coal Tar in years 2007 till 2013 and then in 2018-2022. 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. 4-20. In the carbon balance the amount of carbon in coke, bituminous coal (in 2014–2022) and coal tar (in 2007–2013, 2018-2022) 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. There is only one integrated steelworks in the EU which includes a pelletisation plant (in the Netherlands) and five standalone pelletisation plants in EU. Therefore all pellets are imported to the Czechia and the notation key is “NO”. 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. In the total production of the iron and steel in the Czech Republic, the electric furnaces covers less than 5%. This percentage is calculated using the total volume of iron and steel produced in the country and the volume produced by electric furnaces. The data are provided by CzSO. The rest of the iron and steel is made in blast furnaces and oxygen converters. In the EU ETS forms we can see that from the total amount of CO_2 emissions about 6% is recycled in the process via either following usage of the waste gas, the production of the gray cast iron or with the formation of slug that is subsequently used in the construction industry.

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 data for limestone and dolomite are since 2011 available in the EU ETS data. Since no reliable data for limestone and dolomite used before that year is available in the stastics, the overlap method (Guidelines: Chapter 5: Time Series Consistency, page 5.9) was applied for the time series 1990 – 2010 based on the data available for 2011–2022. The calculation is based on a strong correlation relationship between the desired values of dolomite and limestone mass and the mass of coke utilized in furnaces.

Related CO_2 emissions from 2.C.1 are reported in Table 1.A(d). For more information please see chapter 3.2.3.

The amounts of blast furnace coke consumed and corresponding emissions are given in Tab. 4-20.

Tab. 4-20 The activity data and CO2 emissions in 1990 – 2022

	Coke consumed in blast furnaces [kt]	Other Bituminous Coal [kt]	Coal Tar [kt]	Use of limestone and dolomite [kt]	CO_2 from 2.C.1 [kt]
1990	3 211	NO	NO	1 380.09	9 782.03
1991	2 559	NO	NO	1 099.86	7 768.24
1992	2 624	NO	NO	1 146.50	8 087.05
1993	2 426	NO	NO	1 059.99	7 479.57
1994	2 663	NO	NO	1 163.54	8 188.93
1995	2 587	NO	NO	1 130.33	7 961.45
1996	2 701	NO	NO	1 180.14	8 309.70
1997	2 846	NO	NO	1 279.01	9 003.33
1998	2 750	NO	NO	1 235.86	8 702.15
1999	1 941	NO	NO	892.46	6 273.65
2000	2 327	NO	NO	1 054.91	7 416.03
2001	2 175	NO	NO	994.55	6 987.88
2002	2 252	NO	NO	1 030.01	7 237.87
2003	2 459	NO	NO	1 123.52	7 875.94
2004	2 628	NO	NO	1 170.58	8 221.49
2005	2 260	NO	NO	1 003.79	7 059.99
2006	2 480	NO	NO	1 136.78	7 993.16
2007	2 570	NO	35	1 164.42	8 288.67
2008	2 366	NO	59	1 073.49	7 730.34
2009	1 801	NO	56	822.25	5 947.47
2010	2 082	NO	33	923.20	6 590.18
2011	2 086	NO	26	870.40	6 541.83
2012	2 007	NO	23	859.09	6 374.51
2013	2 057	NO	7	923.53	6 562.69
2014	1 886	276	NO	884.69	6 745.33
2015	1 780	300	NO	789.19	6 471.40
2016	1 842	319	NO	865.81	6 734.22
2017	1 605	278	NO	778.50	5 988.78
2018	1 735	285	30	831.74	6 439.45
2019	1 566	267	27	720.34	5 813.09
2020	1 568	275	3	781.12	5 772.30
2021	1 777	256	NO	845.43	6 347.97
2022	1 586	235	NO	799.29	5 634.33

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, 2012). 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 2022.

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 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

Data for Coal Tar were updated from the questionnaire for the year 2020 – 2021 which resulted in the slight correction of total emission of CO2 in CRF data.

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. The EU ETS data were studied and compared with current CzSO source. However the issue need further investigation to asure the correct transition to the Tier 3 method. The transition process 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. 4-21 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*)	

Composition of ferrovanadium		IPCC 2006 Gls. EF		EF CO_2 (1.5% of Si)	EF CH_4 (1.5% of Si)
Aluminum	1.5% max	FeSIi 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 since there is only one producer of lead in the Czech Republic. 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 2022 equalled to 9.37 kt.

The emissions are under the threshold of significance for the Czech Republic.

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 emissions are all from secondary production, there is one producer of zinc, which is operating since 1998. In 1990 – 1999 were in the Czech Republic one more operator existing, the data are also included in the emission estimates.

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, so 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 2021 equalled 0.88 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

No recalculation in this category was performed in this 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)

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. 4-7 shows the share of individual subcategories in 2.D. 74 % of 2.D CO_2 emissions are produced from Lubricant Use, followed by Urea used as catalysts (18 %) and the use of Paraffin Wax (8 %).

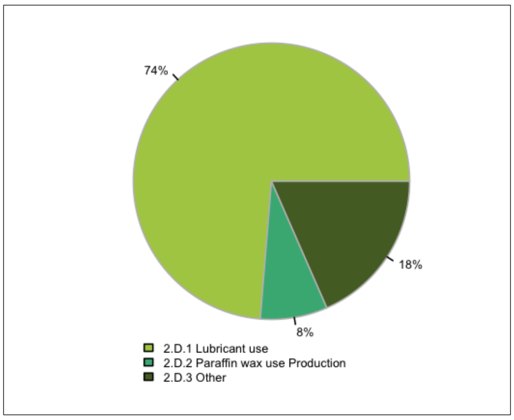

Fig. 4-7 The share of individual subcategories for CO_2 emissions in 2.D in 2022 [kt CO_2 eq.]

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 2022 were equal to 88.42 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 2022 from this category were equal to 9.43 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 emissions from this process should be included in Energy sector, 1.A.3. Since the emissions does not arise from fuel combustion, the emissions are covered under IPPU sector.

4.5.3.2 Methodological issues

Solvent Use

The IPCC 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 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. From 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

The emissions from urea as a catalyst are calculated in COPERT version 5.7. Tier 2 Approach is used. Diesel consumption for each vehicle category is used as activity data and emission is calculated using Eq. 3.2.2 in IPCC 2006 Gl. (IPCC 2006). The program takes into account country specific H:C and O:C ratio in the fuels and also different values of the urea consumption factor according to the vehicle categories (the activity level is from 2 % to 6 % of diesel consumption by the vehicle). Purity of AdBlue used in the vehicles is 32.5 % of urea in 67.5 % of deionized water which is reflected in the final amount of CO_2 emissions (Audiowell 2020). The emission is estimated for 2006-2022 times series. Since year 2006 the urea as a catalyst was used in buses and heavy duty vehicles and since 2014 in light duty vehicles and passengers cars.

CO_2 emissions in 2022 from this category were equal to 22.11 kt CO_2.

4.5.3.3 Uncertainties and time consistency

Solvent Use

Uncertainty of NMVOC emissions is considered to be quite large, based on IPCC 2006 Gl. (IPCC 2006) it is considered as 50%. The uncertainty of activity data is considered based on expert judgement as 25%.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2022.

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.

Road Paving With Asphalt

No specific QA/QC or verification procedures are 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

Whole time series 2006-2022 were recalculated. Previously the default approach, Tier 1, was used to calculate emission from urea as a catalyst. The activity of urea (urea consumption factor) was 2 % for all vehicle categories. Activity data came from COPERT as amount of consumed fuel and emission was calculated using simple equation 3.2.2 in IPCC 2006 Gl. (IPCC 2006).

Newly Tier 2 Approach is used. The emission of urea as a catalyst is newly calculated in COPERT version 5.7. The program takes into account country specific H:C and O:C ratio in the fuels and also different values of the urea consumption factor according to the vehicle categories. Except the new methodology for estimation of emission, there was also update in activity data (mainly for the bus transportation) and new version of Copert program. For detailed explanation of those two changes see chapter 1.A.3.b – Road transport.

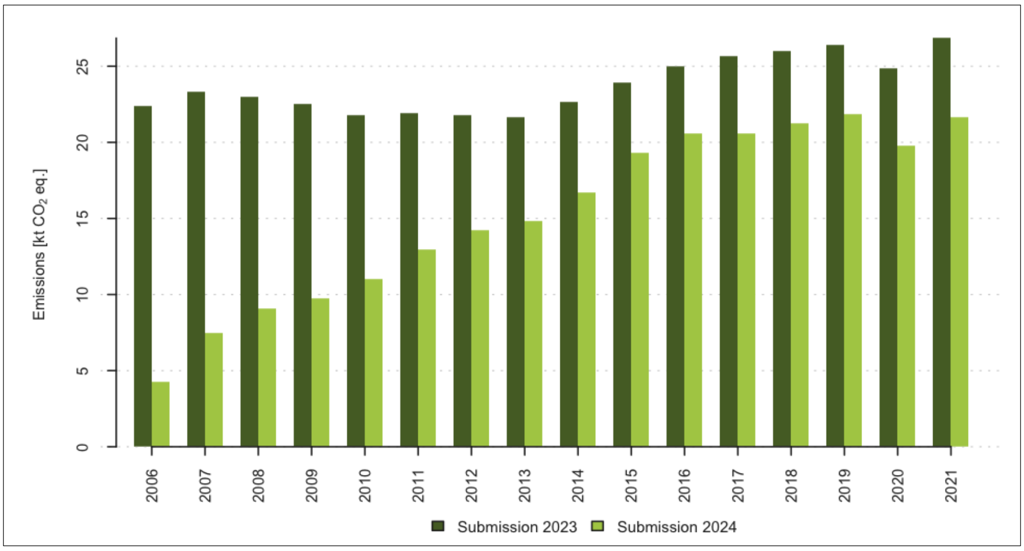

Fig. 4-8 Impact of the recalculations of urea used as a catalyst.

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

No improvements are planned in this category.

4.6 Electronics Industry (CRF 2.E)

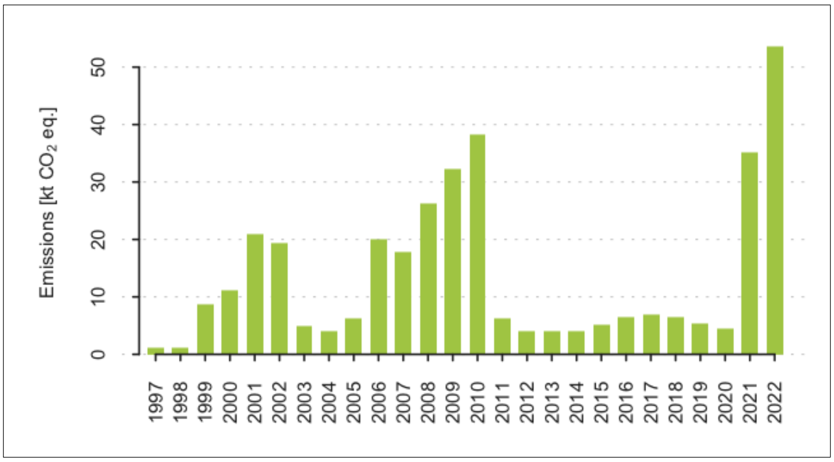

Fig. 4-9 Trend of emissions from 2.E Electronics Industry [kt CO_2 eq.]

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. According to information obtained from manufactures, SF_6 or other fluorine compounds are not used in category 2.E.3 Photovoltaics.

The emission trend for the category 2.E Electronics Industry, which also represent the emission trend of subcategory 2.E.1 is depicted in Fig. 4-9 from year 1997, when the use of CF_4 began, to 2022. Emissions of F-gases equalled to 53.55 kt CO_2 eq. in 2022. Total emissions of F-gases from 2.E increased in 2022 by 18.47 kt CO_2 eq. compared to previous year. Tab. 4-22 lists the exact amount of CO_2 eq. emissions from category 2.E.

Tab. 4-22 Emissions from category 2.E. Electronics Industry in time period 1997 - 2022

		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Emissions	**[kt CO_2 eq.]**	1.02	1.02	8.69	11.16	20.87	19.31	4.79	3.99	6.17	19.99
		2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Emissions	**[kt CO_2 eq.]**	17.81	26.30	32.26	38.28	6.27	3.98	3.88	4.04	5.20	6.32
		2017	**2018**	**2019**	**2020**	**2021**	**2022**				
Emissions	**[kt CO_2 eq.]**	6.95	6.47	5.35	4.51	35.08	53.55				

Tab. 4-23 gives an overview of the emission factors and methodology used for computations of emissions in category 2.E. Electronics Industry in 2022.

Tab. 4-23 Type of CO_2 emissions factors used for computations of 2022 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.

In year 2022 gases C_2F_6, CF_4, SF_6, CHF_3 (HFC-23) and NF_3 were used for semiconductor manufacturing, while in year 2020 only gases SF_6 and NF_3 were used. The change in reported gases is due to the change of company product portfolio. 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

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/year 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. 4-24. 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. 4-24 Emissions factors used for computations of 2022 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 2022.

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 Customs 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

In this year, no recalculations were performed in this category. As the compounds CHF_3, CF_4, C_2F_6 occured newly, there is no need to recalculate the whole time series.

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 detail 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. The base year of using F-gases in the Czech Republic is 1995. The determination of the base year was based on the information from possible emission sources and on fact, that the same base year is determined in neighboring countries with similar composition.

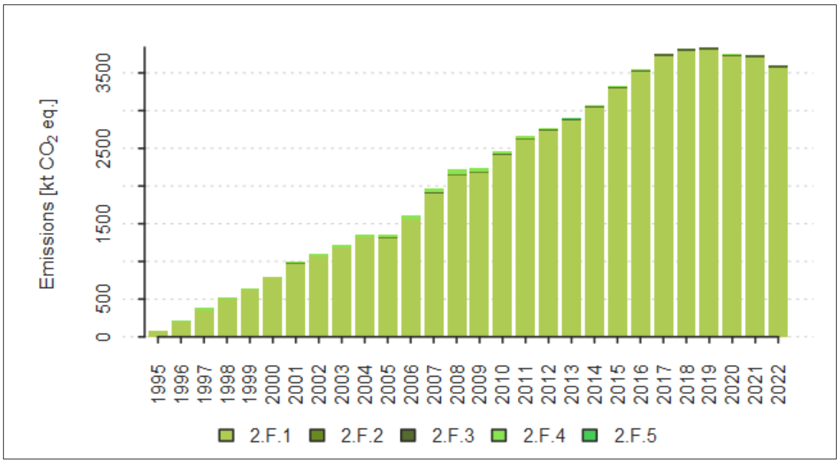

Fig. 4-10 Trend of emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances and share of specific subcategories [kt CO_2 eq.]

The emission trend for category 2.F is depicted in Fig. 4-10. The major share of 99% in the range of actual emissions for year 2022 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 86.90 kt CO_2 eq. in 1995 to 3609.06 kt CO_2 eq. in 2022. 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. 4-25 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. 4-25 Actual emissions of HFCs and PFCs in 1995 - 2022 [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	86.90	86.89	0.01
1996	216.17	215.49	0.68
1997	389.62	389.02	0.60

1998	530.01	529.49	0.52
1999	636.76	635.87	0.89
2000	802.15	800.04	2.11
2001	1001.69	998.32	3.38
2002	1102.27	1098.75	3.52
2003	1218.89	1212.19	6.69
2004	1351.78	1343.12	8.65
2005	1357.33	1347.96	9.37
2006	1610.64	1600.80	9.84
2007	1968.06	1957.64	10.42
2008	2228.87	2217.19	11.68
2009	2244.56	2233.98	10.58
2010	2458.45	2450.62	7.82
2011	2665.40	2659.54	5.86
2012	2769.14	2764.27	4.88
2013	2897.49	2893.55	3.94
2014	3076.25	3073.55	2.70
2015	3326.21	3324.47	1.74
2016	3544.33	3542.93	1.40
2017	3751.21	3749.82	1.39
2018	3816.80	3815.27	1.53
2019	3839.59	3838.46	1.13
2020	3747.82	3747.23	0.59
2021	3737.85	3737.54	0.31
2022	3609.06	3608.90	0.16

Tab. 4-26 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 2022.

Tab. 4-26 Type of emissions factors used for computations of 2022 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 database of Cross-border movements of goods (Customs data).

Collecting of data and preparation of input data for emission estimates is described in more detail in Annex A 3.7.

In 2022 no significant changes occurred in the collection and treatment policies of discarded refrigeration appliances. On the other hand, by 1st January 2020, Regulation EU/2014/517 restricts the use of fluorinated refrigerants with a GWP greater than or equal to 2 500 with a charge size grater than or equal to 40 t CO_2 eq. The regulation is reflected in the first fill emissions of relevant F-gases trought all 2.F category.

Only two companies in the Czech Republic are dealing with regeneration of HFC coolants. 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.

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 and F-gas register, 15.91 t of F-gases were disposed in 2022 in the Czech Republic.

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 33.5% in the range of actual emissions for year 2022 belongs to the subcategory 2.F.1.e, share 32.7% belongs to the subcategory 2.F.1.a, share 21% belongs to the subcategory 2.F.1.f, share 9% belongs to the 2.F.1.c, share 3% belongs to the 2.F.1.d and share 0.02% belongs to the 2.F.1.b. Trend of emissions from 2.F.1 is depicted on Fig. 4-11. Category 2.F.1 was identified as a key category in this submission.

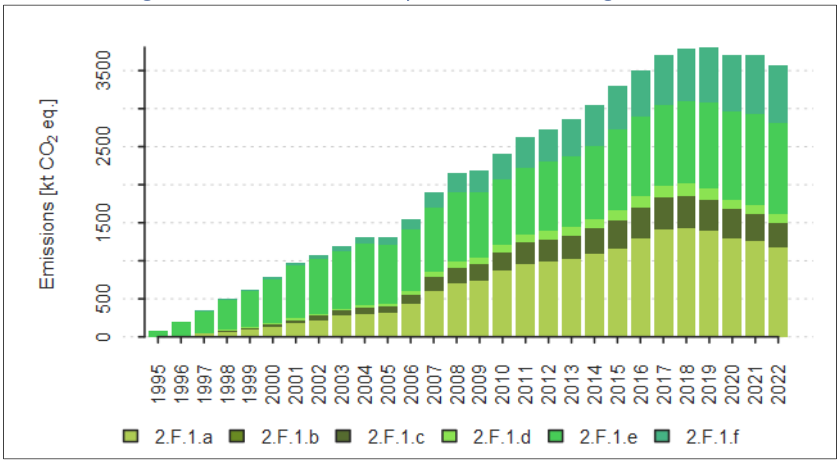

Fig. 4-11 Trend of emissions from 2.F.1 Refrigeration and Air conditioning and share of specific subcategories [kt CO2 eq.]

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-407C and R-507A are used in smaller amounts. 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. R-507A is a mixture of HFC-125 and HFC-143a in a ratio of 50:50. A consumption of blend R-404A has been decreasing since 2018. The blend contains HFC-125, HFC-143a and HFC-134a gases in a ratio of 44:52:4. The decreasing consumption is consequence of fact, that manufacturers are preparing for limitation of this blend according to EU legislative. Blends containing HFO-1234yf and HFO-1234ze have been used in the Czech Republic since 2016. Emissions from these gases are reported separately in category 2.H.3 Other (see chapter 4.9.2 for more information).

An overview of reported gases under specific subcategory is presented in Tab. 4-27. PFCs have not been used in the Czech Republic for many years, but emissions from previous use of PFCs still occur.

Tab. 4-27 An overview of the F-gases reported under subcategory 2.F.1

Source category	Reported F-gases
2.F.1.a Commercial Refrigeration	HFC-125, HFC-143a, HFC-23, HFC-134a, HFC-227ea, HFC-32, HFC-152a, C_6F_{14}, C_3F_8, C_2F_6
2.F.1.b Domestic Refrigeration	HFC-134a
2.F.1.c Industrial Refrigeration	HFC-32, HFC-125, HFC-134a, HFC-143a
2.F.1.d Transport Refrigeration	HFC-32, HFC-125, HFC-134a, HFC-143a
2.F.1.e Mobile Air Conditioning	HFC-134a
2.F.1.f Stationary Air Conditioning	HFC-32, HFC-125, HFC-134a, HFC-143a

4.7.1.2 Methodological issues

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.

INPUT

Input of the model consists of three parts, which are manually updated - activity data, emission factors and legislative measures. Data about direct import/export and destruction are obtained from three different sources. Moreover, AD from these sources are then verified to avoid double counting via possible duplicities across the data sources. For more information about data sources and the sorting system please Annexes, chapter A.3.7.

The data sources cover a trade between the Czech Republic and EU countries and also non-EU countries, the worldwide market is covered. In the AD sources, the importers/exporters/users of F-gases also voluntarily report amounts of consumed F-gases below the threshold. For example, in F-gas register 7 importers out of 22 reported information about imported F-gases although amount of reported F-gases was under the threshold in 2022.

Addition to the stock of specific F-gas, 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. 4-28.

Tab. 4-28 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	0.35	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. 4-29. 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. 4-29 Distribution of HFCs and PFCs use by application area used for emission calculations in 2022

Reported F-gases	2.F.1.a Commercial Refrigeration	2.F.1.b Domestic Refrigeration	2.F.1.c Industrial Refrigeration	2.F.1.d Transport Refrigeration	2.F.1.f Stationary Air Conditioning
HFC-125	40%	x	15%	5%	40%
HFC-143a	60%	x	15%	5%	20%
HFC-23	100%	x	x	x	x
HFC-134a	60%	0%	15%	5%	20%
HFC-227ea	100%	x	x	x	x
HFC-32	40%	x	15%	5%	40%

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. 4-30 depicts emissions of F-gases for the individual sub-applications in 2022 and comparison with levels of emissions in 2021 and in the base year.

Tab. 4-30 Emissions of HFCs and PFCs from subcategories under 2.F.1 in 2022 – comparison to levels of emissions in 2021 and 1995

Source sub-application	Emissions of HFCs and PFCs 2022 [kt CO_2 eq.]	Difference 2022 and 2021 [%]	Difference 2022 and 1995 [%]
2.F.1.a Commercial Refrigeration	1 168.61	-7.38%	99.98%
2.F.1.b Domestic Refrigeration	0.87	-34.54%	99.98%
2.F.1.c Industrial Refrigeration	334.66	-6.26%	99.99%
2.F.1.d Transport Refrigeration	107.70	-8.49%	99.98%
2.F.1.f Stationary Air Conditioning	764.63	-0.82%	100.00%

In some years notation key NE is used under 2.F.1 for the amount remaining in products at decommissioning and the emissions from the disposal and recovery of HFC-134a and HFC-32 gases. Notation key NE is used in accordance with decision 24/CP.19. Emissions are considered to be insignificant. The level of emissions is below 0.05% of the national total GHG emissions and the CRF reporter does not allow report values 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. 4-31.

Tab. 4-31 Subcategories in which is used notation key NE for gases HFC-134a and HFC-32 with related year

Source category	Reported F-gas	Year
2.F.1.a Commercial Refrigeration	HFC-134a	1996
	HFC-32	1998, 1999
2.F.1.b Domestic Refrigeration	HFC-134a	1996
2.F.1.c Industrial Refrigeration	HFC-32	1998, 1999
	HFC-134a	1996
2.F.1.d Transport Refrigeration	HFC-32	1998
	HFC-134a	1996
2.F.1.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. 4-32.

Tab. 4-32 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

Since 2016, car producers started to use HFO-1234yf as a substitute for HFC-134a in accordance with the Directive 2006/40/EC and thus also emissions of HFO-1234yf were calculated. Since CRF Reporter doesn't allow creating node for alternative refrigerant under 2.F.1.e category, emissions of HFO-1234yf are reported under category 2.H.3 Other and then emissions are accounted in 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 Czech Ltd. and Toyota Motor Manufacturing Ltd.), 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 64% 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 directly from each producer and checked with data provided by the Automotive Industry Association. For year 2022, the amount of cars produced in the CR are listed in the Tab. 4-35 bellow.

Tab. 4-33 Number of vehicles produced in the Czech Republic in the year 2022

Car producer	Number of vehicles produced in 2022
ŠKODA AUTO Inc.	693 032
Hyundai Motor Czech Ltd.	322 500
Toyota Motor Manufacturing Ltd.	202 255

- The initial charge of HFC-134a filled into new equipment is estimated for each car type of each producer. Therefore the initial charge is not constant through the time series, neither for all producers. The initial charge varies between 390 g and 865 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-1234yf 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 of each type in the 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 new cars produced in the Czech Republic is calculated as the sum of the amounts used for each car type 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

Detailed data about vehicles stock in the Czech Republic are obtained from COPERT (software and methodology developed by EMISIA S.A.) for 1995 - 2022. Data from COPERT were provided by the Transport Research Centre (CDV). Data contain information about the numbers of passenger cars, light duty vehicles, heavy duty trucks and buses divided by the fuel type, segment and EURO standard as it 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 2018 – 2020 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 2017 – 2019

Type	Fuel	Segment	Euro standard
			Euro 6 2018 – 2020 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 table above is too detailed for the emission estimates of HFC-134a and thus as important input for emission estimates is only taken the type of vehicle (passenger car, light duty vehicle, heavy duty truck and bus) in adequate euro standard (in the case of buses and heavy duty trucks euro standard it's not taken into account).

Operational emissions for cars and light duty vehicles are calculated as follows:

- Number of cars or light duty vehicles in adequate euro standard is obtained from COPERT (e.g. 1 208 979 passenger cars (Euro standard 4) were registered in the Czech Republic in 2022).
- Percentage shares of cars or light duty vehicles equipment with AC in each Euro standard group are based on data from COPERT and expert judgement as it is in following table. Since 2017, cars placed on EU market cannot contain refrigerant HFC-134a. Therefore it is considered that new models are equipped with HFO-1234yf.

Tab. 4-35 AC shares and type of refrigerant in Euro standard

Type	AC Share	Refrigerant
Conventional	10%	HFC-134a
ECE 15/00-01	10%	HFC-134a
ECE 15/02	10%	HFC-134a
ECE 15/03	10%	HFC-134a
ECE 15/04	10%	HFC-134a
Euro 1	20%	HFC-134a
Euro 2	60%	HFC-134a
Euro 3	85%	HFC-134a
Euro 4	95%	HFC-134a
Euro 5	95%	HFC-134a
Euro 6 2017 – 2019	95%	HFO-1234yf
Euro 6 2018 – 2020	95%	HFO-1234yf
Euro 6 up to 2016	95%	HFC-134a
Euro 6 up to 2017	95%	HFO-1234yf
PRE ECE	10%	HFC-134a

- The number of cars equipped with air conditioning is calculated as total number of cars or light duty vehicles in euro standard multiplied by appropriate percentage share as in Tab. 4-35. Newer types containing HFO-1234yf are excluded from calculation.
- 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 2009, 0.6 kg per unit. The lower charges are a result of transformation of the car 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 (HFC-134a)* $_t$ ** 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 - 2022 are obtained from COPERT.
- The percentage share of buses equipment with air conditioning is linearly interpolated from 10 % in 1995 to 74% in 2022; the percentage share of trucks equipped with air conditioning is linearly interpolated from 50% in 1995 to 100% in 2022. 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 system end of life are calculated by the following steps:

- The number of disposed 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 to 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 in comparing with the approach used for the estimation of operational emissions mainly due to the fact that data about disposed vehicles are not sorted to 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 2022 and comparison with emission levels in 2021 and in the base year for HFC-134a.

Tab. 4-36 Emissions of HFCs and PFCs from 2.F.1.e in 2022 – comparison to emission levels in 2021 and 1995

Source sub-application	Emissions of HFCs and PFCs 2022 [kt CO_2 eq.]	Difference 2022 and 2021 [%]	Difference 2022 and 1995 [%]
2.F.1.e Mobile air conditioning	1196.28	-0.70%	92.76%

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 2.28 kt CO_2 eq. in 2022. Use of HFC for foam blowing was not reported in 2022.

Increased amount of emissions from category 2.F.2 in 2016, 2017 and 2018 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 and 2018.

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.3 amounted to 31.41 kt CO_2 eq. in 2022.

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) (CRF 2.F.4)

This category include emission estimates from metered dose inhalers used in medical applications (2.F.4.a), and from general-purpose aerosols (2.F.4.b). Total emissions from 2.F.4 amounted to 2.63 kt CO_2 eq. in 2022.

Metered dose inhalers (MDIs) containing F-gases first appeared on the Czech market in 1995. In these MDIs, HFC-134a was used as a propellant. One year later, MDIs with HFC-227ea started to be sold as well. The number of sold MDIs containing HFC-134a has been increasing with minor fluctuations since 1995. The number of sold MDIs containing HFC-227ea reached its peak in 1999 and since then it has been gradually decreasing. Currently, aproximatelly 90% of the sold MDIs contain HFC-134a.

HFC-134a was used in general-purpose aerosols from 1996 to 2015 and thus emissions from 2.F.4.b are not occurring in 2022. F-gases were replaced by cheaper propellants, specifically dimethyl ether and other hydrocarbons (butane, isobutane and propane).

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).

Information about MDIs supply between 1995 - 2022 is obtained from the State Institute for Drug Control. Amount of propellant is estimated separately for each product. The share of propellant in products varies between 88% and 99%.

Data about consumption of HFC-134a in general-purpose aerosols were obtained from ISPOP, the F-gas register, Database of Cross-border movements of goods (for more details see chapter 4.7.1), and questionnaire survey provided by sectoral expert.

4.7.5 Solvents (Non-Aerosol) (CRF 2.F.5)

Emissions from the use of HFC-245fa are not occurring in 2022 in category 2.F.5; emissions of other gases such as HFC-134a, HFC-152a are not occurring from 2014 and 2007 specifically. Emissions from 2.F.5 are not occurring in 2022.

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 Database of Cross-border movements of goods. 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

Recalculation in subcategory 2.F.1.e

Subcategory 2.F.1.e Mobile Air Conditioning was recalculated due to new source providing more accurate activity data for calculating HFC-134a emissions from the first fill. For previous submissions information about production of certain car types was obtained from Škoda Auto and TMM. For this submission, information from Hyundai was obtained as well**.** The initial charge of HFC-134a filled into new equipment is now estimated for each car type of each producer and not only for each car producer.

Following changes in data from COPERT, activity data for calculating HFC-134a emissions from stocks were updated as well. Furthermore, the calculation of the number of vehicles containing HFC-134a was modified. Newer car types containing HFO-1234yf were excluded from the calculation (see Tab. 4-35)**.** The activity data for operation emission estimates are obtained from the COPERT since 2017 submission.

Also there were changes in emissions from disposal for years 2018-2020 due to changes in activity data for category 2.F.1.e Mobile Air Conditioning.

Recalculation in subcategory 2.F.1.b

Correction of product life implied emission factor was conducted due to review process findings in subsector 2.F1.b Domestic refrigeration.

Change from AR 4 submission in year 2022 to AR 5 in year 2023 is also included in the recalculations depicted bellow.

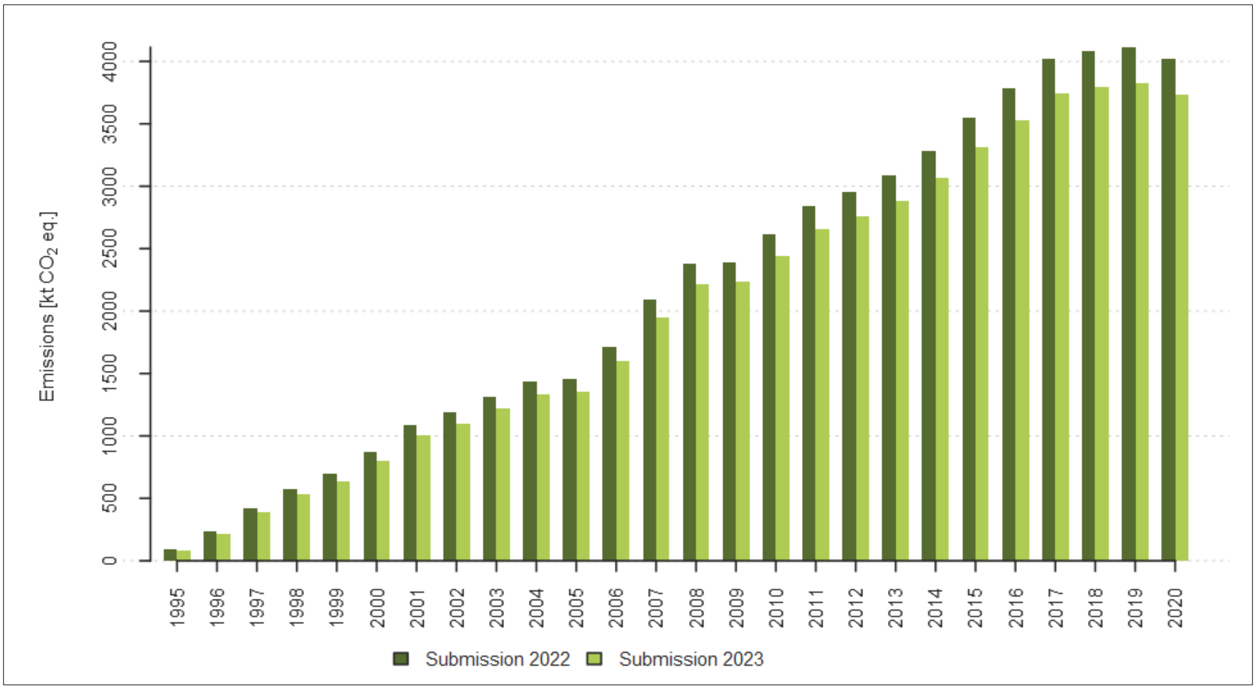

Fig. 4-12 Impact of the recalculations in category 2.F

As can be seen from Fig. 4-12 and in Tab. 4-37, the impact of the all conducted recalculations on the total emissions for category 2.F is relatively low in average level between 6.5 to 9.1 % .

Tab. 4-37 Impact of the recalculations in category 2.F

F-gas emissions	Unit	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Submission 2022	[kt CO_2 eq.]	95.56	237.53	425.27	577.51	692.51	869.60	1 084.26	1 190.96	1 313.50	1 439.79
Submission 2023	[kt CO_2 eq.]	86.88	216.11	389.52	529.86	636.55	801.88	1 001.32	1 101.80	1 218.17	1 336.13
Difference	[%]	-9.09%	-9.02%	-8.41%	-8.25%	-8.08%	-7.79%	-7.65%	-7.49%	-7.26%	-7.20%
F-gas emissions	**Unit**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Submission 2022	[kt CO_2 eq.]	1 459.39	1 715.23	2 096.26	2 379.56	2 393.48	2 616.21	2 838.29	2 949.34	3 088.06	3 278.98
Submission 2023	[kt CO_2 eq.]	1 356.30	1 596.13	1 953.70	2 214.33	2 231.72	2 445.92	2 653.22	2 756.66	2 884.54	3 062.76
Difference	[%]	-7.06%	-6.94%	-6.80%	-6.94%	-6.76%	-6.51%	-6.52%	-6.53%	-6.59%	-6.59%
F-gas emissions	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**				
Submission 2022	[kt CO_2 eq.]	3 546.62	3 785.34	4 018.72	4 078.36	4 113.23	4 020.28				
Submission 2023	[kt CO_2 eq.]	3 311.42	3 529.74	3 743.40	3 794.83	3 824.48	3 734.87				
Difference	[%]	-6.63%	-6.75%	-6.85%	-6.95%	-7.02%	-7.10%				

No new recalculation has been made in submission 2024.

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)

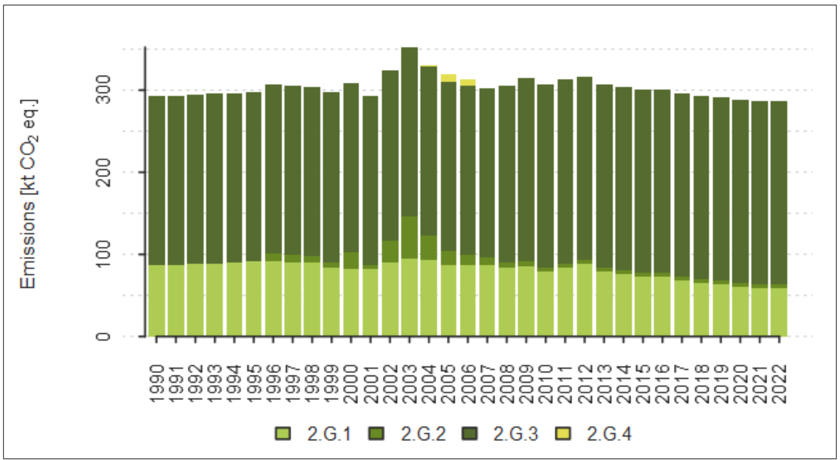

Fig. 4-13 Trend of emissions from 2.G Other Product Manufacture and Use and share of specific subcategories [kt CO_2 eq.]

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.

The emission trend for category 2.G is depicted in Fig. 4-13. The major share of 78% of GHG emissions for year 2022 belongs to category 2.G.3, the share 21% belongs to category 2.G.1 and the share 2% belongs to category 2.G.2. Total GHG emissions from 2.G were higher by 0.50 kt CO_2 eq. in 2022 compared to the previous year.

Tab. 4-38 lists the exact amount of CO_2 emissions from the individual subcategories in 2.G. Other Product Manufacture and Use for the 1990 to 2022 period.

Tab. 4-38 CO_2 eq. emissions in individual subcategories in 2.G Other Product Manufacture and Use category in 1990 - 2022

	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	86.68	0.14	183.38	NO
1991	86.52	0.14	183.38	NO
1992	87.84	0.19	183.38	NO
1993	89.06	0.16	183.38	NO
1994	90.17	0.19	183.38	NO
1995	91.19	0.21	183.38	NO
1996	91.76	9.56	183.38	NO
1997	90.83	8.23	183.38	NO
1998	89.37	8.52	183.38	NO
1999	84.27	6.35	183.38	NO
2000	82.55	20.34	183.38	NO
2001	82.94	3.82	183.38	NO
2002	89.39	27.95	183.38	NO
2003	94.40	51.61	183.38	NO
2004	93.14	29.00	183.38	1.95

	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	87.05	16.89	183.38	10.18
2006	87.18	12.13	183.38	8.23
2007	86.54	9.66	183.38	NO
2008	83.39	7.07	198.75	NO
2009	85.53	5.56	198.75	NO
2010	79.20	4.48	198.75	NO
2011	84.55	4.49	198.75	NO
2012	88.96	4.46	198.75	NO
2013	78.84	4.42	198.75	NO
2014	76.56	4.39	198.75	NO
2015	73.27	4.59	198.75	NO
2016	72.57	4.54	198.75	NO
2017	68.52	4.53	198.75	NO
2018	65.28	4.42	198.75	NO
2019	63.07	4.46	198.75	NO
2020	60.60	4.43	198.75	NO
2021	58.43	4.40	198.75	NO
2022	58.91	4.41	198.75	NO

Tab. 4-39 gives an overview of the emission factors and methodology used for computations of emissions in category 2.G for year 2022.

Tab. 4-39 Type of emissions factors used for computations of 2022 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 Database of Cross-border movements of goods (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. In the year 2021, there is no new SF_6 filled into the new equipment thus zero emissions from manufacturing are occurring for the year 2022.

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 2022.

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 Database of Cross-border movements of goods.

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 category.

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. Since the institute hadn't provided 2019 data in time of 2021 submission preparation, same number of accelerators as in 2018 was used. For the current submission, the data was in time and the value for 2019 was updated from 51 to 54 accelerators. In 2022, there were 56 accelerators in use.

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 2022.

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 category.

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 (80% for anaesthesia) was based only on a rough estimate.

Data from Customs Office were obtained as an attempt to improve emission estimates from this category. Customs data contain detailed information about imported/exported amount of oxides of nitrogen to/from the Czech Republic by a single importer/exporter for a year 2016 and summary data about import/export for 1993 - 2016. Customs code is related to oxides of nitrogen not only N_2O. According to the data, oxides of nitrogen were imported to the Czech Republic by 26 importers (mainly by companies trading with industrial gases not by end consumer) and exported by 15 companies in 2016. Export of oxides of nitrogen is multiple times higher than import every year. Total stock of nitrogen oxides in 2016 for 1993 - 2016 time series is calculated to -20 kt of oxides of nitrogen. It was concluded that customs data are not suitable for emission estimates of N_2O in category 2.G.3. Firstly, customs data are related to import/export of oxides of nitrogen not only N_2O. Secondly, oxides of nitrogen are imported by companies trading with industrial gases. These companies sell their products to the end users and thus information about possible use is missing. And at the end, the amount of exported oxides of nitrogen is every year higher than the amount of imported oxides of nitrogen and thus total stock is calculated in 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 2022.

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 category.

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 category.

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)

This category describes GHG emissions from the subcategories 2.H.1 Pulp and paper production and 2.H.3 Other. Total GHG emissions from 2.H were 0.71 kt CO_2 eq. in 2022.

4.9.1 Pulp and paper (CRF 2.H.1)

In this category, CO_2 emissions from Paper and Pulp industry which do not fall into specific categories (e.g. use of soda ash and urea under category 2.A.4.d) are reported here. The activity data are taken from the EU ETS. One of the paper mills produces its own $CaCO_3$ with a high degree of purity. During this process, CO_2 is reabsorbed. This process was classified as category 2.A.4.d before but it was taken off of the inventory after revision (for more information, see chapter 4.2.4.2).

Emissions reported in this category come from application of liquid CO_2. Liquid CO_2 is used for pH adjustment in the delignification process. There is only one company which uses the technology in the Czech Republic. After the process, used liquid CO_2 is sent to the cleaning zone and then to the combustion boiler afterward. The data comes from the EU ETS for the period 2010–2022. Values for years 2006-2010 were obtained directly from the company. Material flow data provided by the company was used to correlate the figures from 1996, when the technology was implemented, to 2006. Since only one manufacturer reports CO_2 emissions from kraft processes, IEF is reported as C (confidential). CO_2 emissions from 2.H.1 amounted to 0.53 kt in 2022.

4.9.2 Other (CRF 2.H.3)

In category 2.H.3 Other are allocated emissions of HFO-1234yf and HFO-1234ze, which are used as refrigerants, mainly in air conditioning systems. Since CRF Reporter does not allow creating node for alternative refrigerants under 2.F.1.e subcategory, emissions of HFO-1234yf and HFO-1234ze are reported under category 2.H.3 Other. GWP of both gases is considered to be one (IPCC 2014).

HFO-1234yf and HFO-1234ze were implemented into calculation model Phoenix which calculates emissions from 2.F.1.a, 2.F.1.b, 2.F.1.c, 2.F.1.d and 2.F.1.f. For more details, please see chapter 4.7.1. Emissions of HFO-1234yf and HFO-1234ze estimated in Phoenix were 0.01 kt CO_2 eq in 2022.

The main field, where HFO-1234yf is used, are mobile air conditioning systems. A calculation process of these emissions estimates is the same as for HFC-134a in category 2.F.1.e. Estimated emissions of HFO-1234yf from mobile air conditioning were 0.163 kt CO_2 eq in 2022.

4.10 Acknowledgement

The authors would like to thank the Czech Ministry of Environment for providing the EU ETS data and data from the F-gas register and also to CzSO for providing data about cross-border movements of goods and other statistics used for emission estimates.

The authors would like namely thank to Mr. Beck and Mr. Bernauer for their contribution during the inventory preparation as consultants and for final QC/QA checks and to Mr. Řeháček and Ms. Ondrušová for their huge contribution to development of F-gases emission estimates in previous years.

The authors would also like to thank representatives of companies that willingly respond to our surveys and therefore help to bring to life these emission estimates.

5 Agriculture (CRF Sector 3)

5.1 Overview of sector

Agricultural land covers 45% and arable land 31% of the area of the country (CzSO 2023). Czech agriculture is affected by the communist history of the country, when small farmers were almost eliminated by the collectivization process after World War II. Unfortunately, the period with cooperative ownership without any small family farms lasted far too long and only very few original farmers started managing their farms again in the 1990s. At present, 74% of farms are smaller than 50 ha and occupy only 7.5% of agricultural land.

The Czech Republic is situated in the cool climate zone (the long term annual average temperature is 8.3 °C for the period 1991-2020, www.chmi.cz). The level of livestock breeding, manure management and agricultural land management is comparable to that in the developed Western European countries.

The year 2022 was the temperature warmer year in the Czech Republic, with an average annual air temperature of 9.2 °C, which was 0.9 °C above the normal 1991-2020. The average annual precipitation was 634 mm, which was 93 % of long term normal (684 mm).

The total harvested area of cereals in the Czech Republic is 3.0% higher than in the previous year, with wheat, barley, and maize accounting for the largest share. In the long term, the total area of cereals has not changed much. The harvested area of cereals in the Czech Republic was higher than the average of the last five years, by 8.9%. The harvested area of oilseeds in the Czech Republic in 2022/23 repeatedly decreased by 1.2% and accounts for 17.6% of the total arable area. Traditionally, oilseed rape has had the highest share of the harvested area of oilseeds in the Czech Republic. The harvested area of sugar beet and potatoes decreased year-on-year. Total fruit production in 2022 was 7.5% higher compared to the fruit harvest in 2021. Cattle numbers in 2022 increased year-on-year, mainly for BTPM cows. Pig, hen, and fattening chicken numbers were down year-on-year. In 2022, the pig sector was affected by high input costs and environmental constraints. In addition, other factors played a role - notably the African Swine Fever (ASF) outbreak in Central Europe. There was an increase in mineral fertiliser consumption of 2.51% compared to 2021. This was an increase to 106.8 kg DM/ha in 2022. Total net nutrient input from manure and organic fertilisers decreased by 1.88% to 67.9 kg/ha. Total calcium fertiliser consumption increased by 5.97% to 337 thousand t in 2022 compared to 2021.

Under the Czech national conditions, agricultural greenhouse gas emissions consist mainly of emissions from enteric fermentation (CH_4 emissions), manure management (CH_4 and N_2O emissions), agricultural soils (N_2O emissions), urea application and liming (CO_2 emissions). 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 originate primarily from enteric fermentation (digestive processes), which is mostly manifested for ungulate animals (mostly cattle in the Czech Republic). Another 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 manure and soils. The anthropogenic contribution that is determined in the national inventory of greenhouse gases is caused by nitrogenous substances derived from inorganic fertilizers with nitrogen content, manure from animal breeding, sewage sludge application to soils, nitrogen contained in parts of agricultural crops that are returned to soils and nitrogen mineralized in soils. In addition, emissions are also being produced from storage facilities and management of manure as a fertilizer and indirect emissions are being derived from atmospheric deposition and nitrogenous substances leached into water courses and reservoirs.

Carbon dioxide emissions are derived from non-organic fertilization use on agricultural soils based on industrially produced urea and limestone and dolomite applied to soils.

A comprehensive revision of the estimation procedures in categories 3.D was prepared for Submission 2024. In connection with the gradual transition of the methodology to a higher level of estimation (Tier 2), emission factors and volatilized and leaching nitrogen fractions included in the estimation of emissions were updated. Changes are presented in relevant Chapter. Emission factors and fractions were updated according to IPCC 2019. These changes allow consideration of a wider range of manure storage technologies when relevant data is available. The methodology also allows considering the specific climatic characteristics of the regions in the Czech Republic in the estimates once the new activity data on regional nitrogen consumption become available.

In addition, some corrections were made due to technical errors identified during the QA/QC process and the review process. Overall, the implemented improvements and updates of the calculation resulted in an average 4% increase in emissions from the sector (Fig. 5-1) in comparison with previous Submission 2023. A detailed description of each category follows below.

All the above-mentioned changes and improvements were consulted with a team of experts (Dr. Klír, Dr. Wollnerová) from the Crop Research Institute (CRI), which has been involved in the NIS team of the Czech Republic since 2019. The CRI experts are responsible for the implementation of Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources and for EUROSTAT / OECD statistics of nutrient budgets from the agricultural sector. Since 2022, the cooperating CRI experts are members of the Discussion Group on Nutrients Statistics in the framework of Eurostat.

We have also collaborated with Dr. Martin Dědina from the Research Institute of Agricultural Engineering (RIAE), who prepares the reports on pollutant emissions from agriculture for CHMI. Thanks to this cooperation, a unified database of input data in the agricultural sector was prepared for nitrogen emission estimates and their budget (Beranova et al. 2022b).

5.1.1 Key categories

There are six categories of sources evaluated by the analyses described in IPCC 2006 Guidelines as the key categories in the agricultural sector. The sources overview, including their contribution to the aggregate emissions, is given in Tab. 5-1.

[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 section 3.B Manure management EMEP/EEA in Emission Inventory Guidebook (EEA 2023). Ammonia emissions from synthetic fertilizers application are estimated according to the the Tier 2 approach described in the section 3.D Crop production and agricultural soils EMEP/EEA in Emission Inventory Guidebook (EEA 2023).

Tab. 5-1 Overview of significant source categories in agriculture (Submission 2024), 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	Yes	Yes	Yes	Yes	3.06	3.14
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	LA, TA	LA, TA	Yes	Yes	Yes	Yes	2.36	2.43
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	LA	LA	Yes	Yes	Yes	Yes	0.66	0.68
3.B Manure Management	N_2O		LA, TA			Yes	Yes	0.32	0.33
3.B Manure Management	CH_4	TA	TA	Yes	Yes	Yes	Yes	0.31	0.32
3.G Liming	CO_2	TA	TA	Yes	Yes	Yes	Yes	0.13	0.13

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

5.1.2 Quantitative overview

Agriculture is the third largest emissions producing sector in the Czech Republic. In 2022, its contribution represented 7% to the total GHG emissions excl. LULUCF and excl. indirect emissions. This equalled to 8 407 kt CO_2 eq.; 44% of sectoral emissions came from enteric fermentation, 43% from managed agricultural soils, and 9% from manure management. Carbon dioxide emissions from liming and urea application on managed soils contributed by 4% to the total agricultural emissions in 2022. The share of emission categories in the total emissions was relatively stable to year 2 000 and changed gradually since 2001, when the anaerobic digesters were incorporated into estimating nitrous emissions. While the share of emissions from manure management decreased, the share of emissions from managed soils slowly increased. The total emissions from agriculture decreased by about 50% during the period 1990-2022. A quantitative overview and emission trends in the reported period are provided in Tab. 5-2.

Tab. 5-2 Emissions from agriculture, sorted by source categories, 1990-2022

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Agricultural Soils (3.D)	Liming (3.G)	Urea Application (3.H)
	[kt CO_2 eq.]					
1990	15 748	6 612	2 571	5 219	1 237	109
1991	13 147	6 338	2 450	3 897	329	132
1992	11 272	5 669	2 280	3 100	114	109
1993	9 875	4 909	2 096	2 669	108	93
1994	9 060	4 297	1 843	2 722	109	91
1995	9 215	4 276	1 760	2 954	116	109
1996	8 798	4 188	1 756	2 635	118	100
1997	8 500	3 916	1 699	2 721	97	67
1998	8 179	3 653	1 640	2 649	95	143
1999	8 232	3 753	1 659	2 640	91	88
2000	8 529	3 604	1 574	3 117	118	116
2001	8 926	3 605	1 510	3 544	110	157
2002	8 495	3 502	1 467	3 290	104	132
2003	7 822	3 399	1 421	2 799	82	120
2004	8 238	3 267	1 331	3 409	80	151
2005	8 192	3 377	1 312	3 290	67	146
2006	8 222	3 329	1 265	3 390	82	156
2007	8 505	3 365	1 239	3 620	84	197
2008	8 564	3 398	1 185	3 702	100	179

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Agricultural Soils (3.D)	Liming (3.G)	Urea Application (3.H)
	[kt CO_2 eq.]					
2009	7 505	3 316	1 035	2 939	67	148
2010	7 519	3 309	939	3 045	65	161
2011	8 208	3 279	846	3 792	84	207
2012	8 158	3 314	773	3 743	121	206
2013	8 024	3 314	735	3 635	142	198
2014	8 034	3 362	718	3 667	158	130
2015	8 875	3 492	735	4 210	171	268
2016	9 093	3 504	765	4 360	175	290
2017	8 889	3 527	751	4 221	166	225
2018	8 594	3 621	792	3 833	163	185
2019	8 423	3 620	773	3 687	193	149
2020	8 051	3 631	777	3 323	165	156
2021	8 240	3 629	777	3 512	146	176
2022	8 407	3 669	758	3 634	154	192

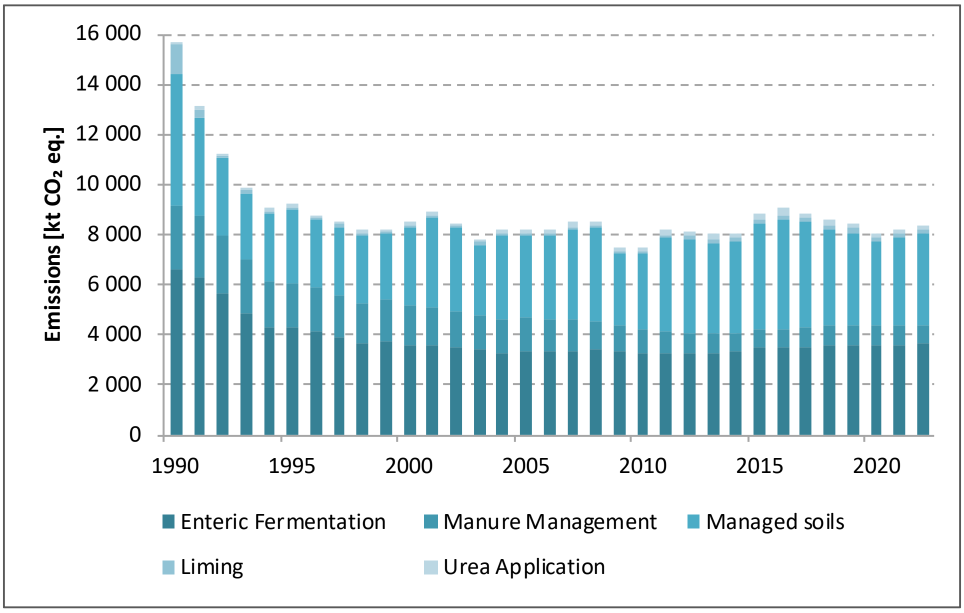

Fig. 5-1 Trend of emissions from agricultural sector [kt CO_2 eq.], 1990-2022

The sum of emissions from agriculture in the Czech Republic culminated in 1990 (100%) and the lowest emissions were estimated in 2009 and 2010 (48% of the total emissions in 1990, a decrease by 52%). The reason for the relatively largest decrease after 1990 was a decrease in the livestock population. Thereafter, the total emissions were relatively stable from 1997 to 2022, fluctuating by 7-20%, 12% on average, with the lowest values in 2009. In 2015 and 2016 the consumption of urea became highest in the reporting period. This negative environmental trend ended in 2017 when the urea consumption decreased. The emissions categories expressed in their relative shares compared to 1990 are shown in Tab. 5-3.

Tab. 5-3 Emission categories expressed in relative shares compared to 1990 (year 1990 is stated as 100%)

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Agricultural Soils (3.D)	Liming (3.G)	Urea Application (3.H)
	Relative share [%]					
1990	100	100	100	100	100	100
1995	59	65	68	57	9	101

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Agricultural Soils (3.D)	Liming (3.G)	Urea Application (3.H)
	Relative share [%]					
2000	54	55	61	60	0	107
2005	52	51	51	63	5	135
2010	48	50	37	58	5	148
2015	56	53	29	81	0	247
2016	58	53	30	84	14	267
2017	56	53	29	81	13	207
2018	55	55	31	73	13	171
2019	53	55	30	71	16	137
2020	51	55	30	64	13	144
2021	52	55	30	67	12	162
2022	53	55	29	70	12	177

An overview of the latest recalculations is given in Chapter 10. The methodology used is in accordance with the IPCC 2006 Guidelines with respect to some provisions of the IPCC 2019 Guidelines in Enteric fermentation (3A) category and Managed soils category (3D).

The total emissions estimated for 2022 (current Submission 2024) are by about 2% higher than estimated for 2021. The share of the main categories in the total GHG emissions from the sector remained without significant changes excluding updated category 3D. The rationale for the increase of the total emissions in recent years is described in the following paragraphs.

5.1.3 General overview of source specific QA/QC and verification

Following the recommendation in the latest in-country review, a sector-specific QA/QC plan was revised, 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 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 inventory in the sector Agriculture. IFER - Institute of Forest Ecosystem Research is the technically responsible institution for preparing emission estimates and reporting for this sector. Since 2019 the experts (Dr. Klír, Dr. Wollnerová) representing the Crop Research Institute (CRI) have joined the inventory team. These experts have been also involved in the QA/QC procedures.

Ministry of Agriculture of the Czech Republic, Czech University of Life Sciences, Institute of Animal Science Prague, Research Institute for Cattle Breeding, Research Institute of Agricultural Engineering, Institute of Agricultural Economics and Czech Hydrometeorological Institute are the additional collaborating institutions contributing with relevant information used in inventory of the sector Agriculture. Finally, the NIR experts from Slovakia responsible for the agricultural sector (Slovak Hydrometeorological Institute, SHMI) also cooperate closely in the inventory methods and potential improvements.

The identified errors and inconsistencies were documented, and corrections were made where needed. In addition to the official review process, the emission inventory methods were reviewed internally by the technical experts involved in the emission inventory of the Agriculture and LULUCF sectors. To comply with QA/QC, it is necessary to check e.g., the comparison of the country-specific and the default values:

- The activity data for livestock categories, annual crop production, the number of synthetic fertilizers, sewage sludge, liming and urea applied to managed soils (Czech official statistics, urea production data)
- The consistency of the time-series activity data and emission factors

- The update of the national zoo-technical data
- All the emission factors and parameters/fractions employed.

QA/QC includes checking the activity data, emission factors and methods employed. Additionally, communication and exchange of information on activity data, emissions factors, and methods with the respective Czech experts responsible for other reporting (Convention on Long-Range Transboundary Air Pollution, in-country reporting of the Ministry of Agriculture, etc.) help retain consistency of emission reporting with other relevant reporting protocols.

The inventory compiling procedure 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. There are some more specific parameters, which are not available from CzSO, required to estimate the country-specific emission factors for cattle (Tier 2). The zoo-technical national data (esp. cattle breeding) is supplied by the experts from the agricultural institutes (see above). The appropriate values in the calculation spreadsheets are updated at IFER, replacing the older values. The verified data are transferred to CRF Reporter, where the data are technically verified once again. The completeness check of the CRF tables is performed for the final time-series approval.

The responsible person (IFER expert) fills in the 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.

In 2021, Dr. Jana Beranová, responsible for the sector Agriculture, was nominated as a member of the new expert group under the European Commission on methane emissions from agriculture. This group carries consultations on the livestock sector, feed and feed additives.

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 for livestock require definitions of livestock sub-categories and their annual population data (see **Tab. 5-4**) and, for the higher Tier 2 methods used for cattle, also a feed intake and other zoo-technical characteristics. The coordinated livestock characterization was used to ensure consistency across the source categories for the whole emission inventory. Statistical Yearbook of the Czech Republic was the source of population data for livestock categories. All the numbers were confirmed by the Ministry of Agriculture.

Tab. 5-4 Trends in livestock populations [1 000 heads], 1990-2022 (CzSO 2023)

	1990	1995	2000	2005	2010	2015	2020	2021	2022
Cattle	3 506	2 030	1 574	1 392	1 349	1 407	1 404	1 406	1 421
Swine	4 790	3 867	3 688	2 877	1 909	1 560	1 499	1 518	1 433
Sheep	430	165	84	140	197	232	203	183	174
Poultry	31 981	26 688	30 784	25 372	24 838	22 508	24 247	23 809	23 026
Horses	27	18	24	21	30	34	39	34	38
Goats	41	45	32	13	22	27	29	25	25

Livestock population trends in key categories (cattle, pig and poultry) determine the emission trends in agricultural sector. The population of cattle in 2022 represented only 40% of the population in 1990 and the swine population in 2022 corresponded to only 32% of the initial population in 1990.

Livestock numbers were reported from 1990 to 2022 at April the 1 of that year. For Submissions 2025, only data as of December 31 of that year will be available. This will mean a decrease in cattle and pig populations by an average of 3% in the whole period. Recalculation is planned for the next submission (2025). Changes in national statistic are a result of implementation the **new regulation on statistics on agricultural inputs and products (SAIO).** This regulation is a part of the modernization of the European system of agricultural statistics and, by improving and strengthening statistics on agricultural inputs and products in agriculture, should help to improve knowledge of agricultural practices and production in connection with the Common Agricultural Policy (CAP), the Green Pact for Europe and the "farm to fork" strategy.

5.2.1 Enteric Fermentation (CRF 3.A)

5.2.1.1 *Source category description*

This chapter describes the estimation of CH_4 emissions from enteric fermentation. In 2022, 91% of agricultural CH_4 emissions, 131.5 kt of CH_4, 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 in the Czech Republic are kept only in several private farms and ZOOs, but the populations of this non-native livestock are very low (hundreds of heads). Their breeding is not very intensive and therefore methane emissions for the non-native livestock were not estimated. Enteric fermentation emissions from poultry were not estimated as the IPCC 2006 Guidelines does not provide any default emission factor for this animal category. The contribution of emissions from livestock other than cattle to the total emissions from enteric fermentation was less than 3.5% (4.34 kt CH_4) of the total CH_4 emissions from the enteric fermentation category.

5.2.1.2 *Methodological issues*

Emissions from enteric fermentation of domestic livestock were calculated using the Tier 2 (cattle category) and Tier 1 (other livestock) methodologies presented in the IPCC 2006 Guidelines and the last Refinement of IPCC Guidelines from 2019 (IPCC 2019).

5.2.1.2.1 Enteric Fermentation of cattle (Tier 2)

The emission factor for methane from enteric fermentation (EF) in kg/head p.a. is proportional to the daily feed 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) in 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 the methane conversion factor presented for cattle in Table 10.12 (IPCC 2006, updated version in IPCC 2019). Methane conversion factor of zero is assumed for all juveniles consuming milk only (calves' categories, first three month of life) – p. 10.48 IPCC 2019. The coefficient of 55.65 is the energy content of methane with unit of MJ/kg CH_4. This equation should be solved for each cattle subcategory, denoted by index i.

EF is estimated for each cattle category and reported for dairy and non-dairy cattle. The value reported for non-dairy (other) cattle is the weighted average of the results calculated in each non-dairy category separately, including calves. Total emissions are the sum of the two products ($EF_{DairyCattle}$*population of dairy cattle + $EF_{NonDairyCattle}$ *population of non-dairy cattle).

There are 10 cattle subcategories in use which the data are available for in Czech Statistical Yearbooks (CzSO 1990-2022):

- Calves younger than 6 months of age, male
- Calves younger than 6 months of age, female
- Young bulls (6-12 months of age)
- Young heifers (6-12 months of age)
- Bulls and bullocks (1-2 years)
- Bulls and bullocks (over 2 years)
- Heifers (1-2 years)
- Heifers (over 2 years)
- Mature dairy cows
- Mature suckler cows

In the calculation, it is also very important to distinguish between dairy and suckler cows, where the fraction of suckler cows (ratio of suckler/all cows) gradually increased in the 1990-2022 period. The population of suckler cows increased from 2% to 64% of the dairy cattle population during the reporting period because of changes in agricultural policy after 1990.

Considering that this is a key source of emissions, the Czech Republic uses Tier 2 methods to estimate methane emission factors for cattle. The calculation procedure was prepared in 2004 as a part of the VaV/740/4/02 project funded by the Ministry of the Environment (Kolář et al. 2004). The activity data was then updated repeatedly, most recently in 2016, when the shares of manure management systems were adjusted. IPCC methodology allows, if the daily food intake for each subcategory of cattle is not known directly, to calculate gross energy intake (GE) 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 the feed not extracted) and the feeding situation (stall, pasture).

The original national zoo-technical inputs (noted above) were updated several times during reporting periods by the experts from the Czech University of Life Sciences Prague in 2006 and 2011 and were discussed with the experts from the Mendel University Brno (prof. Zeman 2021) and from Institute of Animal Science in 2022 (Dr. Joch).

For Submission 2023 and following, the methodological update of enteric fermentation estimation of methane emissions was implemented, including changes in activity data entering the calculations. Update and validation were required in review process (Issue A3). Refined country-specific data used in estimates were the aim of this update, so were the validation and use of methane emission factor calculation based on the data on feeding situation derived from the nutritional standards. Newly we have estimated feed intake using a simplified Tier 2 method according to the procedures updated in IPCC 2019 Guidelines to validate the calculated GE.

The estimation of enteric fermentation was subjected to a rigorous control and validation of activity data entering the estimation of gross energy (GE) intake (digestibility, weight gain, activity coefficient, etc.). The estimation of GE was subsequently compared to the estimation of dry matter intake (DMI) using simplified Tier 2 method (IPCC 2019) and the practice of deriving DMI from the assumed feed rations. In connection with the revision of digestibility data, the Methane Conversion Factor Y_m value was also revised for all subcategories of cattle. The entire procedure is described in detail as an official output (Beranova et al. 2022) of the aforementioned project and was submitted to a review to prof. Zeman, Mendel University Brno, Czech Republic. The calculation spreadsheet has been accordingly corrected and updated.

Specifically, the following adjustments were implemented:

- Country-specific approach to the activity coefficient (C_a), 1990-2022
- AWMS refinement, technical correction and input data unification, 1990-2022
- Increased pregnancy coefficient ($C_{pregnancy}$) for mature heifers, 1990-2022
- Increased value of milk production for suckler cows, 1990-2022
- Body weight increment refinements in the selected categories, 1990-2022
- The digestibility of feed (DE) value refinements, validation reflecting the dry matter intake (DMI) standards 1990-2022, DMI estimates based on the productivity, 2020-2022
- Revised methane conversion factor (Y_m) values for dairy cows from 2014 (6.4%) to the target value of 6.15% (2018) and adjustments for the methane conversion factor (Y_m) values for non-dairy cattle from 2014.

5.2.1.2.2 Activity data overview

The body weight data in relevant cattle categories is derived from the Czech legislation (Decree 377/2013 Coll.) and it is fully harmonized with nitrogen balance reporting and air pollution reporting (Tab. 5-5), no changes in Submission 2024.

Tab. 5-5 Weight of an individual in cattle categories [kg], 1990-2022

Cattle categories	1990-1994	1995-1998	1999-2004	2005-2009	2010-2015	2016	2017	2018-2022
Dairy cattle	520	540	580	585	590	620	620	650
Suckler cows	520	540	580	585	590	620	620	650
Mature heifers >2 yrs.	485	490	505	510	515	541	541	600
Mature bulls >2 yrs.	750	780	820	840	850	850	850	800
Heifers 1-2 yrs.	380	385	395	395	390	410	410	470
Bulls 1-2 yrs.	490	510	530	540	560	560	560	560
Heifers 6-12 m.*	275	280	285	285	290	299	265*	265
Bulls 6-12 m. *	325	330	335	340	350	368	300*	300
Calves <6 m., F*	128	132	133	135	135	139	115*	115
Calves <6 m., M*	128	132	133	135	135	149	115*	115

** Before 2017, the Czech Statistical Office used age categories different from the national legislation (0-8 months, 8-12 months for young categories) and the relevant body weight of calves, young bulls and heifers were used in the estimates. Since 2017 the input data has been adapted to the Czech legislation (0-6 months, 6-12 months). The time series is consistent – data on weight are relevant to the number of heads in the category.*

The feeding situation is the most important input to the estimation of net energy for activity NE_a (Eq. 10.4, IPCC 2006). One of the components of animal´s energy intake is the energy needed for animals to obtain their food, water and shelter (NE_a, eq. 10.4, IPCC 2019). To calculate this energy, the activity coefficients are used to multiply the energy for maintenance (NE_m, eq. 10.3, IPCC 2019). The default values of the activity coefficients C_a are listed in IPCC 2019, Table 10.5.

Based on the expert recommendation, the country-specific technology coefficient (Ki) is used for estimating energy requirements (Zeman, 2006). The following table (Tab. 5-6) shows the differences between the activity and technology coefficient values.

Tab. 5-6 Activity coefficient (adjusted in compliance with IPCC 2019 Gl.) and the corresponding values for the production system (Zeman, 2006)

Feeding situation	Description	C_a Activity coefficient [%/100]	Production system	Ki Technology coefficient
Stall	Animals are confined to a small area and expend very little or no energy to acquire feed	0	Binding	0 No increased energy demands
Pasture	Animals are confined in areas with sufficient forage requiring modest energy expense to acquire feed	0.17	Free housing	0.1 Energy demands higher by 10%
Pasture-grazing large areas/Range	Animals graze in open range land and expend significant energy to acquire feed	0.36	Pasture/Range	0.2-0.3 Energy demands higher by 20-30%

The technology coefficient (Ki) allows an improved coverage of changes in cattle breeding, which occurred in cattle breeding in the Czech Republic after 1990. For the individual time series, it makes possible to consider the development of cattle breeding technologies in the period 1990-2022 and cover the gradual transition from binding housing, which prevailed from 70's, to free housing, which, in compliance with a valid legislation, dominates nowadays. Accordingly, the entire time series was recalculated including the above-described development. The original feeding situation was represented as a percentage of time, which cattle spent on a surrounding pasture and moderate energy was spent in acquiring feed. For the rest of the time, it was assumed that cattle spent in stall with a limited possibility to move (Tab. 5-6). Accordingly, the activity coefficient was calculated as the weighted average C_a of the time share in stall and pasture E.g., in case of 5% of year spent on pasture the activity coefficient value was 0.0085, hence the energy for maintenance value increased by this coefficient.

The following table (**Tab. 5-7**) shows the activity coefficients updated with the country-specific data. It is obvious that the refinement leads to increasing value of the activity coefficient with an increasing proportion of free housing and pasture.

Tab. 5-7 The update of activity coefficient estimation by using the breeding coefficient; dairy cattle, suckler cows and non-dairy cattle as a summarized category

Dairy cattle: technology proportion	1990-1994	1995-2004	2005-2009	2010-2015	2016-2022
Binding housing, %	85	45	19	0	0
Free housing, %	10	45	70	93	100
Pasture/range, %	5	10	11	7	0
C_a, Activity coefficient value	0.020	0.065	0.092	0.107	0.100
Suckler cows: technology proportion	**1990-1994**	**1995-2004**	**2005-2009**	**2010-2015**	**2016-2022**
Binding housing, %	60	25	0	0	0
Free housing, %	10	40	65	50	50
Pasture/range, %	30	35	35	50	50
Ca, Activity coefficient value	0.070	0.110	0.135	0.150	0.150
Non-dairy cattle (weighted average)	**1990-1994**	**1995-2004**	**2005-2009**	**2010-2015**	**2016-2022**
C_a, Activity coefficient value	0.033-0.035	0.078-0.081	0.116	0.124-0.128	0.124-0.128

The daily milk production statistics (Tab. 5-8), in which only milk from dairy cows is considered, increased to 25.59 kg/day/head in 2022 in comparison with data from 2021 (25.11 kg/day), with an average fat content of 3.89%. 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).

Based on information provided by Institute of Animal Science (Beranova 2022) the milk production of suckler cows increased, namely to 8 kg/day (2 920 kg/yr.). Milk production is related to rearing calves. The original value used earlier was 3.7 kg of milk/day.

Tab. 5-8 Daily milk production of dairy cows and fat content in milk, 1990-2022

Year	Dairy cows population [1 000 heads]	Daily milk production [kg/day/head]	Fat content [%]
1990	1 206	10.97	4.03
1995	732	11.66	4.02
2000	548	13.93	4.00
2005	433	17.61	3.90
2010	384	19.44	3.86
2015	376	22.53	3.84
2016	373	22.64	3.91
2017	370	23.16	3.89
2018	365	24.01	3.86
2019	364	23.86	3.98
2020	360	25.04	3.89
2021	359	25.11	3.88
2022	358	25.59	3.89

Based on the information provided by Institute of Animal Science (Beranova et al. 2022), **the share of mature embedded heifers** in the calculation increased to 80%. Earlier, this share was not considered.

Weight gain, based on the expert estimate (Beranova et al. 2022), was adjusted for the entire time period 1990-2022 in category of mature heifers and mature bulls. Earlier, the weight gain in these categories was not considered in the estimation. Based on the expert information, the weight gain was set to 0.12 kg/day up to 0.60 kg/day. Furthermore, the weight gain for growing bulls and calves increased for the period 2010-2022. Development of weight gain in the country is shown in Tab. 5-9.

Tab. 5-9 Weight gain development overview [kg per livestock categories]; dairy and suckler cow weight gains are assumed to be zero and are not listed in the table, 1990-2022 (source: Kolář et al. 2004, Zeman et al. 2021, Beranova et al 2022).

Cattle category	1990-1994	1995-1998	1999-2009	2010-2022
	Weight gain [kg/day]			
Dairy cattle	0	0	0	0
Suckler cows	0	0	0	0
Mature heifers >2 yrs.	0.12	0.20	0.30	0.40
Mature bulls >2 yrs.	0.12	0.20	0.40	0.60
Heifers 1-2 yrs.	0.69	0.74	0.80	0.83
Bulls 1-2 yrs.	0.74	0.76	0.84	1.20
Heifers 6-12 m.	0.55	0.63	0.70	0.70
Bulls 6-12 m.	0.82	0.94	1.12	1.20
Calves <6 m., F	0.50	0.56	0.63	1.00
Calves <6 m., M	0.65	0.68	0.72	1.00

The digestibility of feed is one of the essential inputs into the enteric fermentation calculation. In the original CHMI study „Recalculating cattle enteric fermentation methane emission series“ (Kolář et al. 2004), the digestibility of feed value was estimated as 60% for all cattle categories in the period 1990-2002.

In 2010, the entire time series of emission factors calculation had been recalculated with the digestibility values of dairy cows of 67%, suckler cows 62% and other categories 65%. This value, with a missing country-specific data, had been understood as a conservative estimate of the real digestibility of feed, which, according to a literature data, had ranged between 68-70% for dairy cows (CHMI 2022).

To improve accuracy of the digestibility estimates, which, especially in case of dairy cows, did not correspond with the above-average milk production requiring appropriate feed, there was a study prepared by Zeman et al. (2021) which estimated the digestibility from the composition of a representative set of feeding rations. Feeding ratios were designed to reflect the real conditions of the feeding base in the Czech Republic and various levels of milk production and dairy cow maintenance (Zeman et al. 2021).

Tab. 5-10 shows the resulting digestibility (DE) values for time series. For dairy cows, there were two DE values validated (2010 and 2021), based on which the values for the period 1996-2010 were extrapolated. This follows the fact that the increment in DE is a continuous phenomenon.

Tab. 5-10 Digestibility (DE) of dairy and non-dairy cattle: values development in NIR of the Czech Republic, 1991-2021 (CHMI 2022, Beranova et al 2022)

Time series	DE, Dairy cows [%]	DE, Non-dairy cattle, weighted average [%]	Source
1991-1995	67.0	65.0	CHMI 2022
1996-2000	68.0	64.9	Extrapolated values
2001-2005	69.0	64.8	Extrapolated values
2006-2010	69.5	64.6	Extrapolated values
2011-2022	70.0	65.6	Validation on the basis of DMI

In case of non-dairy cattle, the calculation counts with DE values given for individual categories. Until 2010, DE of 62% applied for suckler cows and 65% for other categories, thus the weighted average of all categories was slightly below 65%, according to the suckler cow representation in the population. Since 2011, the digestibility values reflect the breeding technology and fluctuate from 60% for mature heifers to 71% for growing bulls (1-2 years). The digestibility in other cattle categories is, on average, above 65%.

For the emission factor calculation according to eq. 10.21 of IPCC 2006 Guidelines, the methane conversion factor (Y_m) value is fundamental. As a part of the recalculation update, with a support of the refined IPCC 2019 Gl., Y_m values applicable for the country were updated too (Tab. 5-11). This was based on a better specification of Y_m, derived from feeding ratio quality, digestibility and neutral detergent fibre content as published in IPCC 2019 Gl., Table 10.12. The updated Y_m is shown in Tab. 5-11. Y_m values for calves reflect the fact that milk-fed calves do not produce any methane emissions. 3.32 is the value of the weighted average of Y_m reflecting the circumstance of calves being milk-fed up the age of 3 months.

As for the dairy cows, Y_m factor was adjusted according to the expected feed quality. Factor value of 6.15 is the weighted average of values given for high and medium producing dairy cows with average digestibility of feed 70% and neutral detergent fibre content above 35%. Similarly, Y_m applied for mature bulls represented a weighted average considering the bull share consuming feed of lower digestibility (grazing livestock) and higher digestibility (breeding purposes).

Tab. 5-11 Development of methane conversion factor (Y_m) values in 1990-2022 (Beranova et al 2022)

Cattle category	1990-2010	2014	2015-2017	2018-2022
	Y_m, Methane conversion factor [%]			
Dairy cattle	6.5	6.4	6.3	6.15
Suckler cows	6.5	6.5	6.5	6.5
Mature heifers >2 yrs.	6.5	6.5	7.0	7.0
Mature bulls >2 yrs.	6.5	6.5	6.75	6.75
Heifers 1-2 yrs.	6.5	6.5	6.3	6.3
Bulls 1-2 yrs.	6.5	6.5	6.3	6.3
Heifers 6-12 m.	6.5	6.5	6.3	6.3
Bulls 6-12 m.	6.5	6.5	6.3	6.3
Calves <6 m., F	3.32	3.32	3.32	3.32
Calves <6 m., M	3.32	3.32	3.32	3.32

As the official statistics, specifically from CzSO, provide population values for dairy 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 of non-dairy cattle feeding situation and pregnancy, in %, were calculated and entered in the CRF tables. The weighted feeding situation is mostly affected by time spent on pasture of suckler cows (95%), as well as by the case of pregnancy (90% of suckler cows are pregnant, 80% of mature heifers, zero of other cattle categories). An overview of the current input data (NIR 2023) is presented in Tab. 5-12, and the calculated data are presented in Tab. 5-13.

The sources of input data are as follows:

- CzSO = Statistical Yearbook of the Czech Republic, the Czech Statistical Office
- CS = Country-specific, publicly available data (the Czech legislation, Cattle breeding Yearbook, etc.)
- IPCC 2006 Guidelines, default values, Table 10.4-10.7, 10.12

Tab. 5-12 Activity data and input data used for estimating gross energy intake (GE) and emission factors for all age categories of cattle, actual data for 2022

	Dairy	Suckler	Mature Heifers	Mature Bulls	Heifers 1-2 yrs	Bulls 1-2 yrs	Heifers 6-12 m	Bulls 6-12 m	Calves,F <0,6 m	Calves,M <0,6 m
Population [1 000 heads], CzSO	358	230	68	21	210	105	114	73	138	105
Body weight [kg], CS	650	650	600	800	470	560	265	300	115	115
Mature weight [kg], CS	650	650	650	800	650	800	650	800	650	800
Avg. weight gain [kg/head/day], calc.	0.00	0.00	0.40	0.60	0.83	1.20	0.70	1.20	1.00	1.00
Avg. daily milk production [kg/head/day], CS	25.59	8.00	-	-	-	-	-	-	-	-
Milk fat content [%], CS	3.89	3.89	-	-	-	-	-	-	-	-
Feed digestibility [%], CS	70	64	60	60	66	71	66	66	66	66
Emitting [% of year], CS	100	100	100	100	100	100	100	100	100	100
Number of days with pasture, CS	0	183	183	55	128	55	110	55	18	18
Pregnancy [% of year], CS	90	90	80	-	-	-	-	-	-	-
Protein content in milk [%], CS	3.42	3.42	-	-	-	-	-	-	-	-
Cf_i, net energy for maintenance, T. 10.4	0.386	0.386	0.322	0.370	0.322	0.370	0.322	0.370	0.322	0.370
C_a, activity coef., CS	0.0615	0.150	0.150	0.115	0.135	0.115	0.130	0.115	0.105	0.105
$C_{pregnancy}$, net energy for pregnancy, T. 10.7	0.10	0.10	0.10	-	-	-	-	-	-	-
Y_m, methane conv. factor, T. 10.12	0.062	0.065	0.070	0.068	0.063	0.063	0.063	0.063	0.033	0.033
C, net energy for growth, Eq. 10.6	0.8	0.8	0.8	1.2	0.8	1.2	0.8	1.2	1	1

Tab. 5-13 Calculated values used for estimating methane emissions from enteric fermentation for all age categories of cattle, actual data for 2022

	Dairy	Suckler	Mature Heifers	Mature Bulls	Heifers 1-2 yrs	Bulls 1-2 yrs	Heifers 6-12 m	Bulls 6-12 m	Calves,F <0,6 m	Calves,M <0,6 m
NE_m, net energy for maintenance [MJ/head/day]	49.69	49.69	39.04	55.66	32.50	42.59	21.15	26.67	11.31	12.99
NE_a, net energy for activity [MJ/head/day]	4.97	7.45	5.86	6.40	4.23	5.11	2.86	3.12	1.19	1.36
NE_g, net energy for growth [MJ/head/day]	0	0	9.25	11.31	16.48	18.51	9.26	11.59	6.19	5.30
NE_l, net energy for lactation [MJ/head/day]	77.43	24.21	0	0	0	0	0	0	0	0
NE_w, net energy for work [MJ/head/day]	0	0	0	0	0	0	0	0	0	0
NE_p, net energy for pregnancy [MJ/head/day]	4.47	4.47	3.12	0	0	0	0	0	0	0

GE, gross energy intake [MJ/head/day]	368.86	262.76	217.2	276.83	187.18	203.82	115.05	143.26	66.52	67.67
REM, ratio of net energy for maintenance	0.53	0.51	0.50	0.50	0.52	0.53	0.52	0.52	0.52	0.52
REG, ratio of net energy for growth	0.33	0.30	0.28	0.28	0.31	0.34	0.31	0.31	0.31	0.31
EF from enteric fermentation [kg CH_4/head/year]	148.79	112.02	99.72	122.56	77.35	84.22	47.54	59.20	14.40	14.65

Details of the calculation are given in the above-mentioned studies (Kolář, Havlíková and Fott 2004, Beranová et al. 2022) and the results are illustrated in Tab. 5-13. It is obvious that EFs increased slightly from 1990 because of the increasing weight and milk production of cows and because of the increasing weight and weight gain for other cattle. On the other hand, CH_4 emissions from enteric fermentation of cattle dropped during the period 1990-2022 to about one half of the former values due to the rapid decrease in numbers of animals kept (Tab. 5-14).

Tab. 5-14 Activity data and methane emissions from enteric fermentation of dairy and non-dairy cattle, Tier 2, 1990-2022

Year	Dairy cattle population [1 000 heads]	Other cattle population [1 000 heads]	EF Dairy cattle [kg CH_4/hd/yr]	EF Other cattle [kg CH_4/hd/yr]	Emissions Dairy cattle [kt CH_4]	Emissions Other cattle [kt CH_4]	Emissions Cattle, total [kt CH_4]
1990	1 206	2 300	97.59	46.57	117.71	107.11	224.82
1991	1 165	2 195	94.87	47.77	110.56	104.84	215.41
1992	1 006	1 943	96.71	48.84	97.32	94.90	192.22
1993	902	1 609	97.04	48.62	87.57	78.24	165.82
1994	796	1 366	99.11	48.60	78.86	66.37	145.23
1995	732	1 298	105.23	52.38	77.05	67.97	145.02
1996	712	1 276	104.72	52.74	74.61	67.31	141.92
1997	656	1 210	102.87	53.50	67.51	64.71	132.22
1998	598	1 103	107.44	53.40	64.23	58.90	123.13
1999	583	1 074	112.17	57.12	65.40	61.36	126.76
2000	548	1 026	114.64	57.65	62.80	59.13	121.93
2001	529	1 053	114.23	58.66	60.47	61.76	122.23
2002	496	1 024	117.88	58.78	58.50	60.19	118.69
2003	466	984	120.45	59.92	56.15	58.93	115.08
2004	437	952	122.81	59.85	53.64	57.01	110.65
2005	433	960	126.62	62.47	54.77	59.94	114.71
2006	424	950	126.47	62.48	53.62	59.33	112.96
2007	410	981	128.07	62.71	52.55	61.52	114.08
2008	406	996	129.88	63.24	52.67	62.99	115.66
2009	400	964	130.91	63.43	52.30	61.13	113.42
2010	384	966	131.17	65.03	50.31	62.80	113.10
2011	374	970	133.46	64.17	49.89	62.24	112.13
2012	373	981	135.91	64.04	50.71	62.79	113.50
2013	367	985	136.43	64.29	50.11	63.36	113.47
2014	373	1 001	137.01	64.00	51.05	64.06	115.11
2015	376	1 031	137.08	66.17	51.56	68.22	119.78
2016	373	1 043	140.36	65.16	52.28	67.97	120.26
2017	370	1 051	141.92	65.37	52.48	68.74	121.22
2018	365	1 050	143.29	68.62	52.36	72.07	124.44
2019	364	1 053	143.41	68.52	52.24	72.21	124.45
2020	360	1 044	146.99	69.01	52.90	72.07	124.97
2021	359	1 047	147.11	69.04	52.77	72.34	125.11

Year	Dairy cattle population [1 000 heads]	Other cattle population [1 000 heads]	EF Dairy cattle [kg CH_4/hd/yr]	EF Other cattle [kg CH_4/hd/yr]	Emissions Dairy cattle [kt CH_4]	Emissions Other cattle [kt CH_4]	Emissions Cattle, total [kt CH_4]
2022	358	1 063	148.79	69.05	53.30	73.40	126.70

5.2.1.2.3 Enteric Fermentation of other livestock (sheep, goats, swine, horses)

Compared to cattle, the contribution of other farm animals to the total CH_4 emissions from enteric fermentation is much lower (3.3% in 2022). Therefore, methane emissions from enteric fermentation of other farm animals (other than cattle) are estimated using the Tier 1 approach. Because some of the features of keeping livestock in the Czech Republic are similar to those in the neighbouring countries of Germany and Austria, the default EFs for Tier 1 approaches recommended for Developed countries were employed. The Czech Statistical Office publishes data on the numbers of goats, sheep, swine, horses, and poultry annually in the Statistical Yearbooks (1990-2022). Considering the rather low numbers in these animal categories, the default emission factors (Table 10.10, IPCC 2006 Gl.) were used for estimating methane emissions: 8 kg of CH_4 annually per head for sheep, 5 kg of CH_4 for goats, 1.5 kg of CH_4 for swine and 18 kg of CH_4 for horses. An overview of methane emissions estimated for other livestock in the period 1990-2022 is presented in Tab. 5-15.

Tab. 5-15 Methane emissions from enteric fermentation of other livestock, Tier 1, 1990-2022

Year	Sheep	Swine	Goats	Horses	Total
	CH_4 emissions from enteric fermentation [kt]				
1990	3.44	7.18	0.21	0.49	11.31
1995	1.32	5.80	0.23	0.32	7.67
2000	0.67	5.53	0.16	0.43	6.80
2005	1.12	4.32	0.07	0.38	5.88
2010	1.58	2.86	0.11	0.54	5.09
2015	1.85	2.34	0.13	0.61	4.93
2016	1.75	2.41	0.13	0.58	4.87
2017	1.74	2.24	0.14	0.62	4.74
2018	1.75	2.34	0.15	0.63	4.87
2019	1.71	2.32	0.15	0.66	4.83
2020	1.63	2.25	0.14	0.69	4.71
2021	1.47	2.28	0.13	0.61	4.48
2022	1.39	2.15	0.12	0.68	4.35

5.2.1.3 Uncertainty and time-series consistency

Uncertainty estimates are based on the expert judgement. The uncertainty in the activity data equals 5% and the uncertainty in the emission factors equals 20%. The combined uncertainty, calculated according to IPCC Tier 1 methodology, equals 20.6%.

Several methodological updates were made during the reporting period described in the relevant NIR text. Time series consistency is always preserved. Recalculations due to the methodological updates were carried out for the whole reported period.

5.2.1.3.1 Historical overview

Initially, calculations were based on historical studies (Dolejš 1994 and Jelínek et al. 1996). It has been suggested in several reviews organized by UNFCCC that an approach based on historical studies was obsolete. 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).

For submission 2007 the new concept for calculating CH_4 emissions followed the Good Practice Guidelines (IPCC 2000) was implemented. The estimation was based on the following decisions:

1) Methane emissions from enteric fermentation of livestock (a key source) come predominantly from cattle. Therefore Tier 2, as described in Good Practice Guidance (IPCC 2000) is employed only for cattle.
2) Methane emissions from enteric fermentation of other farm animals are estimated by the Tier 1 approach. Because some features of keeping livestock in the Czech Republic are similar to those in the neighbouring countries such as Germany and Austria, the default EFs for Tier 1 approaches recommended for developed countries were employed.

An increased attention was paid to enteric fermentation. It was stated that cooperation with specialized agricultural experts is crucial for obtaining new consistent and comparable data of suitable quality. The relevant country-specific data for milk production, weight, weight gain for growing animals, type of stabling, etc. were collected by our external experts (Hons, Mudřík 2003). Moreover, the statistical data for sufficiently detailed cattle classification, which is available in the Czech Republic, was also collected at the same time. Calculating the enteric fermentation of cattle using the Tier 2 approach was described in a study (Kolář, Havlíková and Fott 2004) for the whole time series from 1990 using the above-mentioned country-specific data. The necessary QA/QC procedures were performed in cooperation with the experts from IFER. The country-specific data like the weight of individual categories of cattle, weight gains in these categories and recent feeding situations were revised in 2006. The new values were estimated similarly by our external experts (Mudřík and Havránek 2006) for the next period.

The national zoo-technical inputs (mainly weight, weight gain, daily milk production including the percentage content of fat and the feeding situation) were updated several times in cooperation with experts from the Institute of Animal Sciences. These changes in the activity data and input parameters obviously did not result in any changes in emissions for the entire reporting period.

The important revision of cattle weight data (NIR 2018), along with the harmonization of this input data with the national legislation, increased the country-specific emission factors for enteric fermentation as well as increased the total emissions by about 2% in the category of enteric fermentation.

Until 2017, Czech Statistical Office had used age categories different from the national legislation (the age periods had been 0-8 months and 8-12 months for young categories) and the relevant body weight of calves, young bulls and heifers had been used in the estimates. Since 2017, the input data were adapted to the Czech legislation (0-6, 6-12 months). The time series is consistent – the weight data are relevant to the number of heads in the category. This change does not have any significant impact on the livestock emissions.

For the needs of CHMI, based on the knowledge and analysis processed in 2019-2022 during the research project “Development of the methodologies for reporting and projections of greenhouse gas emissions and removals including projections of usual pollutants” funded by The Technological Agency of the Czech Republic (TACR), a specific report "Update of the methodology for estimating emissions from enteric fermentation from cattle, evaluation of the possibilities of using country-specific data for estimating emissions from enteric fermentation" (Beranova et al. 2022) was prepared. As a part of the presented output, the existing estimation procedures used for methane emissions were examined. The estimates were subsequently adjusted according to the IPCC requirements specified in the refinement of the emission estimation methodology for the national GHG inventory (IPCC 2019). In cooperation with the experts from the Institute of Animal Science and Mendel University Brno, the activity data were updated and the entire time series of methane emission estimates for cattle was recalculated. The aim was to effectively use the country-specific data for emission estimation and validate the methane emission factor based on the data on the assumed nutrition of cattle from the nutritional standards (norms). The calculation spreadsheet has been updated consequently in Submission 2023 and 2024.

5.2.1.4 Source-specific QA/QC and verification

Generally, QA/QC includes check on 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. There are some more specific parameters, not available from CzSO, required for estimating the country-specific emission factors for cattle (Tier 2). The zoo-technical national data (esp. cattle breeding) are supplied by the 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 technically verified again. A completeness check of CRF tables was performed for the final time-series approval.

The country-specific parameter, digestibility (DE, %), for cattle was estimated on the basis of the 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, personal communication) determined the conservative average digestibility values for three basic cattle sub-categories. These digestibility values were updated for the entire reporting period (Tab. 5-10).

The new refinement of DE values (validation) was made by comparing the calculated gross energy (GE) results and dry matter intake (DMI, kg/day) values from feed. Three DMI values were available, obtained from the independent information sources:

1. Direct calculation from GE value: DMI = GE/18.45
2. Derivation from average feeding rations standards available for individual dairy categories (Beranova et al., 2022)
3. Calculation according to simplified Tier 2 methodology of IPCC Guildelines 2019 (eq. 10.17-10.18B).

The results of the comparison are shown in table (Tab. 5-16).

Tab. 5-16 Comparison of digestibility values derived from the calculation of DMI from GE values, calculation recommended by IPCC Guidelines 2019, DMI values are from Czech feeding ratio standards, input values: 2021 data

Cattle category	DE [% of energy]	GE [MJ/day]	DMI (GE/18.45) [kg/day]	DMI eq. 10.17-10.18B [kg/day]	DMI Czech feeding standards, avg. [kg/day]	Avg. value of DMI [kg/day]
Dairy cattle	70	364.69	19.77	20.12	19.80	19.90
Suckler cows	64	262.66	14.24	14.30	14.80	14.45
Mature heifers >2 yrs.	60	217.20	11.77	13.20	11.40	12.12
Mature bulls >2 yrs.	60	276.83	15.00	14.81	13.90	14.57
Heifers 1-2 yrs.	66	187.66	10.17	11.74	9.90	10.60
Bulls 1-2 yrs.	71	203.26	11.02	11.52	10.65	11.06
Heifers 6-12 m.	66	114.74	6.22	6.41	6.05	6.23
Bulls 6-12 m.	66	143.11	7.76	7.10	7.60	7.49
Calves <6 m., F	66	66.52	3.61	3.42	3.35	3.46
Calves <6 m., M	66	67.66	3.67	3.42	3.35	3.48

From the comparison of these three DMI values obtained in a different way it is obvious, that the values correspond within the expected uncertainties and, accordingly, they mostly vary by ±5% from the average, in case of heifers and growing heifers by ±10% from the average counted from all the three values.

The updated enteric fermentation emission factors for dairy and other cattle were compared with the default enteric fermentation factors available for the Western Europe region in IPCC 2006 Guidelines (Table 10.11) and IPCC 2019 Guidelines (Table 10.11), Tab. 5-17.

Tab. 5-17 Comparison of emissions factors for methane emissions from enteric fermentation of dairy and non-dairy cattle, factors recommended by IPCC 2006 Gl. for Western Europe, IPCC 2019 Gl. for Western Europe and data calculated for Submission 2024

Cattle category	EF, IPCC 2006 [kg CH_4/head/year]	EF, IPCC 2019 [kg CH_4/head/year]	EF, NIR 2023 [kg CH_4/head/year]
Dairy cattle	117*	126**	149***
Other cattle	57	52	69

*Average milk production 6 000 kg/head/year

** Average milk production 7 410 kg/head/year

*** Average milk production 9 340 kg/head/year

The current emission factor for dairy cows corresponds to high milk production and highly digestible feed and it is about 18% higher than the current default value. The current emission factor for other cattle is 30% higher than the default value according to IPCC 2019 Guidelines. The value needs to be further refined based on the animal nutrition data.

Tab. 5-18 Comparison of two different estimations of emission factors for methane emissions from enteric fermentation of dairy and non-dairy cattle, input data 2021 -2022 (Submission 2023 and 2024)

Cattle category	EF, NIR 2023, eq. 10.21 [kg CH_4/head/year]		EF, eq. 10.21A [kg CH_4/head/year]	
	2021	2022	2021	2022
Dairy cattle	147	149	145	145
Other cattle	69	69	69	69

IPCC 2019 Guidelines methodology makes it possible to estimate the value of the methane emission factor from enteric fermentation from equation 10.21A using the dry matter intake and methane yield value (MY, g CH_4/kg DMI), which is given in Table 10.12 with values corresponding to the quality of the feed rations. Thus, EF can be calculated using different data, which makes it possible to compare the quality of input data. We performed the verification for the data of the current submission (NIR 2023, data from 2021) for all cattle categories (Tab. 5-18). We adjusted used MY values using the same procedure as for the Y_m if the values given in the IPCC table did not exactly correspond to the situation in Czech Republic.

5.2.1.5 *Source-specific recalculations, including changes made in response to the review process and impact of emission trends*

A detailed description of the recalculation related to estimates of emissions from enteric fermentation of cattle is available in the text report Submission 2023.

No recalculation has been done for Submission 2024.

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

Since 2024, Czech Statistical Office will be providing data on the number of farm animals exclusively at the end of the calendar year, not at the end of March as was the case until 2023. For the next submission

(2025), it will be necessary to change all activity data on the number of farm animals as of 31.12. of the given year. Preliminary testing results show that while the number of dairy cows will remain the same, the number of animals in each other category (cattle, swine and other as well) will decrease by an average of 3% in each of them. Both data (end of March, end of the year) are available for the period 2010-2022. Existing parallel data allows to estimate number of cattle by categories for the period 1990-2010.

The relevant research in the Czech Republic should focus on specifying the quality (composition) of the feed rations in terms of dry matter and non-detergent fiber content for individual cattle categories or specifying the composition of the feed rations in grazing and intensive farming. By adjusting the feed rations, a significant reduction in methane emissions from enteric fermentation can be achieved. When the research results are available, the NIR team will use them to update the input data.

5.2.2 Manure Management (CRF 3.B)

This chapter describes the estimation of CH_4 (49% contribution to emissions from the manure management category) and direct (25%) and indirect (26%) N_2O emissions from animal manure management. The total emissions from manure management (CH_4 and N_2O) equalled 758 kt CO_2 in 2022. For detailed information, see Tab. 5-2. The extensive decrease, from 2011 to 2022 by about 18%, is caused by methodological update in shares of different animal waste management systems (AWMS) and a transition to country-specific data of nitrogen excretion rate.

Good agricultural practices were developed, based on agricultural policies and structures that support the trends in the animal waste management system allocation after the Velvet Revolution (1989) and mainly after the Czech Republic entered the European Union (2004). These procedures include inexpensive and austerity measures, such as the incorporation of relevant proteins in livestock feed, regular cleaning of stables or proper timing of manure applications to agricultural land in the period when plants absorb the maximum amount of nutrients. These measures may also involve other procedures, such as using low-emission techniques for manure application, storage and suitable livestock housing.

5.2.2.1 Source category description

This emission source covers manure management for domestic livestock. Both nitrous oxide (N_2O) and methane (CH_4) emissions from manure management of livestock (cattle, swine, sheep, horses, goats and poultry) are reported.

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 matter by anaerobic and facultative bacteria under anaerobic conditions. Emissions are dependent on the amount of organic matter in manure, climatic conditions and manure management. An overview of the total emissions from manure management is presented in Tab. 5-19.

During the period 1990-2022, the emissions from manure management decreased by about 70%. Decreasing emissions from cattle and swine predominated in this trend. The reduction in the cattle population is partly counterbalanced by an increase in cattle efficiency (increasing gross energy intake and milk production and milk quality).

Tab. 5-19 Overview of emissions from manure management [kt CO_2 eq.], 1990-2022

Year	Total emissions, category 3.B	CH_4 emissions	Direct N_2O emissions	Indirect N_2O emissions
	[kt CO_2 eq.]			
1990	2 571	1 575	554	442
1995	1 760	1 115	358	288

2000	1 574	981	328	265
2005	1 312	799	281	232
2010	939	515	226	198
2015	735	354	190	191
2016	765	375	192	198
2017	751	368	189	194
2018	792	391	198	203
2019	773	382	193	198
2020	777	385	193	198
2021	777	385	193	198
2022	758	371	191	196

5.2.2.2 Methodological aspects

5.2.2.2.1 Animal waste management systems

The first country specific AWMS system distribution had been based on the expert study of Mudřík and Hons (2004) and was updated several times (last time in 2011) by the expert opinions during the reporting period. The more recent update of AWMS for cattle, swine and poultry categories was based on Klír (2019) and Nesňal et al. (2018) concerned with the 2016-2021 data series. The amount of manure in liquid and solid forms consumed in anaerobic digesters was derived from the statistical survey. AWMS were upgraded based on Klír et al. (2011) for goats, horses, and sheep as well. This upgrade concerned the data series 2014-2022.

For the previous submission (2023), we ensured that the animal waste management system (AWMS) data were updated and adjusted with respect to the likely development of manure management handling, to remove inconsistencies in individual handling shares. This issue was commented on in the last review (Issue ID A14). The current form of AWMS respects the gradual onset of anaerobic digestion in full compliance with UN-ECE reporting and OECD/EUROSTAT reporting. It is an important step to complete the harmonization of ammonia and NO_x reporting and nitrous oxide reporting. The overview of the country-specific distribution of AWMS is shown in Tab. 5-21, Tab. 5-22 and Tab. 5-23 and Fig. 5-2).

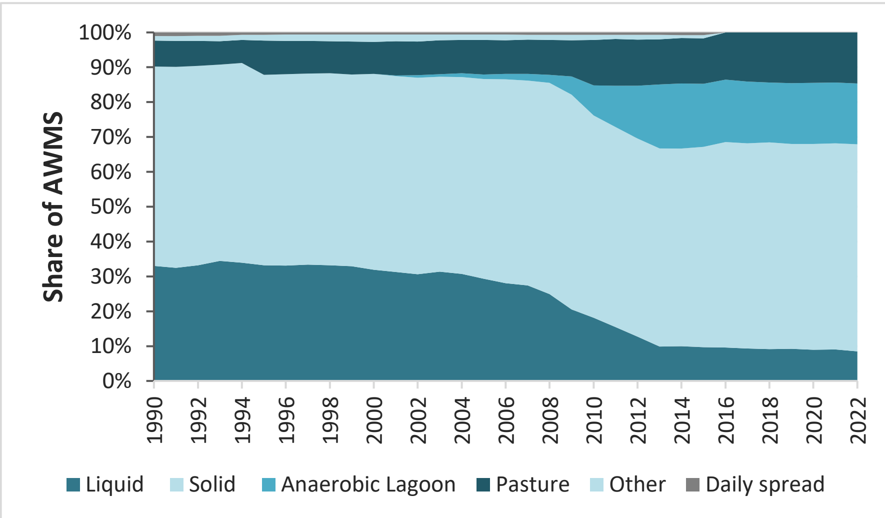

Fig. 5-2 Animal waste management systems distribution, all livestock, 1990-2022

There are four main manure management systems defined in the Czech Republic (Klír 2011, Klír 2019) according to Table 10.18 (IPCC 2006, IPCC 2019), from the reporting year 2015:

1. Anaerobic digesters

2. Liquid storage
3. Solid storage
4. Pasture/Range/Paddock

The use of manure in anaerobic digesters is relevant for cattle, swine and poultry manure. The operation of anaerobic digesters began in 2001 when two biogas stations started to work. The specific structure of Czech animal breeding (mostly in factory farming) made it possible to build anaerobic digesters close to farms to consume daily manure production very efficiently without the need to store the manure. Consumption of manure in anaerobic digesters in the Czech Republic is limited because the sources of biological input (manure, green biomass etc.) are also limited. The number and capacity of anaerobic digesters remained at their maximum number from 2013 (Tab. 5-20).

Tab. 5-20 Increase in the number of biogas stations, estimation of total digestate production and amount of nitrogen in digestate, 2001-2021 (www.biom.cz)

Year	Number of biogas stations	Digestate production [1 000 t/year]	Amount of N in digastate [kg/year]
2001	2	42	210 000
2005	10	210	1 050 000
2010	135	2 835	14 175 000
2011	204	4 284	21 420 000
2012	327	6 867	34 335 000
2013	386	8 106	40 530 000
2014	386	8 106	40 530 000
2015	386	8 106	40 530 000
2020	386	8 106	40 530 000
2021	386	8 106	40 530 000

Animal waste management systems (AWMS) are used for N_2O and CH_4 emission estimations in the same way. The annual update of the AWMS is possible thanks to the cooperation with the Crop Research Institute (Dr. Klír, Dr. Wollnerová) and unification of Nex rate for all categories of farm animals. The result of the intensive cooperation was the unification of input data in all country reports on nitrogen emissions and the nutrition balance from the agricultural sector.

Tab. 5-21 Overview of Czech country-specific AWMS: dairy and non-dairy cattle, fractions of individual manure management systems [%], 1990-2022

Livestock category	Type of AWMS Fraction of manure N per AWMS [%]				
Dairy cattle	Anaerobic digesters	Liquid system	Daily spread	Solid storage	PRP
1990	0	25	2	68	5
1995	0	24	1	65	10
2000	0	25	1	64	10
2005	2	24	1	62	11
2010	15	19	1	58	7
2015	32	11	0	54	2
2020	33	11	0	56	0
2021	33	11	0	56	0
2022	32	11	0	57	0
Non-dairy cattle (weighted avg.)					
1990	0	27	1	60	12
1995	0	23	1	59	17
2000	0	18	1	64	17

Livestock category	Type of AWMS Fraction of manure N per AWMS [%]				
Dairy cattle	Anaerobic digesters	Liquid system	Daily spread	Solid storage	PRP
2005	0	17	1	61	16
2010	2	10	1	63	17
2015	3	6	1	63	25
2020	3	7	0	63	28
2021	3	6	0	63	28
2022	3	7	0	62	28

Tab. 5-22 Overview of the Czech country-specific AWMS: swine and poultry, fractions of individual manure management systems [%], 1990-2022

Livestock category	Type of AWMS Fraction of manure N per AWMS [%]					
Swine	Anaerobic digesters	Liquid system	Daily spread	Solid storage	PRP	Other
1990-2001	0	76	0	23	0	1
2002	1	75	0	23	0	1
2005	2	75	0	23	0	0
2010	19	56	0	25	0	0
2015	47	28	0	25	0	0
2020	45	23	0	32	0	0
2021	45	23	0	33	0	0
2022	48	20	0	32	0	0
Poultry						
1990-2000	0	0	0	84	2	14
2001	1	0	0	84	2	13
2005	2	0	0	84	2	12
2010	3	0	0	84	2	11
2015	6	0	0	84	0	10
2020	9	0	0	91	0	0
2021	7	0	0	93	0	0
2022	7	0	0	93	0	0

Tab. 5-23 Overview of the Czech country-specific AWMS systems: sheep, horses and goats, fractions of individual manure management systems [%], 1990-2022

Livestock category	Type of AWMS Fraction of manure N per AWMS [%]				
	Liquid system	Daily spread	Solid storage	PRP	Other
Sheep	0	0	50	50	0
Horses	0	0	40	60	0
Goats	0	0	40	60	0

The animal waste management system (AWMS) has been updated annually based on a long-term statistical survey of agricultural farms in the Czech Republic. This investigation, ongoing since 2005, evaluated crop production and livestock production of the farms. From the point of view of AWMS, data on livestock housing systems are processed annually. These data show the percentage of individual housing and grazing systems for individual categories of animals. A further complementary basis for the uniform calculation of the AWMS was the statistical study of IAEI (Institute of Agricultural Economics and Information), which surveyed farms for manure transferred annually to biogas stations. Based on these data, nitrogen production in livestock manure (Nex rate) was divided according to the percentage of individual housing systems for each livestock category. Subsequently, the amount of nitrogen in the manure transferred to biogas stations was separated. The result was the determination of the percentage share of individual methods of handling slurry in agriculture.

Manure management storage and usage are subjected to national Decree No. 377/2013 Coll. This regulation is based on EU regulation No. 91/676/EHS from 1991. The manure storage capacity corresponds to the estimated production for 6 months. This does not apply to the storage of solid manure on agricultural land before use. Solid manure may be stored on agricultural land at suitable places in a field for a maximum period of 24 months. The company/owner can store the manure for fertilizer again on the same agricultural land four years after soil cultivation of the agricultural land. Liquid manure is to be stored in leak-proof tanks or scrub areas in stables. Reservoirs and tanks or areas in the stables must match the capacity of at least four months estimated production of liquid manure or share at a minimum of three months estimated production of liquid manure and dung, depending on the climatic conditions of the region. The decree No. 377/2013 Coll. includes five annexes with data for calculating the production of manure in a situation where records of the manure management system evidence on individual farm level are not available (e.g. typical animal mass of livestock, nitrogen content in excrements, dry mass of excrements etc.). A farmer can calculate the production and control the use of manure according to the number of heads of livestock.

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, TA /see Tab. 5-1). The estimation of methane emissions from manure management for cattle and swine categories is performed according to the Tier 2 method. Methane emissions in other livestock categories are estimated according to the Tier 1 approach.

In relation to the decreasing trend in the animal population (especially cattle and swine), the methane emissions from manure management had rapidly decreased during the period 1990-2010. The trend in methane emissions from manure management is presented in Fig. 5-3. Between 2012-2022, emissions increased slightly, on average just under 4%, with a minimum in 2014 and a maximum in 2018.

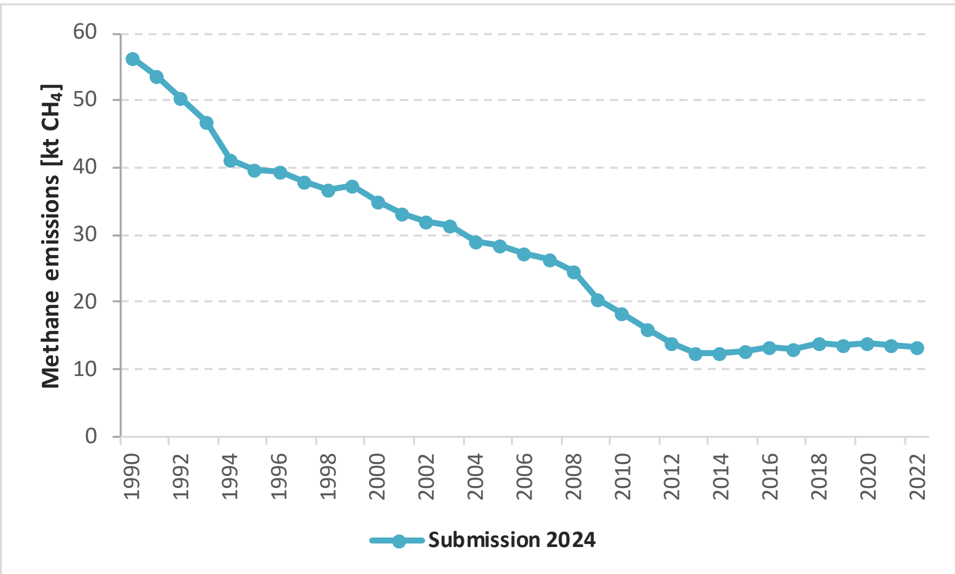

Fig. 5-3 Trend in methane emissions from manure management, 1990-2022

Cattle category

The activity data on cattle population distributed by age and gender were obtained from the Statistical Yearbook of the Czech Republic (CzSO), providing a consistent time series of the animal population numbers during the entire reported period (1990-2022). Gross energy (GE) values were estimated based on the national study of Kolář et al. (2004) and IPCC 2006 Gl. and IPCC 2019 Gl. in the special spreadsheet (more information in the Enteric Fermentation chapter). In connection with the refinement of activity data in the calculation of gross energy intake (chapter Enteric Fermentation), the value of volatile solids (VS) was changed. Methane conversion factor (MCF) changed because of the changes in AWMS (Fig. 5-2). Consequently, the methane emission factor from manure management changed significantly in all cattle categories. GE values are reported in CRF as country-specific data for the entire reported period (**Tab. 5-24**).

Tab. 5-24 Gross energy (GE) for dairy and non-dairy cattle [MJ/head/day], reported period 1990-2022

	1990	1995	2000	2005	2010	2015	2020	2021	2022
Dairy cattle	228.9	246.8	268.9	297.0	307.7	331.8	364.4	364.7	368.9
Other cattle	118.3	131.7	143.3	153.9	163.1	165.8	170.6	170.6	170.7

EF is calculated for each cattle category and reported for dairy and non-dairy cattle. The value reported for non-dairy (other) cattle is the weighted average of results calculated for each non-dairy category separately. The total emissions are the sum of two products ($EF_{DairyCattle}$*population of dairy cattle + $EF_{NonDairyCattle}$ *population of non-dairy cattle).

The current updated data on the AWMS distribution were employed for the emission estimation. Other specific parameters for estimating the emission factors for cattle (B_o, MCF) were obtained from Dämmgen et al. (2012). The specific parameters recommended to use by studies in neighbouring countries are the same as the default values of IPCC 2006 Gl. and correspond to the climate zone in the country. The parameters recommended in Dämmgen et al. (2012) were used for the emission estimation (Tab. 5-25). The VS parameters calculated by Dämmgen et al. (2012) based on B_o, ASH and MCF values and EF for estimating the methane emissions are presented in Tab. 5-25 and Tab. 5-26.

Tab. 5-25 Activity data, input data and calculated data used for estimating methane emission factors for manure management for all age cattle categories, actual data for 2022

	Dairy	Suckler	Mature Heifers	Mature Bulls	Heifers 1-2 yrs	Bulls 1-2 yrs	Heifers 6-12 m	Bulls 6-12 m	Calves,F <0,6 m	Calves,M <0,6 m
Population [1 000 heads], CzSO	358	229	68	21	210	105	114	73	138	105
Body weight [kg], CS	650	650	600	800	470	560	265	300	115	115
GE, gross energy intake [MJ/head/day]*	368.86	262.76	217.20	276.83	187.18	203.26	115.05	143.26	66.52	67.67
DE, digestibility of feed [%], CS	70	64	60	60	66	71	66	66	66	66
ASH, content of manure as a fraction of dry feed intake, [%]	8	8	8	8	8	8	8	8	8	8
VS, volatile solid excr. per day in dry organic matter *	6.25	5.24	4.77	6.07	3.55	3.35	2.18	2.72	1.26	1.28
Sum of (MCF*AWMS) *	0.0332					0.0266				
B_o, maximum methane producing capacity	0.24	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
EF from manure management [kg CH_4/head/year]*	12.04	5.19	4.72	8.96	3.83	3.51	2.59	2.87	1.91	1.95

**Calculated value*
CS – country-specific data
CzSO – Statistical Yearbook of the Czech Republic, the Czech Statistical Office
B_o – Table 10A-4, Table 10A-5, IPCC 2006 Gl.
ASH – recommendation p. 10.42 IPCC 2006 Gl.

Tab. 5-26 List of parameters for methane emission factor estimation from manure management in the Czech conditions, MCF values [%]

Cattle, all age categories	MCF values (IPCC 2006 Gl., Table 10.17) [%]
Anaerobic digesters	1
Liquid system	17
Daily spread	0.1
Solid storage	2
Pasture, range and paddock	1

The equations for determining the emission factors and estimating the methane emissions were taken from IPCC 2006 Guidelines:

1. 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. 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 methane emission factors were estimated using Eq. 10.23 (IPCC 2006 Gl., p. 10.41):

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

An overview of the daily volatile excreted solids (VS, kg dry matter/animal/day), methane emission factor and methane emissions for dairy cattle and non-dairy cattle is presented in Tab. 5-27.

Tab. 5-27 Overview of VS [kg dry matter/head/day], EF [kg CH_4/head/year] and methane emissions [kt] from manure management, dairy and non-dairy category, 1990-2022

Year	Dairy cattle			Other cattle		
	VS [kg DM/head/day]	EF [kg CH_4/head/yr]	Methane emissions [kt CH_4]	VS [kg DM/head/day]	EF [kg CH_4/head/yr]	Methane emissions [kt CH_4]
1990	4.22	14.03	16.93	2.30	5.45	12.54
1995	4.55	14.65	10.73	2.57	5.63	7.31
2000	4.83	15.95	8.74	2.81	5.38	5.52
2005	5.18	17.56	7.60	3.04	5.49	5.27
2010	5.22	14.12	5.41	3.20	4.28	4.13
2015	5.62	10.86	4.09	3.19	3.37	3.47
2016	5.76	11.26	4.19	3.17	3.35	3.50
2017	5.82	11.38	4.21	3.12	3.29	3.46
2018	6.02	11.77	4.30	3.28	3.64	3.82
2019	6.03	11.74	4.28	3.28	3.64	3.83
2020	6.18	12.04	4.33	3.30	3.66	3.82
2021	6.18	12.05	4.32	3.30	3.66	3.84
2022	6.25	12.04	4.31	3.30	3.62	3.85

Swine

In 2019, ERT from EU noted that the Tier 1 methodology used for CH_4 emissions from manure management of swine, which is one of the key sources, resulted in a potential over-estimate exceeding the threshold of significance. Recalculation based on country-specific zoo-technical data was planned for the Submission 2022 according to the improvement plan. In 2020, ERT noted the requirement of a Tier 2 approach to be used obligatorily in Submission 2021 and proposed a Potential Technical Correction (PTC) that used the default IPCC parameters and Eq. 10.23 (IPCC 2006). The list of parameters recommended is listed in the following Tab. 5-28 and Tab. 5-29. Since Submission 2022 this update was implemented in the inventory.

Czech statistical data allows splitting the swine population into two subpopulations: market swine and breeding swine (CzSO). The proportion between subpopulations varies from 9% to 12% over a time series. The proportion of 12% was recorded in the years 1990-1995, the lowest proportion of breeding animals was recorded in 2008. There are the default value data of maximum methane producing capacity and volatile solids available in T. 10A-7 (IPCC 2006). Country-specific AWMS allows to calculate methane conversion factor. Results of the current estimation are available in Tab. 5-30.

Tab. 5-28 List of parameters for estimating methane emissions from manure management of swine in the Czech conditions, data 2022

Input data (2022)	Market swine	Breeding swine	Data source
Swine population [1 000 heads]	1312.63	120.19	CzSO
VS, volatile solid [kg/head/day]	0.3	0.46	IPCC T. 10A-7, T. 10A-8
B_0, maximum methane producing capacity	0.45	0.45	IPCC T. 10A-7, T. 10A-8
MS * MCF, [%]	5.30	5.30	CS, IPCC T. 10.17

Tab. 5-29 List of parameters for estimating methane emissions from manure management of swine in the Czech conditions, MCF values [%], data 2022

Swine, all subcategories	MCF values (IPCC 2006 Gl., Table 10.17, CS) [%]		
AWMS (CS)	Share of MS (2022)	MCF values	MS*MCF
Anaerobic digesters	48.1	2.8*	1.35
Liquid system	19.4	17	3.30
Solid storage	32.5	2	0.65
Other	0	1	0
Sum MS*MCF			5.30

**Recommended value, technical correction, 2021, TERT*

Tab. 5-30 Activity data for estimating methane emissions from manure management of swine in the Czech conditions, 1990-2022

Year	Market swine		Breeding swine		Weighted avg.	
	VS [kg DM/head/day]	EF [kg CH_4/head/yr]	VS [kg DM/head/day]	EF [kg CH_4/head/yr]	EF [kg CH_4/head/yr]	Total emissions [kt CH_4]
1990	0.3	4.43	0.46	6.79	4.71	22.56
1995	0.3	4.43	0.46	6.79	4.72	18.24
2000	0.3	4.43	0.46	6.79	4.70	17.32
2005	0.3	4.36	0.46	6.69	4.63	13.31
2010	0.3	3.31	0.46	5.07	3.49	6.66
2015	0.3	1.74	0.46	2.66	1.82	2.84
2016	0.3	2.12	0.46	3.24	2.22	3.57
2017	0.3	2.07	0.46	3.17	2.17	3.23
2018	0.3	2.01	0.46	3.09	2.11	3.28
2019	0.3	1.93	0.46	2.96	2.02	3.12
2020	0.3	1.90	0.46	2.92	1.99	2.99

2021	0.3	1.89	0.46	2.90	1.98	3.01
2022	0.3	1.75	0.46	2.68	1.83	2.62

** Implementation of AWMS system update*

This methodological update made for Submission 2022 resulted in decreased estimates of methane emissions from manure management.

Other livestock categories

Methane emissions from other farm animals are estimated by the Tier 1 approach. The default EFs for the developed countries were employed (Tab. 5-31):

Tab. 5-31 Default methane emission factors used for estimating CH_4 emissions from manure management (Table 10.15 and 10.14 IPCC 2006 Gl.)

Livestock category	EF [kg CH_4/head/year]
Sheep	0.19
Goats	0.13
Horses	1.56
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 systems (13% wet and 87% dry systems; 0.182 = 1.2 x 0.13 + 0.03 x 0.87).*

A more detailed description of methane emissions from manure management for poultry category is presented in Tab. 5-32:

Tab. 5-32 Activity data, default emissions factors (Table 10.15 IPCC 2006 Gl.) and emissions estimated for poultry population

Poultry population	[1 000 heads] data 2022 (CzSO 2023)	EF [kg CH_4/head/year]	CH_4 emissions [kt/year]
Poultry	23 026	0.104 (IEF)	2.39
Broilers	11 155	0.02**	
Other poultry	11 872	0.182*	
Wet system, 13%		1.2**	
Dry system, 87%		0.03**	

** Weighted average calculated from subcategories*

*** Manure management methane emission factors (T. 10.15 IPCC 2006 Gl.)*

5.2.2.2.3 Nitrogen excretion rate

The determination of Nex rate has undergone development related to the availability of activity data and efforts to unify Nex values within the framework of UN-ECE, OECD and IPCC reporting.

Nex value in all animal categories, except cattle, were based on the national data for typical animal mass (TAM), Eq. 10.30 IPCC 2006 Gl. and the default excretion rate (Table 10.19, IPCC 2006) until NIR 2021 submission. Nex value for cattle had been calculated in a special spreadsheet, common for the calculation of emission factors used for methane emissions from enteric fermentation and manure management. This calculation was based on population data, annual average excretion rates calculated from gross energy intake (GE) and share of protein in feed and milk. The parameters for estimating the Nex value for cattle were collected from literature sources and personal communication with agricultural experts. The value of protein content in milk was obtained from relevant literature (Poustka 2007, Ingr 2003 and Turek 2000). This also applies for protein content in feed (in dry matter) of 16.5% (Zeman, the Czech feeding standards 12-21%, Central Institute for Supervising and Testing in Agriculture 18%, Karabcová, personal communication 16-18%). The Nex rate had been estimated for each cattle category and reported for dairy, non-dairy (weighted average) and as a summarized total for cattle.

The above-mentioned procedure was revised for NIR 2021 submission (data 2019) when the country-specific value of Nex was newly derived from the national legislation (Decree No. 377/2013 Coll.). We made the change effective since 2019, making the data in the time series inconsistent. Therefore, to unify the inputs since 2019 among all relevant reporting (UN-ECE, OECD, EUROSTAT).

Decree No. 377/2013 Coll., on the storage and use of fertilizers states the average values of annual nitrogen production, calculated per unit of livestock (1 Livestock Unit = 500 kg live weight of animals). These values were used as coefficients to derive the Nex rate. The reported coefficients were obtained based on a study of the Ministry of Agriculture of the Czech Republic (research project No. QH82283 "Study on interaction between water, soil and environment from the point of view of manure management in sustainable agriculture", 2008-2012). This study analysed manure production in various systems of animal housing used in the Czech Republic. The research was based on a detailed survey of the annual manure production per one livestock unit (LU), considering the technological systems of animal housing, the production of various types of manure and species and categories of animals. The results of the survey were used for in force legislation amendment from 1998 and further published in the proceedings of an international conference in 2011 (Klír 2011). On 1 November 2021, another amendment to this regulation came into force under No. 392/2021 Coll.

Based on the last review recommendation (Issue ID A7, A5) we eliminated typical animal mass fluctuations for goats, sheep and horses which arose due to a lack of suitable statistical information in the current submission. We verified the TAM values by comparing the default N rate (T. 10.19, IPCC 2006 and IPCC 2019) and country-specific data provided by Decree No. 377/213 Coll. The Nex rate data was revised and corrected for the entire reporting period. Additionally, the erroneous N rate value used for swine was corrected (0.51 instead of incorrectly used 0.68) for this inventory (Submission 2023).

Based on validation, we adjusted the Nex rate value for some livestock categories within a previous Submission 2023. The following adjustments were applied (**Tab. 5-33**), the detailed explanation is provided in the text below the table:

Tab. 5-33 Overview of input data for nitrogen excretion calculation

Livestock category	N rate [kg N/1 000 kg/day]	TAM Typical animal mass	Nex rate 1990-2019 [kg N/head/year]	Nex rate 2020-2022 [kg N/head/year]
Dairy cattle	Country-specific	Country-specific	Country-specific	Country-specific
Non-dairy cattle	Country-specific	Country-specific	N rate * TAM	N rate*TAM
Swine	Default/ Country-specific	Country-specific	N rate * TAM	Country-specific
Sheep	Default/ Country-specific	Default	N rate * TAM	Country-specific
Goats	Default/ Country-specific	Default	N rate * TAM	Country-specific
Horses	Default/ Country-specific	Country-specific	N rate * TAM	Country-specific
Poultry	Default/ Country-specific	Country-specific	N rate * TAM	Country-specific

Dairy cattle - Based on the proposal of experts from CRI, the Nex rate value for the entire time series was taken newly from OECD reporting (Tab 5-35). Estimation of the amount of excreted nitrogen is based on milk production. Country specific N rate corresponds to the default value.

Non-Dairy cattle – validation of nationally specific values was performed by comparing the default N rate value (according to IPCC 2006 and 2019 Guidelines) and the country specific N rate value that can be derived from Decree 377/2013 Coll. The newly determined Nex value was calculated from the weighted average TAM of the non-dairy cattle and the country specific value of the N rate.

Swine - the validation of country specific values was prepared by comparing the default value of N rate (according to IPCC 2006 and 2019 Guidelines) and the country specific value of N rate, which can be derived from decree 377/2013 Sb and whose value from the default parameters corresponds well. TAM values gradually decreased from 62 kg (1990-2005), 60 kg (2006-2014), 59 kg (2015-2021).

Sheep and goats - validation of country specific values were performed by comparing the default N rate value (according to IPCC GL 2006 and 2019) and the nationally specific N rate value, which can be derived from Decree 377/2013 Sb and whose value corresponds well with the default parameters. Because country specific data on sheep and goats TAM are not available, the IPCC Guidelines 2006 default values for the entire time series were used for the calculation (for sheep 59 kg, for goats 38.5 kg).

Horses - the validation of the country specific values was performed by comparing the default N rate value (according to IPCC 2006 and 2019 Guidelines) and the nationally specific N rate value, which can be derived from Decree 377/2013 Sb and whose value corresponds well with the default parameters. Since no country specific data on horse TAM are available, the value determined by expert estimation was adjusted so that its changes were consistent in the time series. TAM is gradually increased: 520 kg (1990-1999), 530 kg (2000- 2008), 540 kg (2009-2018), 550 kg (2019-2021).

All these changes were reflected in the amount of direct and indirect nitrous emissions. Overview of Nex rate values used for calculation is shown in Tab. 5-34:

Tab. 5-34 Nex rate values used for estimating nitrous emission, data 1990-2022

Year	Updated value of Nex rate [kg N/head/year]					
	Non-dairy cattle	Swine	Sheep	Goats	Horses	Poultry
1990	46.4	11.5	9.7	9.7	47.5	0.7
1995	47.8	11.5	9.7	9.7	47.5	0.7
2000	51.2	11.5	9.7	9.7	48.4	0.7
2005	54.4	11.5	9.7	9.7	48.4	0.8
2010	54.7	11.2	9.7	9.7	49.3	0.8
2015	55.1	11.0	9.7	9.7	49.3	0.5
2016	57.0	11.0	9.7	9.7	49.3	0.5
2017	56.3	11.0	9.7	9.7	49.3	0.5
2018	59.9	11.0	9.7	9.7	49.3	0.5
2019	58.7	11.0	9.8	9.8	49.3	0.5
2020	58.7	11.0	9.8	9.8	49.2	0.5
2021	58.8	11.2	9.8	9.8	49.1	0.5
2022	58.8	10.5	9.8	9.8	49.1	0.5

In the case of dairy cattle, the Nex rate value for the entire time series was taken newly from EUROSTAT reporting (the documentation provided by the CRI team responsible for this reporting), because the calculation of the amount of excreted nitrogen is dependent on milk production, which is increasing in the Czech Republic since 1990.

This equation was used for the calculation of nitrogen excretion rate from milk production:

$$Nex\ rate = 46.787 * (\ln(annual\ milk\ yield) - 308.49)$$

Tab. 5-35 Source data for calculation of nitrogen excretion rate for dairy cattle

Year	Milk production [l/year]	Milk production [kg/day]	Nex [kg N/head/day]
1990	3949	11.12	79.0
1991	3712	10.45	76.1
1992	3791	10.68	77.0
1993	3 824	10.77	77.5
1994	3 964	11.16	79.1
1995	4 117	11.60	80.9
1996	4 289	12.08	82.8
1997	4 366	12.30	83.7
1998	4 837	13.62	88.5
1999	5 022	14.14	90.2
2000	5 255	14.80	92.3
2001	5 589	15.74	95.2
2002	5 718	16.10	96.3
2003	5 756	16.21	96.6
2004	6 006	16.92	98.6
2005	6 254	17.61	100.5
2006	6 370	17.94	101.3
2007	6 548	18.44	102.6
2008	6 776	19.08	104.2
2009	6 870	19.35	104.9
2010	6 904	19.44	105.1
2011	7 128	20.07	106.6
2012	7 433	20.93	108.6
2013	7 443	20.96	108.6
2014	7 705	21.70	110.2
2015	8 001	22.54	112.0
2016	8 061	22.70	112.4
2017	8 223	23.16	113.3
2018	8 526	24.01	115.0
2019	8 471	23.86	114.7
2020	8 893	25.05	116.9
2021	8 916	25.11	117.1
2022	9 084	25.59	117.9

An overview of the estimated nitrogen excretion value used for the calculation of N_2O emissions from manure in the cattle category is presented in Tab. 5-34 Tab. 5-37. An overview of all activity data used in the current submission is performed in Tab. 5-36.

Tab. 5-36 Activity data, input data and calculated data used for estimation of annual nitrogen excretion rate for all animal categories, actual data 2022

Livestock category	N Production Decree No. 377/2013 [kg N/1 000 kg/day]	Animal weight [kg]	Nitrogen excretion [kg N/head/year]	N Production [kg N/livestock category]
Dairy cattle	0.49	650	117.90	42 238 265
Non-dairy cattle	0.39	417.9	58.77	62 472 451
Swine	0.52	59	10.5	15 062 069
Goats	0.69	38.5	9.75	239 918
Sheep	0.55	48.5	9.75	1 698 411
Horses	0.24	550	49.13	1 857 430

Livestock category	N Production Decree No. 377/2013 [kg N/1 000 kg/day]	Animal weight [kg]	Nitrogen excretion [kg N/head/year]	N Production [kg N/livestock category]
Poultry	0.50	1.44*	0.51	11 634 566
Total				**135 203 110**

**weighted average*

5.2.2.2.4 Direct and indirect nitrous oxide emissions (CRF 3.B.2)

N_2O emissions from manure management were identified as a key source. Since 2019 (Submission 2021), Tier 2 methodology was used for estimating the emissions in all animal categories. The country-specific value of Nex was derived newly from the national legislation (Decree No. 377/2013 Coll.). The methodological level upgrade was possible due to the use of country-specific input data evaluating the rate of nitrogen excretion. Emissions were calculated based on nitrogen excretion per animal and the animal waste management system. Following the IPCC guidelines, all N_2O emissions that took place before applying manure into soils are reported under manure management (3.B). The IPCC guidelines method for estimating N_2O emissions from manure management entails multiplying the total amount of N excretion (from all animal species/categories) in each type of manure management system by the emission factor for that type of manure management system. The overview of direct and indirect N_2O emissions is provided in Tab. 5-37.

To estimate N_2O emissions from manure management, the default emission factors for the different animal waste management systems were taken from Table 10.21 (IPCC 2006) see Tab. 5-37.

Input data consists of the mass fraction Xi,j of animal excrement in the animal category i (i = dairy cows, other cattle, pigs, …) for various types of waste management (AWMS) j (actually: j = liquid manure, solid manure, pasture, anaerobic digesters). Here, it holds that Xi, 1 + Xi, 2 + ... + Xi, 6 = 1. Within the Tier 1 method, only the values of matrix X for typical means of management of animal excrements in Europe are given. AWMS parameters presented in the IPCC 2006 Guidelines were adapted to the Czech conditions.

Tab. 5-37 Default IPCC emission factors for direct N_2O emissions used actually for different AWMS (T.10.21, IPCC 2006)

AWMS	Emission factor (EF3) [kg N_2O-N per kg N excreted]
Anarobic digesters	0
Daily spread	0
Liquid/Slurry	0.005
Solid Storage	0.005

The emissions are then summed over all the manure management systems. The manure production data for individual AWMS in Submission 2024 are reported in Tab. 5-38. Values reflected the different approaches to AWMS and the use of country-specific values of Nex (data 2010-2022).

Tab. 5-38 Nitrogen production of manure distributed in individual AWMS [kg N/yr], data 2010-2022

AWMS	N Production [kg N/year]				
	2010	2015	2020	2021	2022
Liquid system	24 879 416	12 836 231	12 098 675	12 211 137	11 476 326
Solid storage	79 443 276	75 221 019	80 520 950	80 538 817	80 343 687
Anaerobic digesters	11 719 312	23 905 613	24 207 189	24 131 202	23 581 665
Pasture	17 842 675	17 323 895	19 474 881	19 280 301	19 801 432
Other	2 074 082	1 117 818	0	0	0
Daily spread	931 015	988 928	0	0	0
Total	**136 889 775**	**131 393 503**	**136 301 694**	**136 161 457**	**135 203 110**

5.2.2.2.5 Indirect emissions from manure management (CRF 3.B.2.5)

Indirect emissions originate from volatile nitrogen losses that occur primarily in the form of ammonia and NO_x. 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 nitrogen volatilization in the form of NH_3 and NO_x from manure management systems (MMS) is based on multiplying the amount of nitrogen excreted (from all livestock categories) and managed in each MMS by the fraction of nitrogen volatilized (Eq. 10.26 IPCC 2006). Nitrogen losses are then summed over all the MMS (Eq.10.26, Table 10.22, IPCC 2006 Gl.). For estimating 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). The fraction of the total nitrogen volatilized from manure is about 40% of the total nitrogen excreted by all animal categories excluding MMS „pasture".

In cooperation with the Crop Research Institute, a specific value for the proportion of nitrogen from manure that is leached from MMS "solid storage" was estimated. The results of the recent research (Klír et al. 2018) were used for estimating the country-specific $Frac_{leachMS}$ value. The value is 1% of solid manure stored outdoors or in feedlots.

Tier 1 calculation of nitrogen losses due to leaching from MMS is based on Eq. 10.28, IPCC 2006, where the amount of nitrogen from the solid fraction of annual production of manure per animal is multiplied by the percentage of managed manure nitrogen losses for the livestock category (country-specific value) $Frac_{leachMS}$. Emission factors EF_4 and EF_5 from Table 11.3, IPCC 2006 are used in this estimation.

An overview of indirect and direct N_2O emissions estimated during the period 1990-2022 is presented in Tab. 5-39.

Tab. 5-39 Indirect and direct N_2O emissions from manure management [kt N_2O/year], 1990-2022

Year	N_2O emissions of N from manure management [kt N_2O/year]				Total N_2O emissions
	Indirect			Direct	
	Volatilisation IPCC Eq. 10.27	Leaching IPCC Eq. 10.28	Total		
1990	1.65	0.02	1.67	2.09	3.76
1995	1.07	0.01	1.09	1.35	2.43
2000	0.99	0.01	1.00	1.24	2.24
2005	0.86	0.01	0.87	1.06	1.94
2010	0.74	0.01	0.75	0.85	1.60
2015	0.70	0.01	0.71	0.71	1.42
2016	0.73	0.01	0.74	0.72	1.46
2017	0.72	0.01	0.73	0.72	1.43
2018	0.75	0.01	0.76	0.75	1.50
2019	0.74	0.01	0.75	0.73	1.48
2020	0.74	0.01	0.75	0.73	1.48
2021	0.74	0.01	0.75	0.73	1.48
2022	0.73	0.01	0.74	0.72	1.46

The above-mentioned changes in activity data described in previous chapters caused a decrease in direct and indirect emissions in the all-time series except for the last two years. The decrease was by about 23%

in direct emissions, by about 15% in indirect emissions and by about 20% in total nitrous emissions from manure management.

Coordination with the reporting under the Convention on Long - Range Transboundary Air Pollution

In 2021, a recalculation of ammonia and NO_x emissions originating from manure management and manure application continued. The purpose of this recalculation was a national ammonia and NO_x emissions inventory improvement by use of a Tier 2 approach with implementation of some ammonia abatement measures. Tier 2 uses a mass-flow approach based on the concept of a flow of TAN through the manure management system. The Excel Manure Management N-flow tool was used for it. Except calculation of ammonia and NO_x emissions, the N flow tool is also able to calculate N_2O emissions. These emissions of N_2O are considered as Emissions from Manure Management (CRF 3.B.2.5). The comparison of results generated by N-Flow tool and NIR procedures showed inexplicable differences in estimated N_2O emissions when the same input data were used. The Czech team will continue its efforts to harmonize input data and estimates of the results of emissions reported from the agricultural sector in the Convention on Long-range Transboundary Air Pollution and in the NIR.

For Submission 2023, we ensured that the data on AWMS were updated and adjusted with respect to the likely development of manure handling, in particular to remove jump changes in individual management systems shares. The current form of AWMS respects the gradual onset of anaerobic digestion in full compliance with the UN-ECE reporting. It is an important step to complete the harmonization of ammonia and NO_x reporting and nitrous oxide reporting.

In 2023, the harmonization process focused on the evaluation of measures reducing ammonia emissions on the amount of indirect N2O emissions from manure management. Cooperation in this field will continue.

5.2.2.3 Uncertainty and time-series consistency

Uncertainty estimates are based on the expert judgment. The uncertainty in the activity data equals 5%. The uncertainty in the emission factor equals 20% for estimation of CH_4 emissions and 30% for the estimation of N_2O emissions. The combined uncertainty for CH_4 emissions equals 20.6% and that for N_2O emissions equals 30.4%.

The time series consistency was negatively affected by unequal development of the individual manure systems distribution. The first expert judgement (Mudřík, Hons 2004) had assumed an important decrease in the proportion of the liquid fraction in the dairy cattle category and a decrease in the proportion of solid fraction in the non-dairy cattle category caused by the change in the technology of cattle breeding from the early 1990s. This expectation had not been met and, until the 2019 submission, the manure distribution retained at its original values. This trend was interrupted by the implementation of new AWMS for the concerned time series in 1990-2022, described in the following chapters.

The determination of the Nex rate also underwent development. A significant change was the transition to country-specific data in 2019. The leap changes in the development of Nex values were then removed in this year's submission, which fulfilled two objectives - the data was consistent across the time series and was fully harmonized with the input data used to derive national nutrient balance (EUROSTAT, OECD) and ammonia emissions reporting (UN-ECE). There is important progress in harmonization activities mentioned several times in review reports (Issue ID A9).

All the improvements made for the current submission concerning Nex rate values and AWMS, solved the issue of time series inconsistency mentioned in the last review report. (Issue ID A3, A7, A13, A14, A15).

5.2.2.4 Source-specific QA/QC and verification

QA/QC includes checking the 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. Country-specific Nex rate data are calculated according to the annexes of the Czech Decree No. 377/2013 Coll. and up to date population data (CzSO) as a weighted average of the individual animal category. The zoo-technical national data is supplied by experts from the agricultural institutes (see above). The appropriate values in the calculation spreadsheets are updated at IFER, replacing the older values. The verified data is transferred to CRF Reporter, where the data is technically verified again. A completeness check of the CRF tables was performed for final time-series approval.

Special attention was paid to the validation of the country-specific animal waste management systems – the proportion of individual management systems was estimated by the experts from CRI as well as nitrogen excretion rate. An example of deriving Nex for pigs is shown in Tab. 5-40.

Tab. 5-40 Example of the derived values of Nex for swine with support of data from Decree No. 377/2013 Coll., data 2022

Swine category	Population [1 000 heads]	N Production [kg N/head]	Total production [t N]
Pigs <20 kg live weight	422.45	2.1	887
Pigs 20+ and <50 kg live weight	345.90	7.35	2 542
Fattening pigs 50+ and <80 kg live weight	252.76	11.7	2 957
Fattening pigs 80+ and <110 kg live weight	221.87	17.1	3 794
Fattening pigs ≥110 kg	69.65	21.6	1 505
Boars ready to breed	1.66	29.61	49
Covered sows	97.09	31.49	3 057
Sows not covered – total	21.44	12.6	270
Total	1 432.82	10.51 (WA)*	15 062
Relative share [%]			100%

** calculated as weighted average of N production per listed swine categories*

The emission factor for methane production from manure management is calculated by Tier 2 methods for both cattle categories and swine. The default values of emission factors (Table 10.14, IPCC 2006) are higher than the country-specific ones (Tab. 5-41):

Tab. 5-41 Comparison of methane emission factors for manure management, IPCC 2006 Gl. default and country-specific values (Submission 2024)

Livestock category	CH_4 emission factor for manure management [kg CH_4/head/year]	
	IPCC default value (Table 10.14, IPCC 2006 Gl.)	Country-specific value
Dairy cattle	21	12.04
Non-dairy cattle	6	3.62
Market swine	6	1.75
Breeding swine	9	2.68

The nitrogen excretion rate for dairy cattle and other cattle was compared with the default nitrogen excretion rate factors available for the Western Europe region in IPCC 2006 Gl. (Table 10.19). The updated country-specific data based on Decree No. 377/2013 Coll. were closer to the default values than the previous ones (CHMI 2022).

Tab. 5-42 Overview of N rate values, IPCC 2006 default and country-specific values (long-term average and Submission 2024 values)

Cattle category	N rate [kg N/1 000 kg animal mass/day]		
	IPCC default value (Table 10.19, IPCC 2006)	Country-specific value (long-term average)	Country-specific value (Submission 2023)
Dairy cattle	0.48	0.464	0.497
Non-dairy cattle	0.33	0.390	0.390

Tier 2 procedures were used for estimating the VS parameters for cattle. The country-specific values calculated from national input data were compared with the default value available in IPCC 2006 Guidelines (Tables 10A-4 and 10A-5):

Tab. 5-43 Overview of daily volatile solid excreted values, IPCC 2006 default and country-specific values (long-term average and Submission 2024 values)

Cattle category	VS [kg dry matter/head/day]		
	IPCC default value (Table 10A-4/10A-5, IPCC 2006)	Country-specific value (long-term average)	Country-specific value (Submission 2024)
Dairy cattle	5.10	5.11	6.25
Non-dairy cattle	2.66	2.91	3.30

5.2.2.5 Source-specific recalculations, including changes made in response to the review process and impact of emission trends

Estimation of Nex for poultry category was validated with the new TAM values for the period 2014-2022. The change does not have any impact on estimated data because Nex for poultry is derived from the actual version of Decree No.377/2013 Coll. (Chapter 5.2..2.2.3 in the NIR text).

Update of animal waste management systems was implemented in Submission 2023. Consequences of this improvement were described in text report (Submission 2023). The changes in AWMS affected the value of methane emission factor (through MCF) in cattle and swine categories, additionally the influent estimation of nitrous emissions from manure management and amount of nitrogen inputs to managed soils. In coherence with the changes in AWMS, a revision of Nex rate determination was carried out to ensure the consistency of the data in time series.

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

One of the tasks of the above-mentioned research project finished in 2022 was to directly improve the emission reporting for the agriculture sector. Together with the Crop Research Institute and Research Institute of Agricultural Engineering, we worked on the quantification of nitrogen flow in agriculture in the Czech Republic.

One of the most important results of the joint activity was the unification of input data and the quantification of outputs, respecting their interconnectedness and continuity. The joint work aimed to create a uniform nitrogen balance in agriculture, applicable for all the reporting (OECD, UNFCCC, UN-ECE etc.). The joint work has shown how difficult it is to unify reporting requirements and their interdependence. The Czech Republic must find financial and professional sources for following tasks:

1. Emissions of nitrous oxide, ammonia and other nitrogen oxides from agriculture must be considered in the context of the entire nitrogen flow (N-flow). While the input data are more or less harmonized, there

is a lack of specific information on the effect of abatement technologies on the release of ammonia and nitrogen oxides and the creation of indirect N_2O emissions.

2. It is necessary to synchronize the various systems for transmitting data from agricultural practice towards EUROSTAT so that data are available for the calculation of GHG emissions from mineral, farm, and organic fertilizers within the National Inventory System (NIR) and from the reporting of pollutant emissions (UN-ECE).

3. Concerning to the harmonization of manure management systems for the needs of NIR and UN-ECE, the proportions of individual methods of management (AWMS) need to be unified and specified so it is possible to take into account the reduction measures taken into account within UN-ECE. Currently, NIR only works with 4 basic loading methods.

4. The unification of AWMS makes possible to determine accurately the amount of volatilizable nitrogen from animal excrements and from washings, which will make the Nutrient Balance of the Czech Republic (losses) more accurate and will make it possible to link NIR with the reporting of ammonia and NO_x emissions.

5. Specifying the amount of releasable nitrogen when handling farmyard manure in stables and warehouses will further specify the amount of nitrogen that reaches the soil in the form of farmyard manure. The Nutrient Balance and NIR work with the value.

Harmonization with the reporting under UN-ECE is a logical part of the nitrogen flow model in agriculture. In close cooperation with Dr. Dědina, responsible for UN-ECE reporting for the sector of agriculture, we continue with comparison of estimating indirect emissions at NIR.

For the upcoming submissions (2025 and subsequent), the improvement to MCF value calculation according to the IPCC 2019 is planned.

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 indirect nitrous oxide emissions from agricultural soils. Both subcategories (direct and indirect emissions) are the key sources of N_2O emissions (Tab. 5-1). Nitrous oxide is produced from agricultural soils because of microbial nitrification and denitrification processes. The processes are influenced by the chemical and physical characteristics (availability of mineral N substrates and carbon, soil moisture, temperature, and pH). Thus, the addition of mineral nitrogen in the form of synthetic fertilizers, animal manure and other organic nitrogen applied to soils, crop residue/renewal and sewage sludge enhance the formation of nitrous oxide emissions.

In connection with the gradual transition of the methodology to a higher level of estimation (Tier 2), emission factors and volatilized and leaching nitrogen fractions included in the estimation of emissions were updated according to IPCC 2019. These changes allow consideration of a wider range of fertilizers application technologies when relevant data is available. The methodology also allows considering the specific climatic characteristics of the regions in the Czech Republic in the estimates once the new activity data on regional nitrogen consumption become available.

Nitrous oxide emissions from agricultural managed soils include these subcategories:

- Direct emissions (synthetic fertilizers, animal manure applied to soils, crop residues, sewage sludge and other organic fertilizers applied to soils)
- Emissions from pasture manure (PRP)
- Amount of nitrogen mineralized in mineral soils considered for Cropland remaining Cropland
- Indirect emissions (atmospheric deposition and nitrogenous substances flushed into water courses and reservoirs – leaching).

An overview of direct and indirect emissions by individual sources is presented in Tab. 5-44.

Tab. 5-44 Direct and indirect N_2O emissions from agricultural soils [kt N_2O], 1990-2022

Year	Total emissions	Synthetic fertilizers	Organic fertilizers*	Crop residues	Mineral. soil	PRP	Atmosph. deposition	Leaching
				[kt N_2O]				
1990	19.7	10.5	1.4	2.4	NO	0.2	1.8	3.5
1995	11.2	5.8	0.9	1.8	NO	0.2	1.1	1.4
2000	11.8	6.6	0.8	1.6	0.01	0.1	1.1	1.5
2005	12.4	7.4	0.7	1.5	0.01	0.1	1.1	1.6
2010	11.5	6.8	0.6	1.4	0.01	0.2	1.0	1.5
2015	15.9	10.0	0.7	1.6	NO	0.2	1.4	2.0
2016	16.5	10.2	0.7	1.8	NO	0.2	1.4	2.1
2017	15.9	10.0	0.7	1.6	NO	0.2	1.4	2.1
2018	14.5	8.8	0.8	1.5	NO	0.2	1.3	1.9
2019	13.9	8.4	0.8	1.6	NO	0.2	1.3	1.8
2020	12.5	7.2	0.7	1.7	NO	0.2	1.1	1.6
2021	13.3	7.8	0.7	1.7	NO	0.2	1.2	1.7
2022	13.7	8.2	0.7	1.6	NO	0.2	1.2	1.8

** Animal manure + Sewage sluge + Digestate*

In 2022, 90% of the total N_2O emissions from agriculture originated from agricultural soils, while the rest originated from manure management (10%). The trend in N_2O emissions from this category decreased during the reporting period 1990-2010 (to a minimum level) and then increased slightly. The emissions from managed soils decreased by about 30% from 1990 to 2022. Tab. 5-44 and Fig. 5-4 show N_2O emissions from agricultural soils by individual sub-categories.

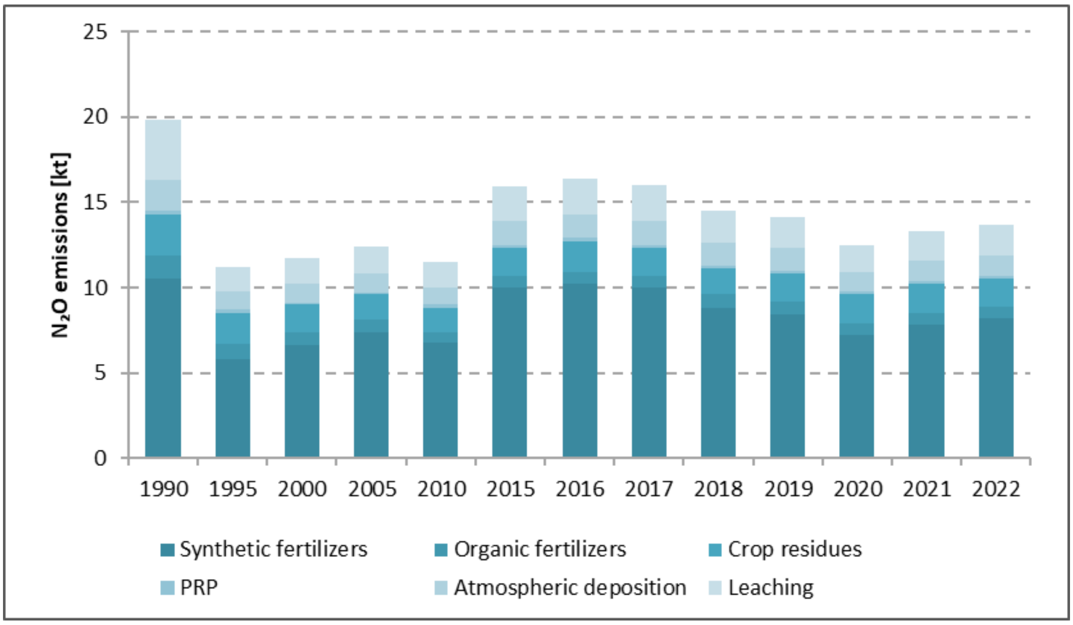

Fig. 5-4 N_2O emissions of agricultural soils by individual sub-categories, 1990-2022

5.4.2 Methodological aspects

Although agricultural soils are a key source, the emissions of N_2O are estimated and analysed using the Tier 1 approach of IPCC 2019 Guidelines. For several years, a set of interconnected spreadsheets in MS Excel has been used for the relevant calculations. The emissions from nitrogen excreted by livestock on pastures and paddocks were reported under livestock production in the CRF table.

5.4.2.1 Activity data

The standard calculation according to Tier 1 required the following input information:

- Amount of nitrogen applied to soil in the form of industrial nitrogen fertilizers (CzSO data, Statistical Yearbooks, Ministry of Agriculture, CRI, 1990-2022);
- Managed manure nitrogen available for application to soil (NIR data, Eq.10.34, IPCC 2006 Gl.);
- Annual yields (harvest/production area) (CzSO data, Statistical Yearbooks, 1990-2022)
- Annual amount of urine and dung N deposited by grazing animals on PRP (NIR data, Eq.11.5, IPCC 2006 Gl.)
- Amount of sewage sludge applied directly to agricultural soils (CzSO data, Statistical Yearbooks, 2002-2022, retrospective analysis for the period 1990-2001)
- Amount of mineralized N in soils, in association with loss of soil C in the Cropland remaining Cropland category (LULUCF sector)
- Amount of organic nitrogen inputs applied to soil (digestate, compost), statistical survey and CRI analysis and UN-ECE reporting).

5.4.2.2 Direct emissions from managed soils (CRF 3.D.1)

The emission factors used for the calculation of the direct N_2O emissions are shown in Tab. 5-45. The IPCC 2019 Guidelines default values suitable for wet climate are used to estimate direct N_2O emissions.

Tab. 5-45 Emission factors for estimating direct emissions from managed soils (Table 11.1, IPCC 2019).

Direct emissions	Synthetic fertilizers	EF_1 = 0.016 kg N_2O-N/kg N
	Animal waste, digestate	EF_1 = 0.006 kg N_2O-N/kg N
	Sewage sludge	EF_1 = 0.006 kg N_2O-N/kg N
	N-crop residues	EF_1 = 0.006 kg N_2O-N/kg N
	Mineralized N	EF_1 = 0.006 kg N_2O-N/kg N
Pasture, range & paddock manure	Cattle, swine, poultry	EF_3 = 0.006 kg N_2O-N/kg N
	Sheep, others	EF_3 = 0.003 kg N_2O-N/kg N

5.4.2.2.1 Synthetic N fertilizers (FSN, CRF 3.D.1.1)

The application of agricultural fertilizers had been formerly intense in the Czech Republic but decreased radically after 1990. The activity data is taken from the official statistical source (CzSO). The amount of nitrogen fertilizers applied in 1990 equalled more than 418 kt, which decreased to 180 kt in 1993. From that year, nitrogen consumption slowly grew to 407 kt in 2016 (the highest value). Hopefully, this negative trend ended in 2017. In 2022, only 325 kt of fertilizers were applied (18% less in comparison with 2017). The actual trend is presented in Fig. 5-5.

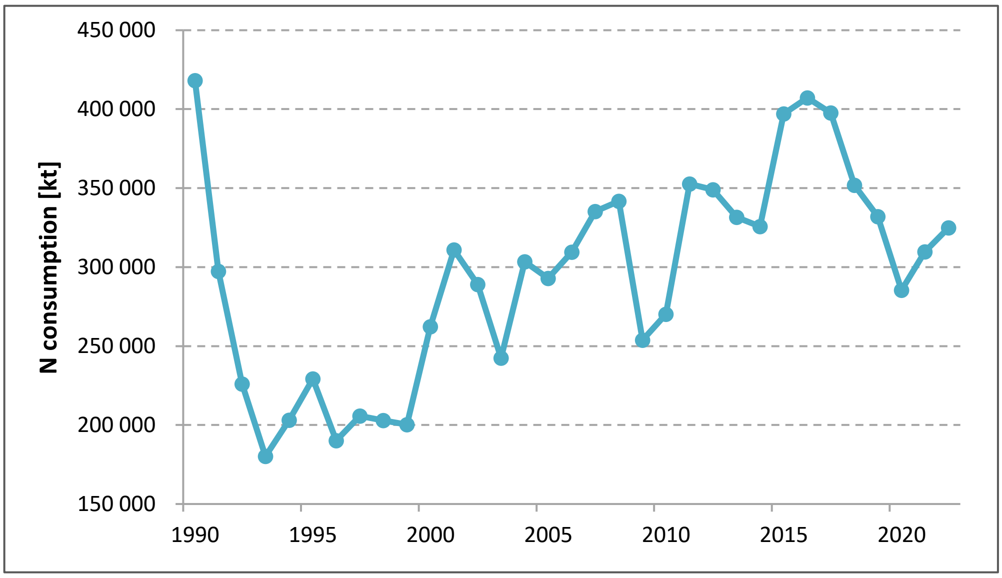

Fig. 5-5 Consumption of nitrogen from synthetic fertilizers [kt], 1990-2022

5.4.2.2.2 Organic N applied as fertilizer (FON incl. animal manure and sewage sludge, digestate, CRF 3.D.1.2)

The amount of managed manure nitrogen available for application to managed soils (FAM) is calculated as the product of the annual average N excretion per animal per species and the fraction of the manure management system and (1 – $Frac_{lossMS}$). The default value of the fraction $Frac_{lossMS}$ is given in Table 10.23, Equations 10.34 and 11.4 (IPCC 2006).

The data on sewage sludge applied to soils has been officially available since 2002. The data for the previous period was estimated by statistical methods. Specifically, linear regression was used to estimate the trend from known activity data from 2003 to 2016 (r^2 = 0.62). This trend was used to estimate the missing AD from 1990. The regressed values are not used in the period where AD is available from CzSO. The country-specific value of nitrogen content of 3.7% (Černý et al. 2009) and default emission factor (EF_1, Table 11.1., IPCC 2019) were employed for estimating the emissions from sewage sludge (FSEW).

Implementation of the anaerobic digestion in AWMS was also reflected in N_2O emissions from managed soils. The corresponding amount of animal manure available for managed soils was reduced, but, on the other hand, a new source of nitrogen was added as "Other organic fertilizers applied to soils" – digestate and or compost (F_{OOA}). The amount of digestate is estimated as a share of total digestate produced by the biogas station. The share corresponds to the amount of manure used for biogas production (Klír 2020).

The total amount of organic N fertilizer applied to soils (F_{ON}) is calculated as the sum of F_{AM} + F_{SEW} + F_{OOA}. An overview of activity data inputs is presented in Tab. 5-46.

Tab. 5-46 Activity data inputs to calculation of FON: annual amount of animal manure N (FAM), annual amount of sewage sludge N (FSEW) and annual amount of digestated N and compost N (FOOA) [kt N/year], 1990-2022

Year	FAM	FSEW	FOOA	FON
		[kt N/yr]		
1990	147 147	253		147 400
1995	93 200	656		93 856
2000	84 328	1 059		85 387
2005	72 646	1 275	785	74 706
2010	58 367	2 244	7 474	68 085
2015	54 618	2 333	20 745	77 696
2016	55 034	2 314	20 950	78 298
2017	54 206	2 792	20 980	77 978
2018	56 423	3 289	20 972	59 712
2019	55 721	3 354	21 055	80 130
2020	55 720	2 333	21 066	79 119
2021	55 690	2 445	21 067	79 201
2022	55 165	2 340	21 066	78 572

5.4.2.2.3 Urine and dung N deposited on pasture by grazing animals (FPRP, CRF 3.D.1.3)

The annual amount of N deposited by grazing animals on pasture, range and paddock soils was estimated using Eq. 11.5 (IPCC 2019) 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 the estimation of nitrogen content in AWMS and the share of PRP in the relevant livestock category. The trend of the development of the total amount of nitrogen from pasture was the steady state for the whole reporting period, while the trend of total excreted N decreased rapidly because of the substantial changes in the livestock population (Fig. 5-6) and Tab. 5-47.

Tab. 5-47 Development of the amount of N and emissions from urine and dung from grazing animals, 1990-2022

Year	F_{PRP} cattle, swine, poultry	F_{PRP} horses, goats, sheep [kt N/yr]	Total F_{PRP}	N_2O emissions [kt/year]
1990	18 027	3 099	21 126	0.185
1995	16 861	1 579	18 440	0.166
2000	14 428	1 292	15 720	0.142
2005	13 514	1 367	14 881	0.134
2010	15 869	1 974	17 843	0.159
2015	15 034	2 290	17 324	0.153
2016	16 060	2 179	18 239	0.162
2017	16 568	2 257	18 824	0.167
2018	17 620	2 297	19 917	0.177
2019	17 324	2 316	19 640	0.176
2020*	17 172	2 303	19 475	0.175
2021	17 241	2 040	19 280	0.174
2022	17 694	2 108	19 801	0.177
Relative difference 2022/1990 [%]	2%	32%	6%	4%

**Country specific Nex values implemented (2019-2021)*

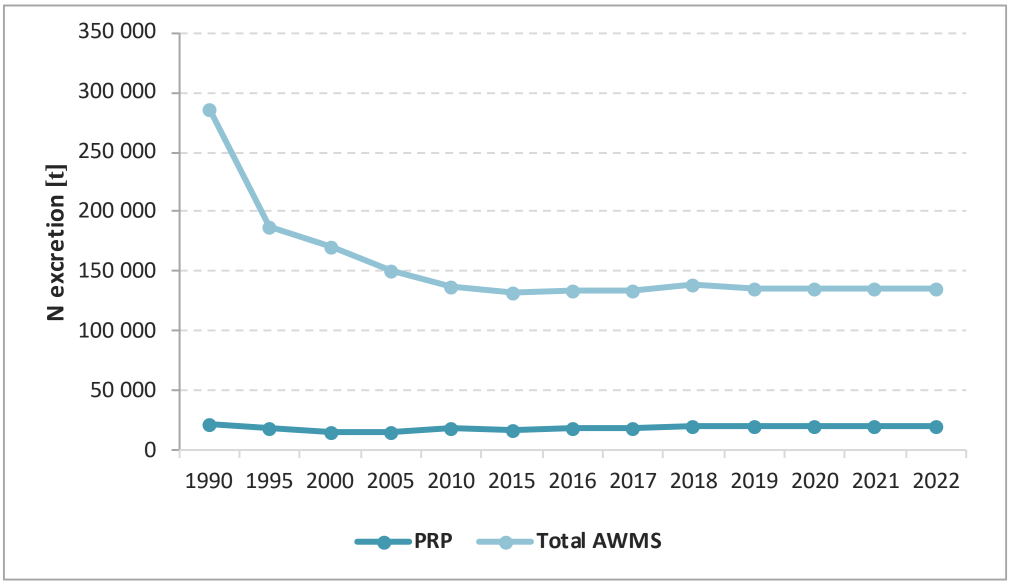

Fig. 5-6 Trend of total amount of nitrogen excretion from AWMS and nitrogen excretion from pasture, 1990-2022

Two default emission factors (Tab. 5-48) are used for estimating emissions from different animal categories (Table 11.1, IPCC 2019). The fraction of livestock N excreted and deposited onto soils during grazing ($Frac_{GRAZ}$) varied from 0.074 in 1990 to 0.146 in 2022.

Tab. 5-48 IPCC default emission factors for animal waste management system: pasture, range and paddock (PRP)

AWMS	EF_3 [kg N_2O-N per kg N excreted]
PRP (cattle, swine, poultry)	0.006
PRP (sheep, others)	0.003

5.4.2.2.4 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 the N of N-fixing crops returned to soils annually. It also includes the nitrogen from N-fixing and non-N-fixing forages mineralized during forage or pasture renewal and straw used for bedding. A part of crop residues is used in biogas stations for energy production, and it is returned to the field as a digestate. This amount is reported in this chapter as well.

N-crop residues were estimated from crop yield statistics (CzSO) and the default factors for above/below-ground residues: yield ratios and residual N contents (see Tab. 5-51). The zero values were applied as parameters $Frac_{REMOVE}$ (excluding grains and green maize for which the country specific data are available) and $Frac_{BURN}$, because no survey data is available from experts in the country as required on page 11.14 IPCC 2019.

An overview of the annual yield of agriculture products is presented in Tab. 5-49, and Tab. 5-50. The 2022 yield of agricultural products was higher compared to the same data for the previous year 2020. Newly, we added to the estimation the yield of rape which is one of the important crops of the Czech Republic. As a result, crop residue nitrogen estimates now apply to 95% of arable land of the Czech Republic.

Since different crop types vary in residues, yield ratios, renewal time and nitrogen contents, separate calculations were performed for major crop types and then the nitrogen values for all the crop types were summed. Crops were 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) 6) soya and 7) rape. Eq. 11.6 was used for estimating N from crop residues and forage/pasture renewal for the Tier 1 approach. The default values of input factors and country-specific value of the dry matter content used in the estimation are presented in Tab. 5-51.

For nitrogen sources from plant residues, the 1-Frac remove coefficient was newly adjusted for grains and green-harvested corn. An estimate of 10% of cereal straw is taken from the field for feed, and 10% of the straw leaves agriculture entirely for bioenergy (to be burned). Thus, 80% of the straw of cultivated cereals remains on the soil in the form of bedding manure). In the case of green maize, 60% of the grown biomass is used for silage (feeding). The rest, i.e. 40%, is taken to BGS and returned to the soil in the form of digestate. This modification was proposed by experts from CRI where the same procedure is used for EUROSTAT/OECD reporting (Tab. 5-51,Tab. 5-52).

Tab. 5-49 Annual yield of agricultural products, 1990-2022

Year	Grains	Pulses	Potatoes [t/ha]	Sugar beets	Soya beans	Rape
Average crop area (ha)	*1 392 000*	*32 184*	*23 697*	*60 909*	*12 667*	381 208
1990	5.42	2.68	16.00	33.89	3.67	2.43
1995	4.17	2.38	17.04	39.63	1.29	2.43
2000	3.92	2.09	21.32	45.62	1.25	2.61
2005	4.81	2.44	28.08	53.31	2.04	2.88
2010	4.71	1.86	24.56	54.36	1.70	2.79
2015	5.83	2.89	22.26	59.38	1.64	3.43
2016	6.36	2.37	29.88	67.81	2.64	3.46
2017	5.50	2.34	29.42	66.56	2.41	2.91
2018	5.21	2.26	25.50	54.96	1.66	3.43
2019	5.65	2.20	27.20	61.84	2.27	3.05

2020	6.04	2.46	29.16	61.51	2.33	3.38
2021	6.11	2.60	29.44	67.69	2.62	2.99
2022	5.93	2.72	30.22	69.64	2.30	3.39

Tab. 5-50 Annual yield of fodder [t/ha] including total crop area, 1990-2022

Year	Fodder dry matter	Silage maize fresh matter	Perennial fodder fresh matter	Annual Fodder fresh matter	Total area
		[t/ha]			ha[ha]
1990	6.77				1 099 907
1995	6.13				872 494
2000	5.60				725 250
2005	6.20				491 888
2010	6.05				406 450
2015		30.84	6.16	19.02	458 266
2016		39.53	7.42	22.20	484 835
2017		34.50	6.55	17.11	465 391
2018		29.88	5.50	14.77	468 328
2019		35.63	5.94	17.91	498 628
2020		37.63	6.42	20.42	515 335
2021		38.86	6.29	16.99	495 292
2022		35.96	6.28	17.19	467 085

Tab. 5-51 Default values of input factors used for estimating FCR (Table 11.2, IPCC 2006 and 2019), calculated data (Submission 2024)

	Grains	Pulses	Potatoes	Sugar beets	Soya beans	Rape*
Dry mater (CS)	0.85	0.85	0.22	0.22	0.91	0.91
R_{AG}, calculated	1.27	2.10	0.26	0.40	2.10	1.50
AG_{DM}, calculated	6.37	3.46	1.73	2.59	3.29	4.63
$Frac_{Remove}$ (CS)	0.200	0.0	0.0	0.0	0.0	0.0
NAG	0.006	0.008	0.019	0.019	0.008	0.011
R_{BG}-BIO	0.497	0.48	0.25	0.23	0.46	0.48
N_{BG}	0.009	0.008	0.014	0.014	0.008	0.017

*Note: Parameters R_{AG} and AG_{DM} are calculated by using Eq. 11.6 and 11.7A (IPCC 2019) and adequate parameters. * Input data for rape are derived from GNOC model.*

Tab. 5-52 Default value of input factors used in estimation of fodder (Table 11.2, IPCC 2006), calculated data (foder dry matter 2014, silage maize and perennial and annual fodder, Submission 2024)

	Fodder dry matter 2014	Silage maize fresh matter	Perennial fodder fresh matter	Annual fodder fresh matter
Dry mater (CS)		0.35	0.85	0.17
R_{AG} calculated	0.30	0.30	0.30	0.30
AG_{DM}, calcul.	2.29	3.78	1.60	0.88
$Frac_{Remove}$ (CS)	0.0	0.6	0	0
NAG	0.027	0.027	0.027	0.027
R_{BG}-BIO	0.52	0.44	0.50	0.52
N_{BG}	0.022	0.022	0.022	0.022

Note: The parameters R_{AG} and AG_{DM} are calculated by using Eq. 11.6 and 11.7A (IPCC 2019) and adequate parameters.

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 employed to estimate dry matter yields where appropriate (Eq. 11.7). The default values for dry matter content from Table 11.2 were employed or country specific data if available. Only forage production activity data is presented as dry matter in the CzSO statistics.

Since 2015, CZSO has also been providing data on maize that is harvested green and used as fodder. For this reason, since 2015, the fodder data has been divided into green maize, perennial fodder and annual fodder crops.

5.4.2.2.5 Mineralization/Immobilization Associated with Loss of Soil Organic Matter (FSOM, CRF 3.D.1.5)

The annual amount of N in mineral soils that are mineralised because of the loss of soil carbon from soil organic matter (F_{SOM}), is a result of land-use changes or management practices. The emission of N_2O associated with soil disturbance during land-use changes are estimated in the LULUCF sector (see chapter 6.5.2.2).

N_2O emissions from mineralisation due to management changes on Cropland remaining Cropland are calculated using Eq. 11.8 (IPCC 2006), employing a default emission factor of 0.01 kg N_2O-N/kg N (EF_1, IPCC 2006), and C:N ratio of 10. The activity data are represented by the carbon loss under subcategory 4.B.1 Cropland remaining Cropland (CRF Table 4.B.1) due to mineralization. That amount of carbon loss in category 4.B.1 is based on the detailed land-use change matrices and carbon maps, in connection with the set of emission factors applicable to seven crop subcategories. In this Submission the above source activity data were recalculated in the LULUCF sector for the entire reporting period. Therefore, they also affected the estimates of N_2O emissions from N mineralization/immobilization, which were accordingly recalculated for the entire reporting period since 1990.

Tab. 5-53 Overview of activity data and N_2O emissions from loss of soil organic matter (F_{SOM})

Year	Net carbon stock change in soils CL/CL [kt C]	Conversion C to N (DV 10) [kg N]	N_2O emission [kt N_2O]
1990	0.16	NO	NO
1991	0.06	NO	NO
1992	0.00	NO	NO
1993	0.12	NO	NO
1994	0.19	NO	NO
1995	0.22	NO	NO
1996	0.27	NO	NO
1997	0.29	NO	NO
1998	0.42	NO	NO
1999	0.42	NO	NO
2000	0.43	NO	NO
2001	0.46	NO	NO
2002	0.37	NO	NO
2003	0.01	NO	NO
2004	-0.12	12 230	0.031
2005	-0.32	32 206	0.080
2006	-0.36	35 565	0.089
2007	-0.32	31 562	0.079
2008	-0.32	32 188	0.080
2009	0.04	NO	NO
2010	0.05	NO	NO
2011	0.23	NO	NO
2012	0.45	NO	NO
2013	0.33	NO	NO
2014	0.27	NO	NO

Year	Net carbon stock change in soils CL/CL [kt C]	Conversion C to N (DV 10) [kg N]	N_2O emission [kt N_2O]
2015	0.16	NO	NO
2016	0.11	NO	NO
2017	0.24	NO	NO
2018	0.33	NO	NO
2019	0.71	NO	NO
2020	1.07	NO	NO
2021	1.62	NO	NO
2022	2.27	NO	NO

Note: NO = no net loss of soil carbon from soil carbon in the given year

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 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. 5-55**): one associated with volatilized and re-deposited N (EF_4), and the second associated with N lost through leaching/runoff (EF_5). The overall value for EF_5 equals 0.0075 kg N_2O-N/kg N leached/ in runoff water. The method also requires using 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. 5-54**.

Tab. 5-54 IPCC default parameters/fractions used for estimating indirect emissions (Table 11.3, IPCC 2019)

Parameters/Fractions	Default value
$Frac_{GASM}$ (volatilization from organic N fertlizers and PRP)	0.21
$Frac_{GASF}$ (volatilization from synthetic N fertilizers	0.11
$Frac_{LEACH-(H)}$	0.24

Tab. 5-55 Emission factors (EFs) used for estimating indirect emissions (T 11.3, IPCC 2019) wet climate choice.

Indirect emissions	Atmospheric Deposition	EF_4 = 0.014 kg N_2O-N per kg emitted NH_3 and NO_X
	Nitrogen Leaching	EF_5 = 0.011 kg N_2O-N per kg of leaching N

Volatilization

The N_2O emissions from atmospheric deposition of N volatilized from managed soils are estimated using Equation 11.9. The equation inputs are estimated for direct emissions from managed soils. The inputs are the annual amount of synthetic fertilizer N applied to soils, the annual amount of managed animal manure, sewage sludge N and other organic N applied to soils, the annual amount of urine and dung N deposited by grazing animals. The conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed using factor 44/28.

Leaching/Runoff

The N_2O emissions from leaching and runoff in regions where leaching and runoff occur are estimated using equation 11.10 IPCC 2006 Guidelines. The equation inputs are estimated for direct emissions from managed soils, where FON also includes sewage sludge inputs. The inputs are the annual amount of synthetic fertilizer N applied to soils, the annual amount of managed animal manure, sewage sludge N and other organic N applied to soils, the annual amount of urine and dung N deposited by grazing animals, the amount of N in Crop residues and the annual amount of N mineralised in mineral soils. The conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed using factor 44/28.

The last review identified the error in reporting of N lost through leaching and run-off in CRF table 3D cell C21 (Issue A16). This error did not have impact to reporting emissions and was corrected.

An overview of estimated values of indirect emissions is presented in Tab. 5-44.

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 2019. But all recent input data are harmonized with other national “nitrogen” reporting.

The quantitative overview and emission trends during the 1990-2022 period are shown in Fig. 5-1 and the trend in N_2O emissions from agricultural soils is summarized in Tab. 5-44. During 1990-2022, the total emissions from Agricultural soils decreased by 30% (with the minimum in 2010).

The changes in AWMS and Nex that were prepared for Submission 2023 led to the elimination of jump changes in time series and in the same way affected the inputs to the calculation of direct and indirect emissions from organic fertilizers.

Uncertainty estimates are based on expert judgment. The uncertainty in the activity data for estimation of direct and indirect emissions from agricultural soils equals 20%; this value equals 10% for Pasture, Range and Paddock Manure (PRP). The uncertainty in the emission factor for the estimation of direct and indirect emissions from agricultural soils equals 50%; this value equals 100% for the estimation of emissions from PRP. The combined uncertainty for the direct and indirect emissions from agricultural soils equals 53.9%; this value equals 100.5% for N_2O emissions from the manure management system PRP.

Missing data about the amount of sewage sludge applied to agricultural soils were added to the reported time series thanks to a statistical retrospective analysis of the available data about sewage sludge production for the previous submission (see Chapter 5.4.5., NIR 2018). The including of nitrogen from compost among organic fertilizers is the next step to harmonization of input data with UN-ECE reporting and NIR. CRI provides this data biannually.

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 a 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 and NIR reports of neighbourhood European countries as well.

As a result of the validation of activity data with CRI experts, the quantity of mineral fertilizers used in managed soils has been updated since 2000. Data on fertilizer consumption for FAOSTAT and other international reporting are provided by the Ministry of Agriculture, Department of Agricultural Commodities (Mrs. Budňáková)

A workshop of experts involved in NIR (IFER), IIR reporting (Dr. Dedina, Research Institute of Agricultural Technology) and EUROSTAT reporting (Dr. Wollnerová, CRI) is happened regularly every 3 months. There is a platform for the exchange of information and data between relevant experts and share experiences.

In the frame of the research project "Development of the methodologies for reporting and projections of greenhouse gas emissions and removals including projections of usual pollutants" funded by The Technological Agency of the Czech Republic (TACR) a separate output summarizing the issue of reporting nitrous oxide emissions from the agricultural sector (3D emissions from the management of agricultural land) was prepared based on findings and analyzes processed in the years 2019-2022. In addition, the possibility of creating a unified national nitrogen flow balance in agriculture was analyzed (Beranova 2022b). The requirements of IPCC GL 2006 and 2019 were analyzed in detail to link the reporting of air pollutants (ammonia, nitrogen oxides) carried out under the Economic Commission of the United Nations (UN-ECE) with the reporting of greenhouse gases (nitrogen oxide). Furthermore, the status of the implementation of the national nitrogen balance, which is being prepared for EUROSTAT in the reporting of nitrogen substances with the agricultural sector, was described, and the steps that were implemented during the project solution in the field of harmonization of inputs for international reporting in the field of nitrogen flow in agriculture were described in detail. The report is written in Czech, and it is available in CHMI.

During 2023, the comparison of calculation of typical specific greenhouse emissions gases from agricultural cultivation and processing on regional level (NUTS 2 and NUTS) was prepared for scientific output (certified methodology) (Dedina, M. et al, 2024).

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

In connection with the gradual transition of the methodology to a higher level of estimation (Tier 2), emission factors and volatilized and leaching nitrogen fractions included in the estimation of emissions were updated. Changes are presented in **Tab. 5-56** and

Tab. 5-57. Emission factors and fractions were updated according to IPCC 2019. These changes allow consideration of a wider range of manure storage technologies when relevant data is available. The methodology also allows considering the specific climatic characteristics of the regions in the Czech Republic in the estimates once the new activity data on regional nitrogen consumption become available.

Tab. 5-56 Changes in activity data used for estimation of direct N_2O emissions from managed soils.

Nitrogen sources	Emission factor (IPCC 2006) kg N_2O-N/ kg N input	Emission factor (IPCC 2019) kg N_2O-N/ kg N input	Relative effect to emission estimation	Share of total emission from 3D1 category (submission 2024)
Synthetic N fertilizers	0.01	0.016	Increase by 60 %	76 %
Organic N applied as fertilizer	0.01	0.006	Decrease by 67 %	7 %
Urine and dung N deposited on pasture (cattle, swine, poultry)	0.02	0.006	Decrease 70 %	2 %
Urine and dung N deposited on pasture (other animals)	0.01	0.003		
N in crop residues	0.01	0.006	Decrease 25-30 %	15 %
N mineralisation with loss of soil organic matter	0.01	0.006	-	-
Direct emission from managed soils			**Increase 11% in average**	**100 %**

Tab. 5-57 Changes in activity data used for estimation of indirect N_2O emissions from managed soils.

Nitrogen sources	Emission factor (IPCC 2006) kg N_2O-N/ kg N input	Emission factor (IPCC 2019) kg N_2O-N/ kg N input	Relative effect to emission estimation	Share of total emission from 3D2 category (submission 2024)
EF4 N volatilization and redeposition	0.01	0.014	Increase in average 34 %	41 %
Frac GASF (volatilisation from synthetic fertiliser)	0.1	0.11		
Frac GASM (volatilisation from organic fertilizers and PRP)	0.2	0.21		
EF5 leaching/runoff	0.0075	0.011	Decrease in average 18 %	59 %
Frac Leach (N loss by leaching)	0.3	0.24		
Indirect emission from managed soils			**Increase 4% in average**	**100 %**

The use of new activity data resulted in an increase in N_2O emissions from the sector of 4% on average and an increase in emissions from 3D category by 9%. The share of emissions from synthetic fertilizers in total emissions from managed soils has increased significantly.

A above mentioned increase in subsector 3D was supported by including rape crops to estimation of nitrogen from Crop residues. Rape covers approx. 14 % of areas under crops in the Czech Republic. We consider its importance as a source of nitrogen from crop residues to be significant. Neither the IPCC 2006 nor IPCC 2009 methodology provides suitable parameters for estimating the amount of nitrogen in rapeseed biomass. We estimated the contribution of nitrogen from rape cultivation thanks to the data available from the GNOC model (Global Nitrous Oxide Calculator). The recalculation was made for the whole time period.

Emissions from crop residues originating from rape constitute approx. 15% of emissions from total crop residues (FCR) in Submission 2024. The increased emissions were partly compensated by applying a reduced emission factor 0.006 (as compared to the earlier 0.01) which decreased estimates of N_2O emissions from FCR by 27% on average.

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

As part of a research project financed by TACR, it was possible to unify the inputs to the national nitrogen balance. The next step to increase the level of GHG reporting will be the preparation of regionally (NUTS 2) specific data on the consumption of organic and inorganic fertilizers and cultivated crops. The implementation of the reporting is planned for Submission 2027 or later. Due to the legislative changes that took place through the latest amendment to Act No. 156/1998 Coll., on fertilizers, the obligation of farmers to submit data to the Central Institute for Supervising and Testing in Agriculture on the use of fertilizers and on yields for the year 2023 cannot be enforced at the beginning of 2024 in electronic form. This does not change the long-standing obligations of agricultural entrepreneurs to keep records of the use of fertilizers and the determined yields. By the end of February 2025, the keeping of records in electronic form and the transmission of this data for the year 2024 will be mandatory for agricultural entities farming on an area of more than 200 ha. In 2025, this will apply to agricultural entities operating on an area of more than 100 ha, and from 2026 on to more than 20 ha.

Since 2024, the team cooperates with the AdAgriF project "Advanced methods of greenhouse gases emission reduction and sequestration in agriculture and forest landscape for climate change mitigation" (CZ.02.01.01/00/22_008/0004635), funded by Ministry of Education and coordinated by GCRI (prof. Trnka). The aim of the cooperation is to gradually increase the methodological level of estimates in 3D category.

5.5 Prescribed burning of savanna (CRF 3.E)

This activity is prohibited by the Czech Legislation (Air Protection Act) and 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 Legislation (Air Protection Act) and 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 to improve plant growth in managed systems, particularly agricultural soils, 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 dissolves and releases bicarbonate, which decomposes to CO_2 and water. Liming on all the managed soils is reported under this category, i.e. arable lands, grasslands, and forest lands.

5.7.2 Methodological aspects

However, the reactions associated with limestone application also led to the 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. 5-58**). Of the total reported limestone applied in agriculture, 95% was ascribed to agricultural soils in cropland (5% to grassland) based on the expert judgment (Klement, Central Institute for Supervising and Testing in Agriculture, personal communication 2005).

The Statistical Yearbook of the Czech Republic does not provide any data on the consumption of limestone and dolomite separately. Based on ERT recommendation and lack of country-specific information, the total amount of lime applied to soils was reported as corresponding to 90% limestone and 10% dolomite from 2017.

The more accurate activity data about dolomite consumption were obtained from the Ministry of Agriculture, Department of Agricultural Commodities (Mrs. Budňáková) for 2018 -2021. These data made it possible to estimate accurately the proportion of limestone and dolomite consumption 2018-2021. The missing data about dolomite proportion of liming was adjusted according to the information available on this proportion from the last two submissions. The share of dolomite was decreased to 60% over the entire time period. The exact data about consumption of limestone and dolomite are available for EUROSTAT and are provided by CRI expert from 2021.

The share of liming of forest lands in the total liming in the Czech Republic was the highest in the period 2000-2002, when its value was over 10% and as much as 18% in 2000. In 2019, the liming of forests equalled almost 3.9% and no liming was applied to the forest land in 2021 and 2022 (**Tab. 5-58**).

Tab. 5-58 Amount of limestone and dolomite applied to managed soils [1 000 tons]

Year	Lime applied to Cropland and Grassland	Lime applied to Forest Land	Total amount of lime applied	Amount of Limestone	Amount of Dolomite	CO_2 emissions from liming
			[kt]			
1990	2 650	27	2 677	1 070	1 606	1 236
1995	248	2	251	100	150	116
2000	209	47	255	102	153	113
2005	143	3	145	58	87	67
2010	135	5	140	56	84	65
2015	353	18	371	148	222	171
2016	366	13	379	152	227	175
2017	345	13	358	143	215	166
2018	340	13	354	141	212	163
2019	402	16	418	175	243	193
2020	338	16	354	112	243	165
2021	318	0	318	140	178	146
2022	337	0	337	192	145	154

The quantification followed the Tier 1 method (Eq. 11.12, IPCC 2006), with the emission factor of 0.12 t C/t $CaCO_3$ and 0.13 t C/t $CaCMgCO_3$. To convert CO_2–C emissions into CO_2, the factor of 44/12 was used. Application of agricultural limestone used to be intensive in this country, but decreased radically during the 1990s, then increased slightly from 2010. This increase ended in 2018, when the amount applied was about 2% lower than in 2017 and 8% lower than in 2016. The activity data corresponds to the trend reported for the use of fertilizers, which decreased a lot in the early 1990s (Sálusová et al. 2006).

The application of limestone to agricultural land (incl. forest) in 2022 was 337 kt. No application was performed to forest areas. Total emissions from liming equalled 154 kt CO_2 eq. In 2022, there is no trend in consumption of limestone and dolomite in the Czech Republic.

5.7.3 Uncertainties and time-series consistency

Uncertainty estimates are based on expert judgment (AD) and the default values (EF). The uncertainty in the activity data for estimating the emissions from liming equals 20% and the uncertainty in the emission factor equals 50%. The combined uncertainty of emission estimates from liming equals 53.9%.

5.7.4 Source-specific QA/QC and verification

A detailed description of source-specific QA/QC and inventory verification of agriculture is presented in section 5.1.3.

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

No recalculation was made in this chapter.

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

No improvements are planned in this chapter.

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 and hydroxyl ions 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 (IPCC 2006) are utilized for estimating CO_2 emissions. Domestic production records for urea and DAM (synthetic fertilizer, the share of urea is 32.6%) were used to obtain an approximate estimate of the amount of urea applied to soils on an annual basis (**Tab. 5-59**). 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. For estimating 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 to CO_2 by multiplying by a factor of 44/12.

Two different data sources were used for estimating: the first one was the data on urea application from the Czech Statistical Office used from 1990 to 1999. The values of urea application to agricultural land ranged from 92 to 195 thousand tons.

From 2000, a new source of activity data was obtained and employed in the inventory estimation. The statistical production data were replaced by more accurate data, corresponding to the real consumption of fertilizers, by the Ministry of Agriculture, Department of Agricultural Commodities (Mrs. Budňáková). These data available from 2000 until 2020 were based on farmers fertilizer records and annual nutrient intake from urea and DAM. At the beginning of the 21st century, there was an extreme decrease in urea production and its application to farmland because of the significant restrictions on Czech production and the transition to import policy. The extreme consumption started in 2015 and finished in 2017.

The application of urea to agricultural land in 2022 reached 261 kt. This amount is higher than in 2021 (239 kt) but still confirmed the declared general goal of the Ministry of Agriculture to reduce the consumption of mineral fertilizers in agriculture in the Czech Republic.

Tab. 5-59 Estimated consumption of urea and urea in DAM (IPPU) applied to managed soils in the Czech Republic during reporting period (MA, 2022) and estimated emissions [kt CO_2 eq.]

Year	Urea consumption	Urea in DAM consumption	Total consumption	CO_2 emissions
		[kt]		
1990	148	-	148	109

Year	Urea consumption	Urea in DAM consumption	Total consumption	CO_2 emissions
		[kt]		
1991	180	-	180	132
1992	148	-	148	109
1993	127	-	127	93
1994	124	-	124	91
1995	149	-	149	109
1996	137	-	137	100
1997	92	-	92	67
1998	195	-	195	143
1999	120	-	120	88
2000	66	92	158	116
2001	107	107	214	157
2002	88	92	180	132
2003	85	79	164	120
2004	97	109	206	151
2005	103	97	200	146
2006	114	99	213	156
2007	169	100	269	197
2008	139	106	244	179
2009	118	83	202	148
2010	154	65	219	161
2011	153	129	282	207
2012	188	93	281	206
2013	174	96	270	198
2014	79	99	177	130
2015	259	106	365	268
2016	292	103	395	290
2017	222	85	307	225
2018	174	79	253	185
2019	132	72	203	149
2020	161	52	213	156
2021	182	57	239	176
2022	168	55	207	192

5.8.2.1 Uncertainties and time-series consistency

Uncertainty estimates are based on expert judgment (AD) and the default values (EF). The uncertainty in the activity data for estimating the emissions from urea application equals 20%, the uncertainty in the emission factor equals 50%. The combined uncertainty of emission estimates from urea application equals 53.9%.

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 was provided by the Ministry of Agriculture and discussed with relevant experts. The amount of urea applied to soils was confirmed by other entities (Institute of Agricultural Economics and Information, Crop Research Institute).

The review process identified the inconsistency in activity data in use by crosschecking NIR input with FAOSTAT data. The same activity data is used for reporting in other national reports (Transboundary convention, EUROSTAT/OECD).

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.

5.9 Acknowledgement

We greatly appreciate the support of Martin Dědina, Research Institute of Agricultural Engineering, related to harmonizing the reporting of ammonia emissions by using well documented national data. Thanks belong to IFER employees Martina Roubalová and Tereza Fukalová for the maintenance of the specific calculation spreadsheets and Radka Mašková for the technical support. We also thank to Michaela Budňáková from the Ministry of Agriculture for providing the activity data (mineral fertilizers, urea consumption, liming) in the required quality. The biggest thanks go to colleagues from CRI (Dr. Wollnerová, Dr. Klír), who with great patience helped to improve reporting in this sector.

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 is based on the application of 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). The current LULUCF reporting is also guided by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC 2014a) and 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019). This methodological guidance is used to prepare the assessment and reporting of annual changes in carbon stocks in IPCC land-use categories, and emission contribution from the Harvested Wood Products (HWP).

The current inventory of the LULUCF sector uses the recommended reporting structure. 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 system of land use representation and land-use change identification at the level of the individual cadastral units, based on the data administered nationally by the Czech Office for Surveying, Mapping and Cadastre (COSMC). The Czech LULUCF inventory remains in the process of continuous refinement and consolidation, but it represents a solid system for providing information on GHG emissions and removals in the LULUCF sector.

The current LULUCF 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 implicitly 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 2022. The currently reported estimates changed in comparison with the previously reported values due to minor methodological improvements, refinements in activity data and adopted emission factors affecting emission estimates for some categories that resulted in recalculations for the entire reporting period. Also, this inventory includes the revised global warming potential values (GWP) applicable to CH_4 and N_2O as recommended by IPCC Fifth Assessment Report (AR5).

The current sectoral estimates of greenhouse-gas emissions and removals are shown in Fig. 6-1. For 2022, the most recent reported year, we report overall emission contribution from the LULUCF sector for the fourth year in a row, i.e., 2019-2022. This is due to the exceptionally high sanitation harvest following an unprecedented drought and bark-beetle outbreak experienced in the Czech forestry in the recent years (since 2015). The data shown in Fig. 6-1 include emissions and removals for all land use categories including HWP contribution. Detailed information on the current emission estimates, implemented changes and performed recalculations is provided below for the individual LULUCF categories.

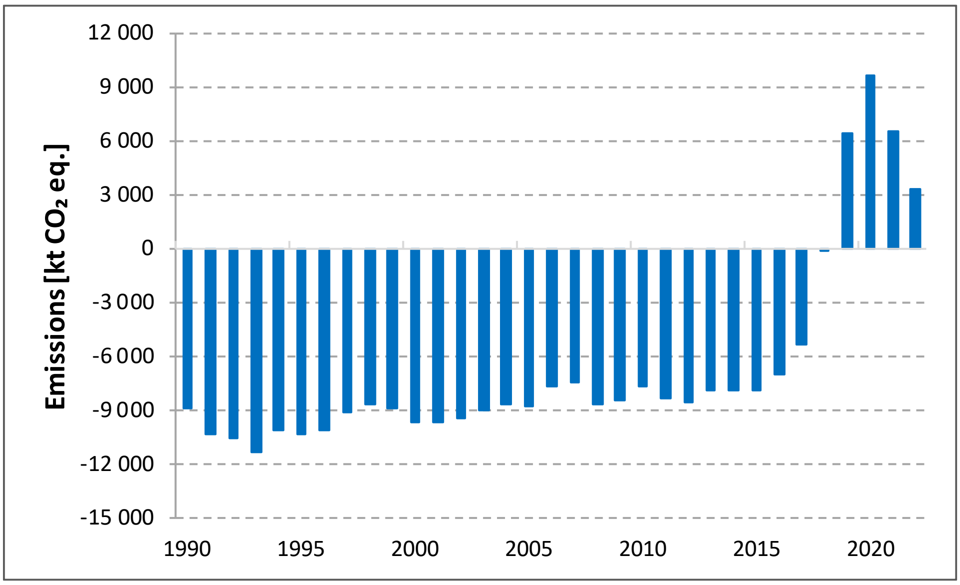

Fig. 6-1 The currently reported estimates of emissions for the LULUCF sector. The negative values correspond to net removals of green-house gases. The positive values are net emissions of green-house gases reported for years 2019-2022, when the emission balance turned positive due to the development in forestry sector.

6.1.1 Estimated emissions and removals

Tab. 6-1 provides a summary of the LULUCF GHG estimates for the base year of 1990 and the most recently reported year, 2022. They are listed by the major LULUCF categories and their sub-categories.

Tab. 6-1 GHG estimates in Sector 4 (LULUCF) and its categories in 1990 (base year) and 2022

Sector/category	Emissions 1990 [kt CO_2 eq.]	Emissions 2022 [kt CO_2 eq.]
4 Total LULUCF	-8 835	3 378
4.A Forest Land	-7 472	5 528
4.A.1 Forest Land remaining Forest Land	-7 237	6 079
4.A.2 Land converted to Forest Land	-235	-551
4.B Cropland	116	45
4.B.1 Cropland remaining Cropland	-13	-21
4.B.2 Land converted to Cropland	129	67
4.C Grassland	-144	-501
4.C.1 Grassland remaining Grassland	0	-311
4.C.2 Land converted to Grassland	-144	-190
4.D Wetlands	24	57
4.D.1 Wetlands remaining Wetlands	(0)	(0)
4.D.2 Land converted to Wetlands	24	57
4.E Settlements	319	195
4.E.1 Settlements remaining Settlements	(0)	(0)
4.E.2 Land converted to Settlements	319	195
4.F Other Land	(0)	(0)
4.G Harvested Wood Products	-1 680	-1 946

Note: Emissions of non-CO_2 gases (CH_4 and N_2O) are also included.

In 2022, the net GHG flux for the LULUCF sector, estimated as the sum of emissions and removals, equalled 3 378 kt CO_2 eq. This represents a net source of GHG gases, for the fourth time in a row reported for the LULUCF sector in the country. In relation to the estimated emissions in other sectors for the inventory year 2022, these emissions generated from the LULUCF sector represent a contribution of 2.8% on the total GHG emissions in the country. Correspondingly, for the base year of 1990, the total emissions and removals in the LULUCF sector equalled -8 835 kt 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 4.6% 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 be interpreted with care.

The aggregated emissions estimates reported for the major LULUCF categories (i.e., by land use and HPW contribution) are shown Tab. 6-2. The entire data series can be found in the corresponding CRF Tables.

Tab. 6-2 Estimated emissions and removals for the major land-use categories and HWP contribution for the entire reporting period 1990 to 2022 by 5-years and annually since 2020. IE for 4.F Other land – included within 4.E Settlements.

Sector	4.A Forest land	4. B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G HWP	4. LULUCF Total
				[kt CO_2 eq.]				
1990	-7 472	116	-144	24	319	IE	-1 680	-8 835
1995	-9 714	153	-302	12	295	IE	-827	-10 382
2000	-8 496	128	-371	35	289	IE	-1 271	-9 684
2005	-7 365	102	-359	27	307	IE	-1 434	-8 722
2010	-6 056	101	-360	37	186	IE	-1 620	-7 712
2015	-7 209	82	-427	27	150	IE	-478	-7 854
2020	12 670	50	-476	34	214	IE	-2 792	9 700
2021	9 153	48	-495	26	245	IE	-2 390	6 588
2022	5 528	45	-501	57	195	IE	-1 946	3 378

Tab. 6-3 Key categories of the LULUCF sector (2022)

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	5.02
4.C.1 Grassland remaining Grassland	CO_2		LA, TA		Yes	-0.26
4.A.2 Land converted to Forest Land	CO_2	LA	LA	Yes	Yes	-0.46
4.G Harvested wood products	CO_2	LA	LA, TA	Yes	Yes	-1.62

KC: key category
[1] including LULUCF

Within the LULUCF sector, four categories were identified as key categories according to the IPCC 2006 for 2022. The most important is 4.A.1 Forest Land remaining Forest Land with a contribution of 5.02%, which is the major LULUCF category identified by both the level and trend assessment (Tab. 6-3). The emissions in this category are mostly determined by changes in living biomass carbon stock (see more in Section 6.4.6). The other two categories are 4.C.1 Grassland remaining Grassland and 4.A.2 Land converted to Forest Land, with a contribution of under 0.5 % each. The fourth key category is 4.G Harvested wood products that offset 1.62% of the total GHG emissions in the country. Tab. 6-3 lists all key categories evaluated based on the approach 1 (KC A1) and approach 2 (KC A2) specified in IPCC 2006 Guidelines (IPCC 2006).

6.1.2 Coverage of pools and methodological tiers

The current inventory submission of the LULUCF sector includes all the mandatory categories and carbon pools (Tab. 6-4), 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).

Tab. 6-4 Carbon pools in LULUCF and in their finer resolution under the former KP LULUCF reporting

Carbon pools in LULUCF reporting	Carbon pools in KP LULUCF format	Definition
Living biomass	Aboveground biomass	All biomass above stump height (1% of tree height)
	Belowground biomass	All biomass below stump height (1% of tree height)
Dead organic matter	Deadwood	Standing deadwood, dead stumps, roots and logs (min. 7 cm diameter)
	Litter	Needles, leaves and branches up to a diameter of 7 cm
Soils	Soil organic matter	Mineral soils up to 30 cm depth and organic soils

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 greenhouse 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 IPCC 2006 Gl. (IPCC 2006)) imply that, for the reported period of 1990 to 2022, 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 (1992-2020) 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 2022, 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. Before 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 Tab. 6-5 and it can also be found in the respective Chapters 6.4 to 6.9 devoted to each of the major land-use categories.

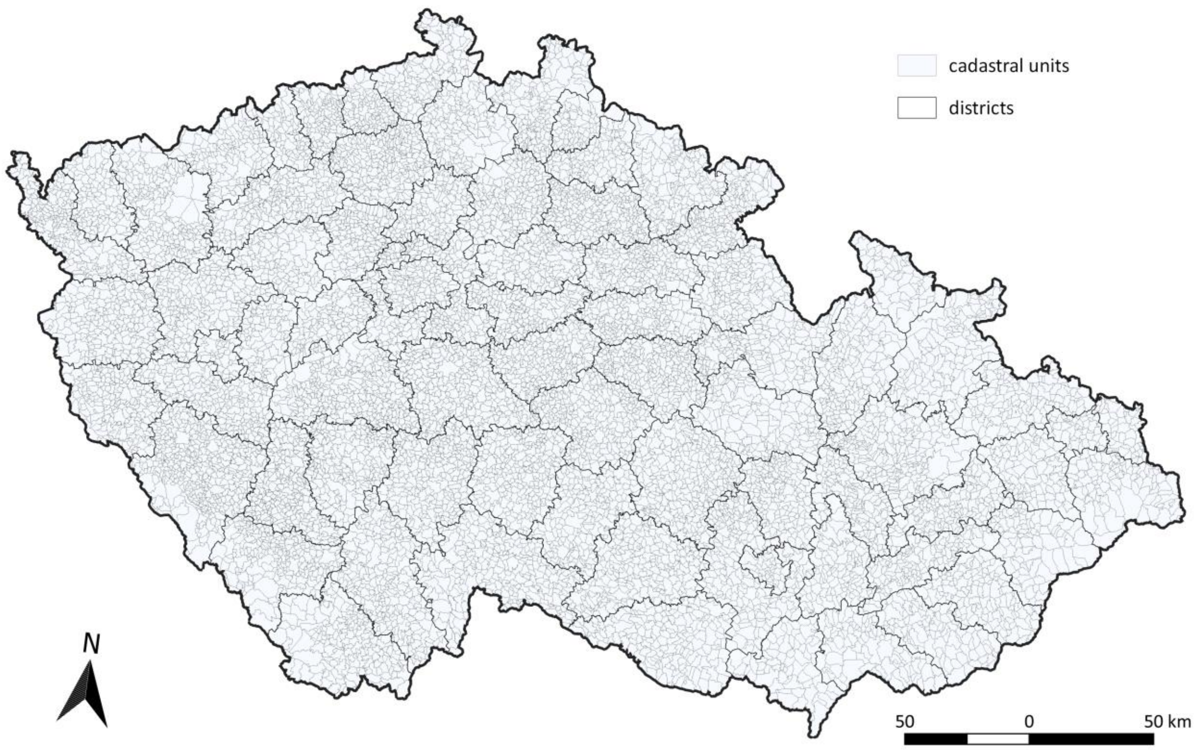

Fig. 6-2 Cadastral units (grey lines; n = 13 076 in 2022) and districts (black lines; n=77), the basis of the Czech land use representation and land use change identification system.

Tab. 6-5 Linking the Czech national cadastral (COSMC) land-use categories to the IPCC land-use categories. COSMC codes in parenthesis combine types of properties and their dominant use.

IPCC land-use category		CRF coding	Czech national cadastral (COSMC) ID code and land-use category
Forest land		4.A	10. Forest land - Land with forest stands and land, where forest stands were removed to permit their regeneration, forest break and unpaved forest road, not wider than 4 m, and land, where forest stands were temporarily removed due to a decision of state forest administration (Forestry Act 289/1995)
Cropland		4.B	2. Arable land - Land of arable soil according to the Agriculture Act 3. Hop fields - Land of hop field according to the Agriculture Act 4. Vineyards - Land of vineyard according to the Agriculture 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 Agriculture Act
Grassland		4.C	7. Permanent grassland - Land of permanent grassland according to the Agriculture Act
Wetlands		4.D	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)
Settlements		4.E	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
Other land		4.F	NO since 2018 NIR submission, earlier represented by (21) Other area – unfertile land

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 conversions 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 Other land representing unfertile land with no specific type of land use, which was considered constant until 2003. 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
31-12-2010	661635 (Kácov)	1992637	2627349	1186759	376350	1415821	NO	7598916
31-12-2011	661635 (Kácov)	1979724	2633115	1181825	376350	1427904	NO	7598918
Difference		-12913	5766	-4934	0	12083	-	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 the cadastral unit 661635 (Kácov) – total difference between years for all land-use categories as well as the specific conversions between concrete land use categories as provided by COSMC. The spatial unit is m². Not occurring (NO) noted for Other land.

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 2022, 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 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

[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. This reconciliation of land-use information is still 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.*

working in collaboration with COSMC on further consolidation of the system to provide the specific information required for the estimates in the LULUCF sector.

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 categories to IPCC land use categories is summarized in Tab. 6-5 and 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

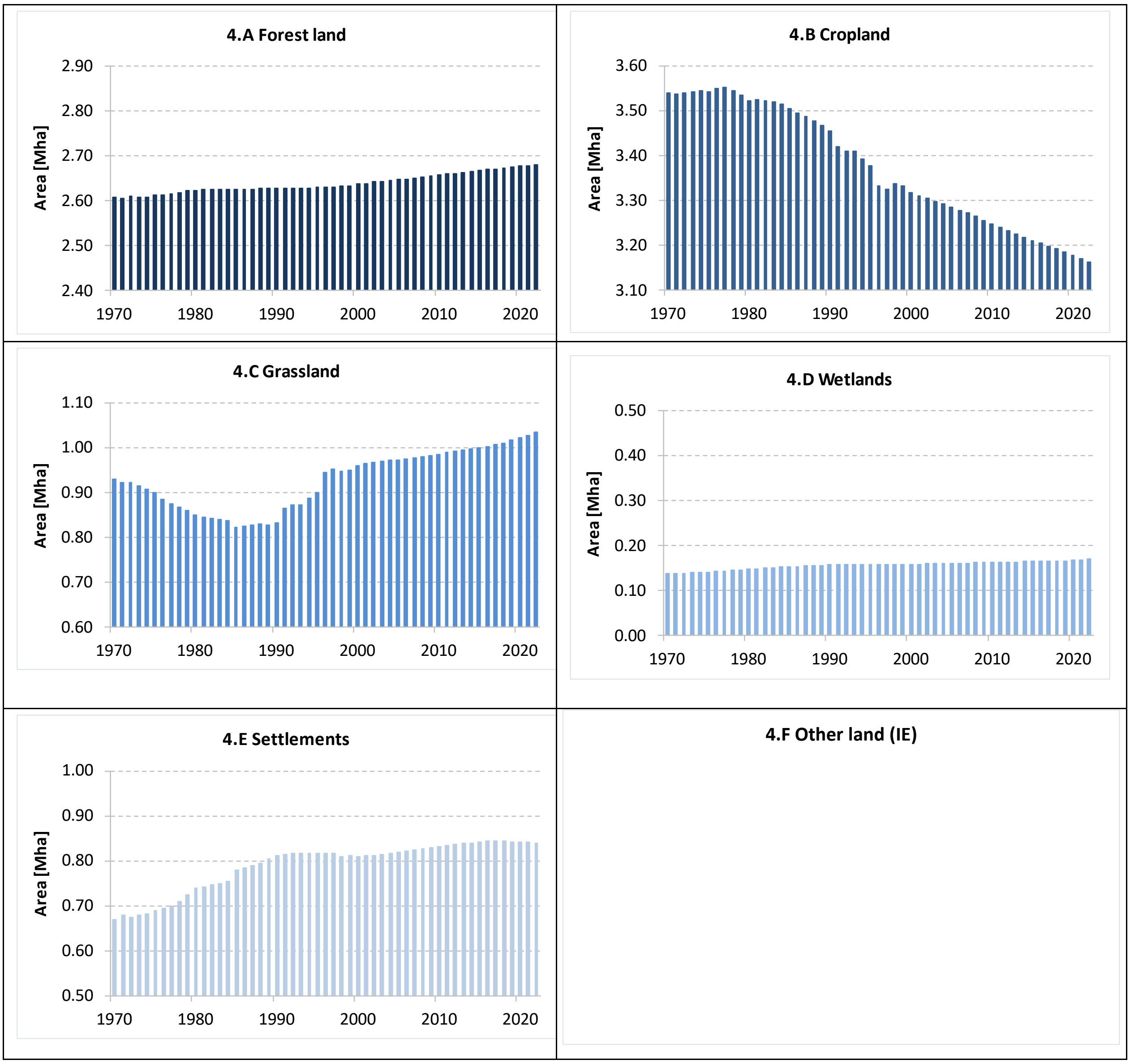

Fig. 6-4 Trends in areas of the six major land-use categories in the Czech Republic between 1970 and 2022 (based on information from the Czech Office for Surveying, Mapping and Cadastre). 4.F Other land (IE) is included within 4.E.

The overall trends in the areas of the major land-use categories in Czech Republic for the period 1970 to 2022 are shown in Fig. 6-4. The largest quantitative change is associated with the Cropland and Grassland land-use categories.

Tab. 6-6 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 2022

1990		Initial (1989)						*Area [kha]*
	Category	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	
Final (1990)	Forest Land	2 628.6	0.5	0.4	0.0	0.0	0.0	**2 629.5**
	Cropland	0.0	3 454.5	0.4	0.0	0.1	0.0	**3 455.0**
	Grassland	0.1	8.8	823.6	0.0	0.0	0.0	**832.5**
	Wetlands	0.0	0.4	0.4	155.9	0.8	0.0	**157.5**
	Settlements	0.3	3.7	3.7	0.1	804.1	0.0	**811.9**
	Other Land	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	Area [kha]	2 629.0	3 467.9	828.5	156.1	805.0	0.0	**7 886.4**
2022		**Initial (2021)**						***Area [kha]***
	Category	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	
Final (2022)	Forest Land	2 678.4	0.4	0.4	0.0	1.1	0.0	**2 680.4**
	Cropland	0.0	3 159.5	1.3	0.0	0.9	0.0	**3 161.8**
	Grassland	0.0	7.3	1 025.9	0.0	1.5	0.0	**1 034.9**
	Wetlands	0.1	0.2	0.2	168.4	1.4	0.0	**170.3**
	Settlements	0.2	2.7	0.7	0.2	836.0	0.0	**839.8**
	Other Land	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	Area [kha]	2 678.8	3 170.1	1 028.6	168.7	840.9	0.0	**7 887.1**

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. 6-6 shows a product of that analysis (for the base year 1990 and the latest reporting year 2022), namely the areas of land-use change among the major land-use categories in the form of land-use change matrices for the individual years. This is available for all years of the reporting period. It is important to note that the annual totals for the individual years in the matrices do not necessarily correspond to the areas that appear in the CRF Tables, which account for the progressing 20-year transition period that began in 1970. This is the recommended assumption of IPCC (2006) for estimation of changes in soil carbon stock.

6.4 Forest Land (CRF 4.A)

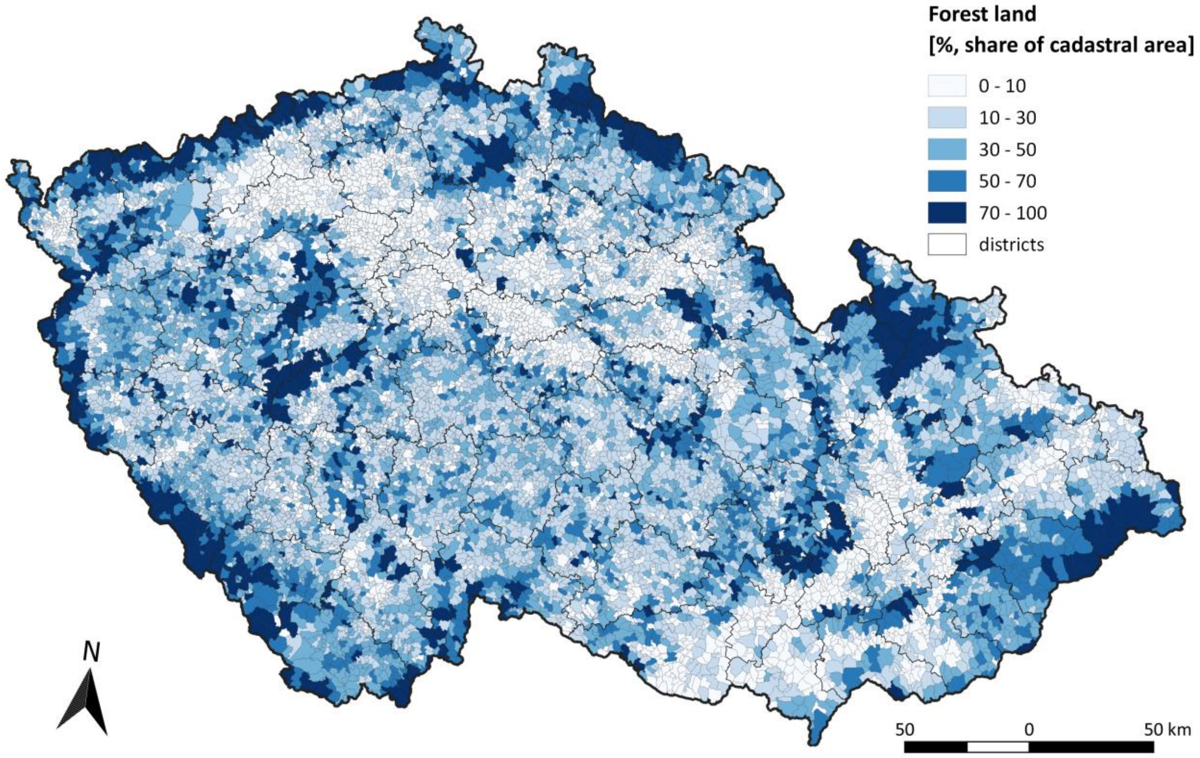

Fig. 6-5 Forest land in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2022)

6.4.1 Source category description

The Czech Republic is a country with a long forestry tradition. Practically all the forests can be considered as 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 10) 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 a 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 some areas of currently (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 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 (see more below) are collected as a bottom-up process based on the mandatorily elaborated forest management plans (FMPs). FMPs and/or forest management outlines (for forest properties under 50 ha) serve for overall assessments of the state of forests, which are requested under the Czech Forestry Act (289/1996).

[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. Thereafter, these parameters were used in subsequent policies on forestry (e.g., KP II for 2013-2020 or EU Regulation on LULUCF 2018/841).

In 2022 (1990), the area of Forest Land equalled 2 680 (2 629) th. ha, whereas the stocked forest area (timberland) corresponded to 2 618 (2 583) thousand ha, representing 97.7 (98.2)% of the cadastral forest land in the Czech Republic. Hence, the temporarily unstocked area, not accounted in forest biomass emission estimates, represents 2.3 (1.8)% of the forest land according to the Czech cadastral data as of 2022 (1990).

Forests (cadastral forest land) currently occupy 34% of the area of the country (based on MA, 2023). The tree species composition is dominated by conifers, which represent 68.4% of the timberland area. The four most important tree species in this country are spruce, pine, beech and oak, which account for 46.8, 16.0, 9.6 and 7.8% of the timberland area, respectively (MA, 2023). Broadleaved tree species have been favoured in afforestation since 1990. The proportion of broadleaved tree species increased from 21% in 1990 to 29.5% in 2022. 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 689 mil. m^3 (under bark) in 2022 (MA, 2023).

Several sources of information on forests are available in the Czech Republic. The primary, official source of activity data on forests in the country, which are also used for this emission inventory, is the forest taxation data in Forest Management Plans (further denoted as FMPs). These data are administered centrally by the Forest Management Institute (FMI), Brandýs n. L., representing an official source of information on forest resources in the country. 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 an FMP represents an ongoing national stand-wise type of forest inventory. An auxiliary source of information is the 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 were gradually released during the period from 2016 to 2019 (Kučera and Adolt 2019). Since 2016, FMI initiated a continuous inventory with a 5-year cycle on individual plots. The pilot assessments of that inventory (NFI3) were released in 2023 (Máslo et al. 2023). Another auxiliary statistical information on forests at a country level is provided by the Czech landscape inventory (CzechTerra; www.czechterra.cz), which 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 a 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 been used in this inventory report as a basis for tree species allometry and for verification purposes. However, the emission inventory is still primarily based on the FMP data, which are the main continuous data source used for domestic and international reporting on forests in the Czech Republic since 1990 to date.

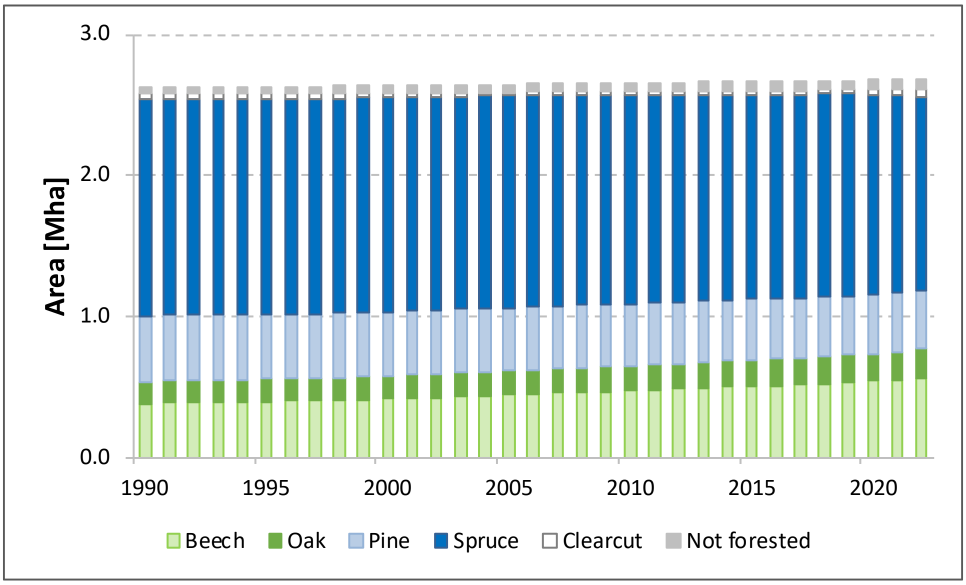

Fig. 6-6 Activity data – area for the four major tree species groups and clear-cut area during 1990 to 2022 (total area of Forest Land shown)

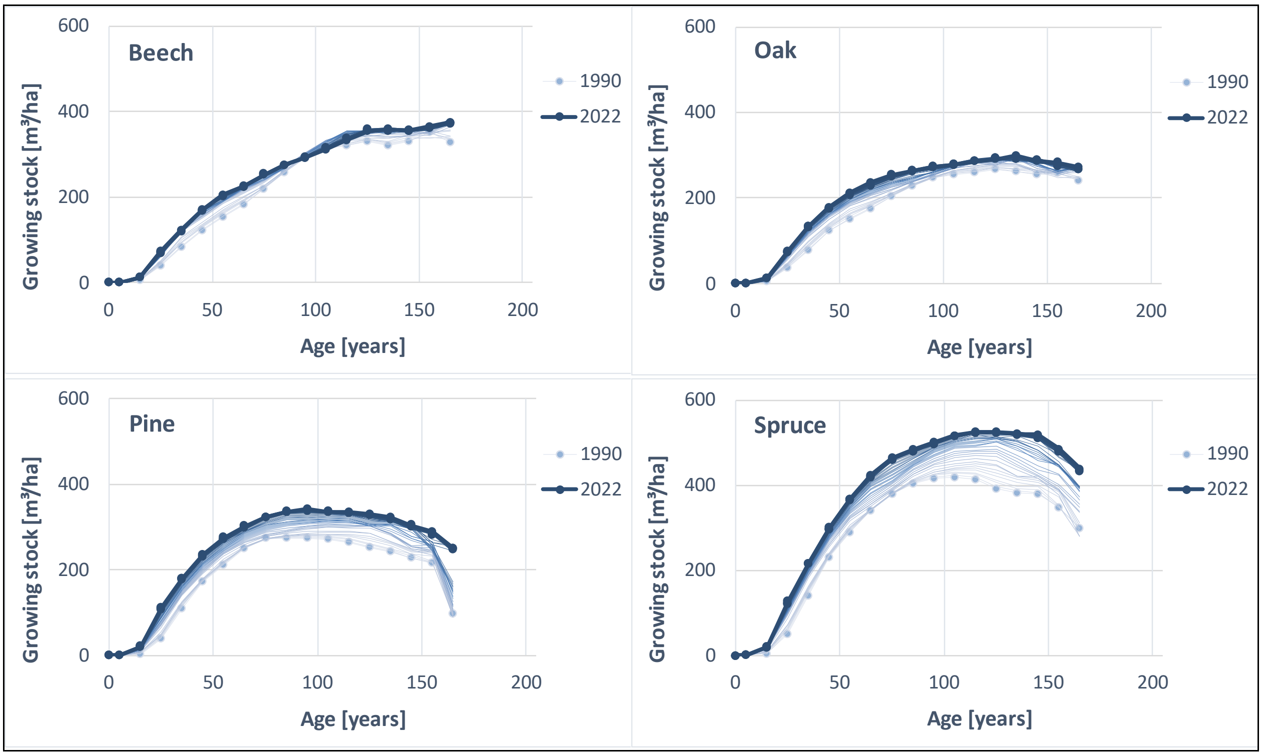

Fig. 6-7 Activity data – mean growing stock volume against stand age for the four major groups of species during 1990 to 2022; each line corresponds to an individual inventory year. The symbols identify only the situation in 1990 and 2022.

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-pines, iv-spruce: all conifers except pines) and age-classes (10-year intervals). For these categories, growing stock (merchantable volume, defined as a tree stem and branch volume under the 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). Fig. 6-7 shows the average growing stock for all tree species groups. According to the official data based on FMP (MA 2023), it has increased steadily for broadleaved tree species groups since 1990 in this country.

On the contrary, tree species area for the coniferous tree species steadily declined since 1990 (Fig. 6-6). This decline accelerated during the period 2019-2022, when also a reduction in spruce growing stock volume was detected. This is coherent with the actual independent estimation on growing stock based on NFI sample-based monitoring, which also suggests a significant reduction of the growing stock of coniferous trees, which is mainly related to the accelerating spruce forest decline (Adolt et al., 2020, Máslo et al. 2023).

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 2022, clear-cut areas represented 2.1% of the timberland area within Forest Land according to FMP data and the published official national information based on these data (MA 2023). Note, however, that this may differ from actual clear-felled areas as detected by remote sensing (https://www.kurovcovamapa.cz/) for the most recent period. Although this is an example of the inadequate representation of clear-felled areas during the current calamity outbreak, it does not explicitly impact the reported harvest volumes, which are obtained independently as described below.

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 based on 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 base harvest of merchantable wood from forests increased from 13.3 mil. m^3 in 1990 to 25.1 mil. m^3 in 2022. This is less than in 2020, when the highest ever harvest volume was recorded in the country, reaching 35.8 mil. m^3, and less than 30.3 mil. m^3 recorded in 2021 (all data refer to under-bark volumes, MA 2023). This confirms a turnover of the recent (2017-2020) drought-induced bark-beetle calamity trend. Also, a share of sanitary volume successively declined from 95% in 2020 to 79% in 2022. Sanitary felling is mandatorily prioritized in reaction to the exceptional bark-beetle outbreak during the recent years. Hence, it is confirmed that the sanitary (and total) harvest peaked in 2020 and the positive trend showing some stabilization of the Czech forestry sector since 2021 is expected to continue in the coming years.

The Czech emission inventory also includes the harvest loss, which represents the additional removal of wood and forest residues associated with planned harvest and natural disturbance events. This additional harvest drain estimate is officially reported by the Czech Statistical Office (CzSO), which became available since 2009 and included since year 2011 (J. Kahuda, CzSO, personal communication 2013). It consistently complements the previously employed harvest loss estimates increasing the base (wood industry) reported harvest by an extra 2.5 and 4% of the final and salvage logging volumes, respectively (see Section 6.4.2 below). The additional removals of solid wood and forest residues enter the estimation using partitioning of 15 and 85 % between the two woody components, respectively, which represents a conservative estimate of the extra harvest while preventing double counting. Hence, the total woody drain is the sum of the base merchantable harvest and the estimated fraction of additional woody extraction (0.44 mill. m^3 in 2022), as graphically show in Fig. 6-9. See also explanatory pictures in Fig. 6-8 providing more transparency into this. The additional harvest loss represents about 2.6 % of the base harvest volume across the entire reporting period. There is no trend in the estimated volume of additional harvest quantity in the reporting period (OLS regression p-value of 0.219). However, the estimation of additional extraction of harvest residues remains uncertain and will be further verified once the new empirical evidence of the

National forest inventory (NFI) becomes available and the NFI estimates become implemented in the emission inventory of the LULUCF sector.

Fig. 6-8 Illustration of base harvest (left) and additional (extra) harvest (right) volume as reported by CsSO and used as activity data as described in the text.

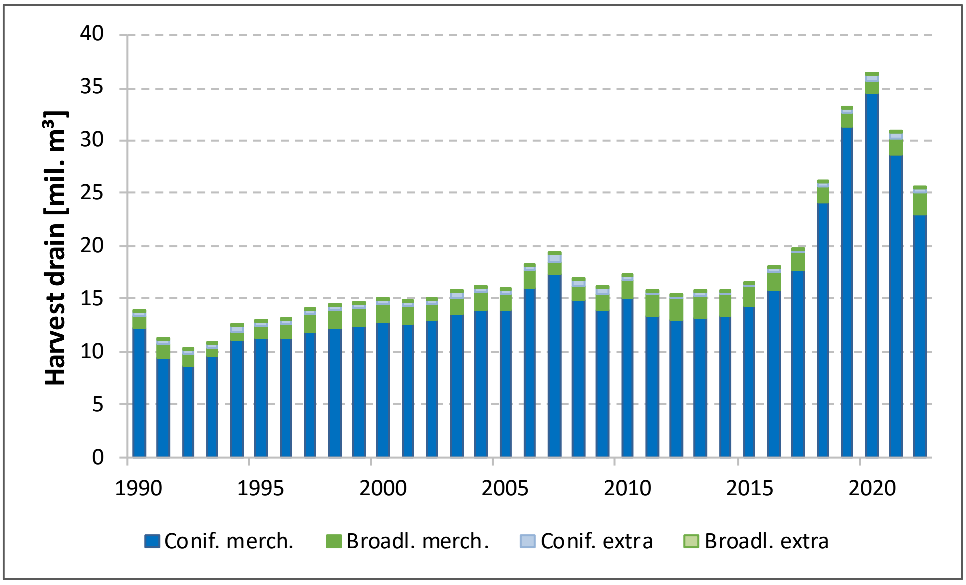

Fig. 6-9 The applicable total annual harvest for coniferous (Conif.) and broadleaved (Broadl.) tree species, which includes both the reported quantities of merchantable wood for the two categories (Conif. merch, Broadl. merch.) and the estimated/reported additional harvest drain (Conif. extra, Broadl. extra) for the entire reporting period of 1990 to 2022.

Salvage logging operations in this country are predominantly related to stands affected by windstorms, snow and bark-beetle calamities. 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). The actual share of salvage logging is annually reported by CzSO and elsewhere (MA 2023). In 2022, the applicable salvage volume of the total annual base harvest reached 20.1 mill. m^3, down by 14.2 mill. m^3 from the earlier maximum estimated for 2020, and down by 6.5 mill. m^3 estimated for 2021. Although this is a clear improvement and evidence of stabilization in the Czech forestry, the share of the sanitary harvest observed for 2022 (79% of the total base harvest) remains excessive, representing a challenge for the forest management in the country. The total harvest applicable for the emission inventory for the entire reporting period since 1990 to 2022 is shown in Fig. 6-9. The information on the reported harvest, share of salvage logging, quantity of harvest by disturbance type and applicable additional harvest is also provided in Tab. 6-7. Fig. 6-9 also shows the total harvest drain separated by species groups for 1990 to 2022.

Tab. 6-7 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 extraction (source information IFER, CzSO)

Variable	Unit	Year							
		1990	2000	2005	2010	2015	2020	2021	2022
Reported base harvest	Mm^{-3}	13.3	14.4	15.5	16.7	16.2	35.8	30.3	25.1
Share of salvage logging	% of reported harvest	74	23	29	39	50	95	87	79
- abiotic/natural	Mm^{-3}	8.70	2.39	2.30	4.07	4.39	4.60	4.86	5.86
- pollutants	Mm^{-3}	0.29	0.08	0.04	0.03	0.03	0.01	0.02	0.00
- insect outbreaks	Mm^{-3}	0.18	0.32	0.98	1.79	2.31	26.24	18.29	11.54
- other	Mm^{-3}	0.65	0.50	1.22	0.57	1.43	3.06	3.11	2.37
Additional extraction of harvest residues (IFER, CzSO)	Mm^{-3}	0.48	0.41	0.46	0.52	0.30	0.41	0.44	0.44
Total harvest removals	Mm^{-3}	13.8	14.9	16.0	17.3	16.5	36.2	30.7	25.5

As apparent from Tab. 6-7, the most notable disturbance type requiring salvage logging is the insect outbreak in the country that peaked in 2020 with a trend reversal in 2021. Also important is damage by abiotic factors, such as wind, snow and other climatic phenomena. On the contrary, damage attributable to pollutants became insignificant in the two recent decades and compared to the late 1980s and early 1990s, when the region suffered from significant air pollution impacts. However, residuals from that period can still be detected in soils, which remain regionally acidified and apparently degraded in terms of nutrients (Hruska and Cienciala 2003). In this context, it is also important to note that a causal attribution of factors responsible for declining tree health is complex and forest management evidence, which is the basis of information shown in Tab. 6-7, does not discern the underlying factors such as sensitivity to drought or unfavorable soil chemistry, but reports on the final visible phenomena of affected trees (Cienciala et al. 2017). It is generally agreed that the recent insect outbreak calamity was induced by exceptional cumulative drought conditions combined with above-average temperatures (MA 2019), which the country has been experiencing since 2015. The recently published literature confirmed that the cumulative drought observed for 2015-2018 was unprecedented for over two millenia in the country (Büntgen et al. 2021). In the context of the reported harvest logging estimates, it is important to understand that the inventory team is not in a position to conduct any independent verification of the national information on disturbance types and additional harvest (Tab. 6-7). Hence, the information provided centrally by CzSO remains the official national source of information on harvest levels in the country, and it is used consistently for the entire reporting period.

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 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 to 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., 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. 6-6 above.

In terms of emission estimations, the earlier inventory submission (NIR 2022) introduced a major methodological upgrade applicable to 4.A Forest Land (as well as to the then mandatory KP LULUCF activities) by adopting Tier 3 estimation methodologies facilitated by the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3, ver. 1.2, here denoted also as CBM; Kurz et al. 2009, Kull et al. 2019). An overview of the emission categories and carbon pools affected by the improved methodological tier is shown in Tab. 6-8 for the UNFCCC land use categories concerned as well as the corresponding former KP LULUCF activities. The methodological changes implemented in the previous inventory submission (NIR 2023) additionally included changes in living biomass for Forest land converted to other land use (Deforestation), which is estimated solely by CBM, in coherence with other subcategories of 4.A Forest land (Tab. 6-8). The current inventory submission retains these methodological approaches, while it improves the estimates of input activity data (extraction of harvest residues as above) and rectifies the proportions of dead organic matter components within the model.

Tab. 6-8 Methodological tier indicating use of CBM in estimation carbon pools for the concerned land use categories and the former KP LULUCF activities. *Carbon stock change in organic soil is not included (not estimated).

Emission category (UNFCCC) or Activity (KP LULUCF)	Carbon pool UNFCCC	Carbon pool KP LULUCF	Methodological tier and comment
4.A.1 FL remaining FL Forest Management	Living biomass	Aboveground biomass	T3, CBM
		Belowground biomass	T3, CBM
	Dead organic matter (DOM)	Deadwood	T3, CBM
		Litter	T3, CBM
	Soil (Mineral soils)*	Soil (Mineral soils)	T3, CBM
4.A.2 Land converted to FL Afforestation/Reforestation	Living biomass	Aboveground biomass	T3, CBM
		Belowground biomass	T3, CBM
	Dead organic matter (DOM)	Deadwood	T2/T3, CBM
		Litter	T2/T3, CBM
	Soil (Mineral soils)*	Soil (Mineral soils)	T2/T3, Soil carbon maps
4.B.2.1 FL converted to Cropland 4.C.2.1 FL converted to Grassland 4.D.2.1 FL converted to Wetland 4.E.2.1 FL converted to Settlements Deforestation	Living biomass	Aboveground biomass	T3, CBM
		Belowground biomass	T3, CBM
	Dead organic matter (DOM)	Deadwood	T2/T3, CBM
		Litter	T2/T3, CBM
	Soil (Mineral soils)*	Soil (Mineral soils)	T2/T3, Soil carbon maps
Harvested Wood Products	Harvested Wood Products	Harvested Wood Products	T2, Production approach

6.4.2.1 Description of the CBM-CFS3 carbon model application

We provide a detailed model description, its country-specific calibration and independent verification in Annex 3.6 of this NIR submission. In the text below, we give essential methodological information on model-aided estimations of emissions resulting from changes in individual carbon pools. Hence, the readers are advised to seek the detailed CBM-specific information in Annex 3.6 to complement understanding of the estimation approach.

In general, application of the CBM model was set up to resemble the NIR reporting strategy (key input data use, stratification) adopted in the gradually developing Czech emission inventory of the LULUCF sector. The CBM simulation run is set to start in 1990 and progresses in an annual time step until 2021, i.e., for the entire reporting period. The model integrates the key activity data as used in the emission inventory to the present. These include land-use areas related to forests, data on growing stocks by tree species and age class from the national stand-wise inventory of FMP and the related volume increment data, and data on disturbances (management practices).

CBM simulates the transfer of carbon between pools and the atmosphere (Fig. 6-10). Specifically, it simulates mortality and litter fall representing transfers from biomass to other dead organic matter (DOM) pools resulting from tree, foliage, branch and root mortality (Kurz et al. 2009). The calibrated country-specific equations to convert volumes to biomass components, turnover and transfer rates between DOM pools are specified in the AIDB database (a CBM-specific database in MS Access format, Kull et al. 2019).

The detailed model handling of carbon turnover including DOM pools was one of the fundamental reasons for implementing this Tier 3 modelling approach to ensure that the complete carbon cycling in forest ecosystems was fundamentally captured. This is important specifically in the recent conditions of significantly changing wood harvest and mortality in the country, which directly affect inputs into and emissions from the DOM pools. Decomposition of DOM pools is modelled using a temperature dependent decay rate function (Kurz et al. 2009). Disturbances including forest management interventions such as thinning, harvest and afforestation are each defined in a matrix describing the proportion of carbon transferred between pools, fluxes to the atmosphere, and transfers to the DOM pools and the timber sector (Fig. 6-10). The emission contribution of HWP is calculated separately as described in Section 6.10.

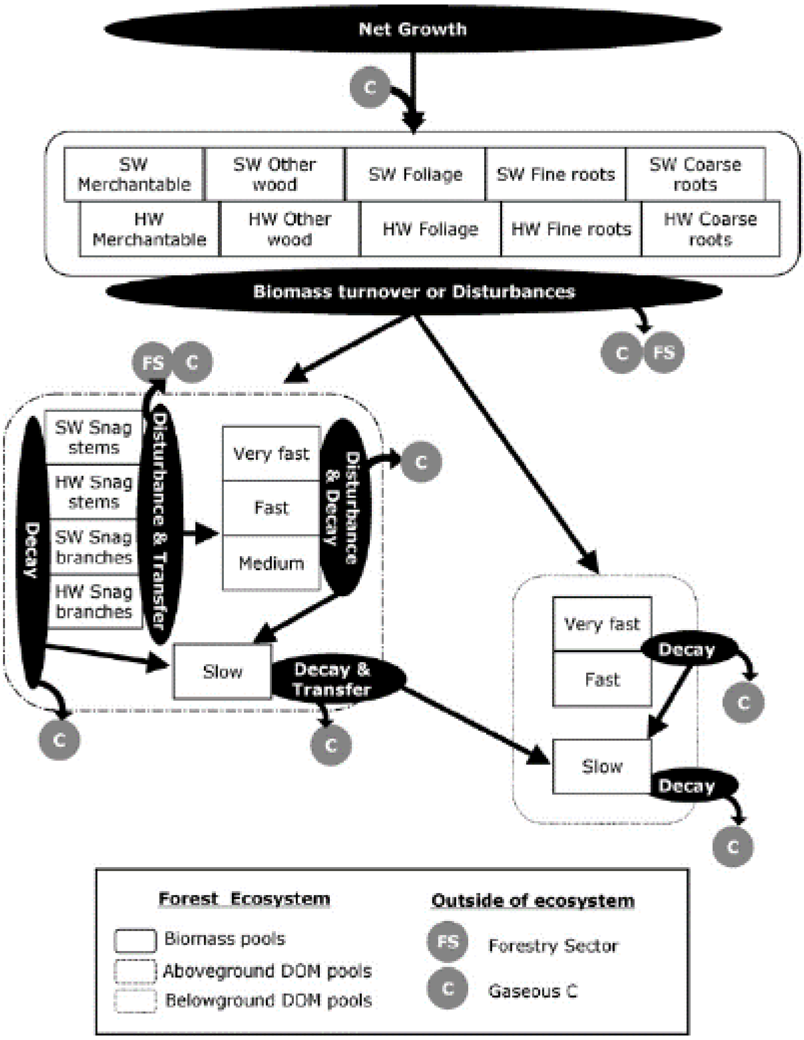

Fig. 6-10 Conceptual diagram of CBM (taken from Kurz et al. 2009) showing the individual biomass and dead organic matter (DOM) carbon pools and key governing simulated processes (in ovals) and transfers in forest ecosystem carbon balance.

The key input activity data and parameters used in CBM include:

- Land use areas of forest land, land use conversions to Forest Land (former KP LULUCF activity Afforestation/Reforestation) and from Forest land (former KP LULUCF activity Deforestation) as described in Section 6.2 and 6.4.1. These activity data come from the Czech Office for Surveying, Mapping and Cadastre (COSMC). Other related details are described in Section A.3.6.2.1.

- Growing stock by age classes categorized into four main species groups (beech, oak, pine, spruce) as described and visualized in Section 6.4.1. CBM simulation is initiated with the state of the forest resources, i.e., growing stock volume by species groups and age classes as of 1990 (see section A.3.6.2.1). These activity data were provided by Forest Management Institute, Brandys n. Labem (FMI).

- Volume increment data used in CBM are derived from the identical source as described in Section 6.4.2.2. However, CBM uses a specific concept of current and historical growth curves (yield tables, CYTs and HYTs, respectively), which is detailed in Annex 3.6.2.2. In brief, the current yield tables (CYTs) are derived from the current annual increment (CAI) using the official increment estimates as provided by FMI as shown in Fig. 6-11. CYT and HYT curves were derived from the age class structure for the individual species-group strata. While HYT correspond to the initial state of the forest resources as of 1990, the CYT growth curves were fitted on data as of 2004, representing the middle of the growth period. Thereafter, a set of relative scaling factors applicable to individual tree species groups and the reporting period 1990 to 2022 were used within CBM to assure the full correspondence of the CYTs with the input activity data on the CAI shown in Fig. 6-11. Annex 3.6.2.2 provides complete information on this parameterization and applicable scaling factors by individual tree species groups.

- Country-specific allometric equations to estimate individual tree components and biomass proportions as a function of tree age are an essential step of CBM calibration to local conditions. To provide biomass estimates for individual tree parts, a set of relevant national allometric studies and/or biomass compilations that include data from equations of the Czech Republic was used. These sources are coherent with those used in the earlier Tier 2 estimates (NIR 2021), but the calibration procedure was extended as required by CBM according to Boudewyn et al. (2007), Kurz et al. (2009) and Kull et al. (2019). Specifically, we used the following sources of allometry: beech (Vonderach et al. 2018, Wutzler et al. 2008 for leaves only), oak (Cienciala et al. 2008a), pine (Cienciala et al. 2006b), spruce (Vonderach et al. 2018) and complementarily birch (Marklund 1988, Repola 2008 for leaves only). The calibration process is detailed in Annex 3.6.2.4.

- Turnover rates and transfer to DOM carbon pools are based on the values published for CBM in the European CBM-specific database AIDB by Pilli et al. (2018), with stem biomass mortality derived from the Czech NFI (Adolt et al. 2016). The information on biomass turnover, designated DOM pools and litter transfer rates as applied by CBM is provided for individual pools in Annex 3.6.2.4.

- Forest management interventions and other disturbances represent the changes to forest ecosystems that are specifically defined by disturbance matrices for individual intervention (disturbance) types. They define the changes in carbon pools and transfers between them. Forest management interventions include commercial thinning, salvage logging either with or without resulting clearcuts, and final cut. Disturbances such as wildfires and slash and burn are used to initialize DOM pools. Additionally, deforestation events leading to other land-use (Cropland, Grassland, Wetlands, Settlements) are also governed by specific matrices. All disturbances used by CBM are detailed in full in Annex 3.6.2.5.

6.4.2.2 Forest Land remaining Forest Land

The 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.

Until NIR 2021, the carbon stock change in living biomass was estimated using the default method[4] according to eq. 2.7 of IPCC (2006). This method is based on a separate estimation of increments and removals, and their difference. Since the 2022 submission (NIR 2022), the living biomass carbon stock change has been solely estimated by the Tier 3 method using CBM. The earlier estimates by the Tier 2 approach (as in NIR 2021) serve only as an independent verification of the CBM estimates of carbon stock changes in living biomass (Annex A 3.6.3).

The reported growing stock of merchantable volume from the database of FMP forms the basis for assessment of the carbon increment in living biomass for the Tier 3 CBM estimates. The key input to calculate the carbon increment is the volume increment (I_v) data. In the Czech Republic, these values have been calculated at FMI (FMP database administrator; see also Acknowledgment) and reported to the national and international statistics. The calculation is performed at the level of the individual stands and species using the available growth and yield data and models. The increment data were partly revised in the earlier NIR (2008) to unify two different base information sources (Schwappach 1923, Černý et al. 1996) for increment estimates and to employ only the latest source across the entire reporting period. This procedure was implemented to comply with the reporting requirements of consistent time series. No change thereafter, apart from entering the actual increment for the latest reported year, has been made to the increment in the inventory submissions (Fig. 6-11).

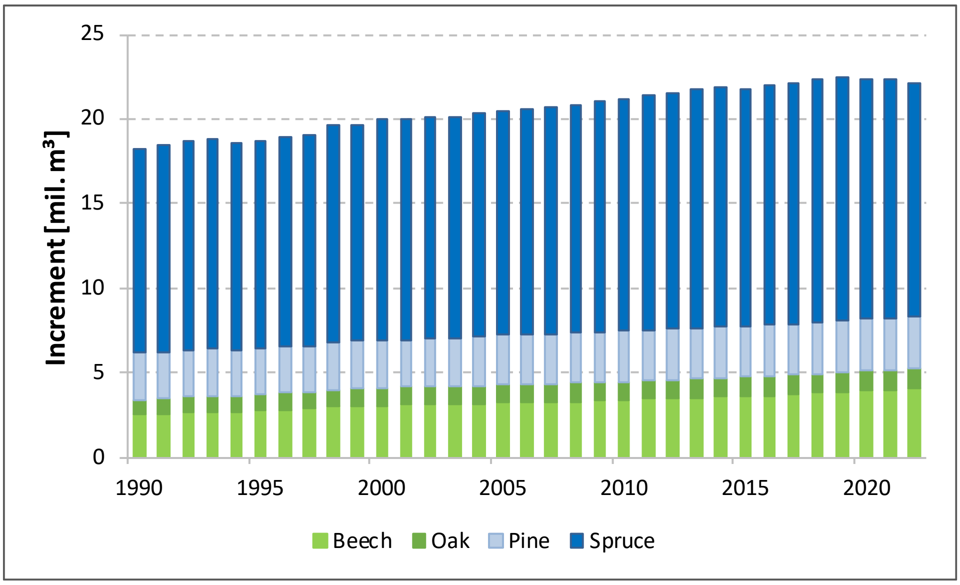

Fig. 6-11 Current annual increment (Increment, mill. m³ under bark) by the individual tree species groups as used in the reporting period 1990 to 2022 (source data FMI)

The merchantable volume increment (I_v) is used as an input to CBM following the procedure described above and detailed in Annex 3.6.2.

The estimation of carbon loss in the category 4.A.1 Forest Land remaining Forest Land 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 reported nationally by CzSO since 2009. Therefore, the total harvest drain (H) covers thinning and final cut, the amount of fuel wood, which is reported as an assortment under the conditions of Czech Forestry, as well as the associated harvest loss that is also linked to the amount of salvage logging (disturbances). To include the biomass loss associated with harvest, a fraction F_{HL} was added to the reported harvest volume; this was calculated from the annual harvest data and the share of salvage logging, assuming a 2.5% loss under planned forest harvest operations and 4% for

[4] *Alternative approaches of the stock-change method (Eq. 2.8; IPCC 2006) were also earlier analysed (Cienciala et al. 2006a) for this category. However, for several reasons the default method was finally adopted and is discussed in the cited study.*

accidental/salvage harvest that concern forest stands affected by natural disturbances. Hence, the harvest volume entering the actual emission calculation (Fig. 6-12 below) includes a correction by the above-described fraction, F_{HL}. This estimate was used to account for harvest losses associated with the reported harvest of merchantable wood volume and share of salvage logging until 2010. Since 2011, however, the introduced harvest loss estimate available from CzSO is used exclusively. The additional removals of solid wood and other harvest residues enter the estimation using a partitioning of 15 and 85% between the two woody components, respectively. This represents a conservative estimate of additional harvest losses that otherwise would not be accounted for. The total harvest loss is shown in Fig. 6-9. For CBM, this input is disaggregated by individual species groups and disturbance types relevant to harvest (Annex 3.6.2.5), specifically thinning (Dist. 2 in CBM, Annex 3.6.2.5), salvage felling resulting in clearcut (Salvage A, Dist. 3a in CBM), smaller-scale (spot-wise) salvage felling without clearcut (Salvage B, Dist. 3b in CBM) and planned, regular final cut (Dist. 4 in CBM). These harvest quantities by harvest types and species groups, as prescribed for the individual years of the reporting period, are shown in Fig. 6-12. Detailed information on the disturbance types and associated carbon matrices are shown in Annex 3.6.2.5.

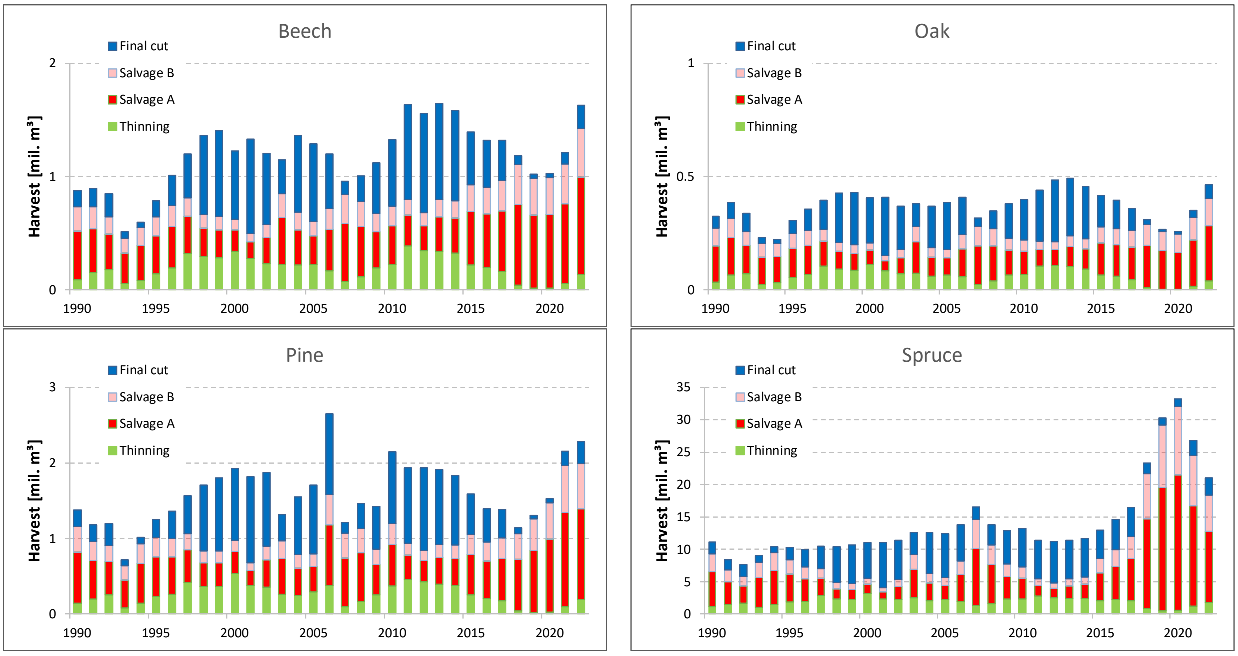

Fig. 6-12 Harvest of merchantable volume (mill. m^3) by species groups (Beech, Oak, Pine, Spruce) and type of harvest including thinning, salvage felling with (A) or without (B) clearcut and the planned final cut for the reporting period 1990 to 2022, serving as the prescribed management/disturbance inputs in CBM (converted to carbon units).

Hence, the impact of disturbances is included in full within the total harvest drain volume (*H*). Disturbances in the country are mandatorily registered in terms of salvaged wood volumes. Therefore, the available data on salvage logging from CzSO (and MA 2023) are also traceable in terms of disturbance origin by categories including natural disaster, air pollution, insect and other (Tab. 6-7 above). This information is also obligatorily reported by the forestry practice, which must always prioritize salvage logging on account of the planned harvest. Consequently, any salvage felling is allocated to the total amount of wood removals, and it is thereby accounted for in the reported harvest volumes as shown in Fig. 6-12. Merchantable wood volume entering the requested disturbance quantity in the CBM input file was first converted to biomass using the prescribed species-specific wood densities (IPCC 2006) for beech and oak (0.58 t/m^3), pine (0.42 t/m^3) and spruce (0.40 t/m^3). Secondly, a carbon fraction of 0.5 was used for all species groups. The detailed biomass and deadwood carbon allocation pattern linked to harvest-disturbance types applied in CBM is described by the disturbance matrices included in Annex 3.6.2.

The assessment of the net carbon stock change in dead organic matter, including deadwood and, litter and transfers to soil for category 4.A.1 was fully revised in the earlier (NIR 2022) inventory submission using the Tier 3 approach using CBM. Earlier (until NIR 2021 inclusive), a stock difference method according to Eq. 2.8 of IPCC (2006) was used to assess two deadwood components (lying deadwood wood and standing dead trees with a mean diameter of at least 7 cm) taken from the two NFI campaigns (Kučera and Adolt 2019). The current assessment by CBM differs substantially, as it covers the entire carbon budget (including the essential biomass components less than 7 cm; see Annex Tab. A3 10 for the carbon pool attribution) and key ecosystem processes involved as represented by CBM (Fig. 6-10). Next, the adopted Tier 3 approach uses an annual time step covering the entire reporting period, avoiding any extrapolation as used earlier. This is specifically important for the conditions of dynamically changing harvest intensity in recent years, which inherently affect the entire biomass and DOM carbon turnover.

As for the litter pool of DOM in CBM, it includes three specific components (Annex Tab. A3 10). For an empirical verification, only data of the CzechTerra campaign 2008/2009 (CZT1) were available, providing a reference mean carbon stock held in litter (11.1 t C/ha; Cienciala et al. 2015). These data were not adequate for confirming carbon stock change estimates in litter for category 4.A.1, which resorted to using the Tier 1 assumption of no change (IPCC 2006) for this category until NIR 2021. Since NIR 2022 inventory submission, Tier 3 estimates by CBM are exclusively used to include emissions and removals from carbon stock changes in this DOM pool component.

Similarly, the NIR 2022 inventory submission adopted the Tier 3 estimate of soil carbon stock change in mineral soils by CBM for category 4.A.1, including its two relevant components (Annex Tab. A3 10). This replaces the earlier Tier 1 (default) assumption of carbon stock changes considered to equal zero (Tier 1, IPCC 2006) in the earlier (until NIR 2021) submissions, which is currently retained only for organic soils. 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.

With respect to significance of the soil carbon pool, the former (until NIR 2021) substantiation of the default (Tier 1) assumption for mineral soil carbon stock on forest land was based on the fact that this pool has not been reported as a key category for any country in the Central-European or temperate region. The current adoption of the Tier 3 estimation for carbon stock changes in mineral soil by CBM cannot be completely verified with the empirical estimates, but verification data for forest soil carbon stock changes under category 4.A.1. may become available once the NFI program in the country (Kučera and Adolt 2019) conducts the repeated quantitative forest soil survey. This can be expected by the mid-2020s.

The estimated emissions and removals for individual carbon pools can be found in the corresponding reporting tables. For transparency, the estimated emissions by major pools for category 4.A.1 are displayed also graphically in Fig. 6-13.

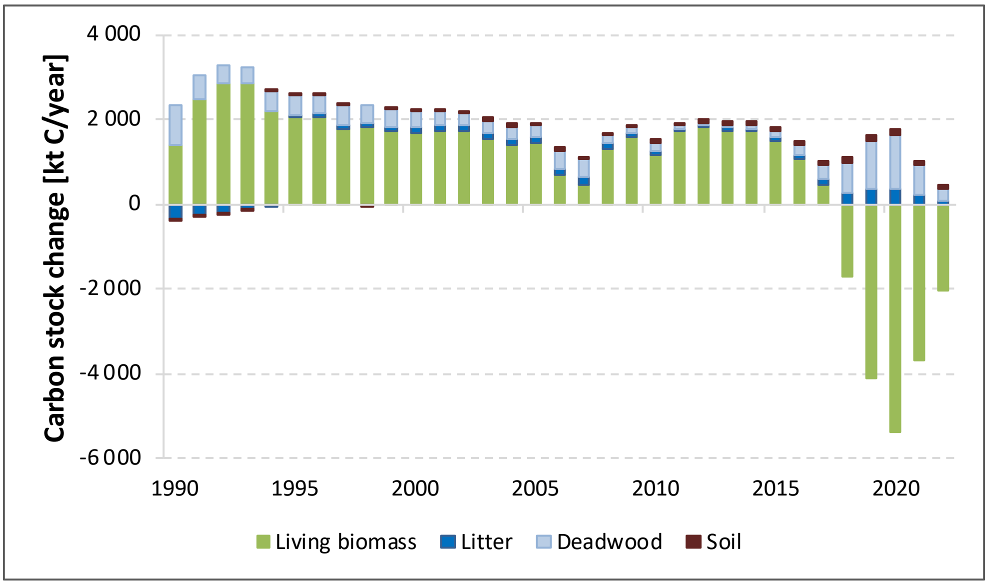

Fig. 6-13 Carbon stock changes estimated for the category 4.A.1 Forest Land remaining Forest Land by major pools, namely living biomass, dead organic matter (litter and deadwood) and mineral soil.

Emissions in category 4.A.1 Forest Land remaining Forest Land include, in addition to CO_2, other greenhouse gases (CH_4, CO, N_2O and NO_X) resulting from burning. This encompasses both prescribed fires associated with the burning of biomass residues associated with harvest, and emissions due to wildfires. The emissions from prescribed burning of biomass residues were estimated according to Eq. 2.27 of IPCC (2006) and the emission and combustion factors in Tables 2.5 and 2.6, respectively (IPCC 2006). Equation 2.27 reads as

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3} \qquad (1)$$

where L_{fire} is the amount of greenhouse gas emissions from fire in tons of the gas considered (CH_4, N_2O), A is the area burnt (ha), M_B the mass of fuel available for combustion (t/ha), C_f the combustion factor (-) and G_{ef} the emission factor (g/kg).

Under the conditions in this country, part of the biomass residues is occasionally 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 1% of the biomass residues including bark is burned. This is less than assumed for the inventory years until 2000 (10%), 2010 (5%) and after 2011 (1%), respectively. It corresponds with the trend in current forest management practices in the country. The biomass fraction burned was quantified based on 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 221 kt in 1990 and 42.6 kt in 2022. These values, as well as the applicable factors used in Eq. 1 to estimate emissions from fire, are listed in Tab. 6-9.

Tab. 6-9 Specific input data and factors used to estimate emissions of N_2O and CH_4 from prescribed burning in forests (1990 and 2022 shown) according to Eq. (1)

Variable or conversion factor	Unit	Year 1990	Year 2022
Amount of biomass burnt (AxM_B)	kt	220.8	42.6
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. 6-9 does not show a factor associated with the 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. Finally, Tab. 6-9 also does not list the factors used to estimate gases of CO and NO_x, which are complementarily estimated using Eq. 1 together with emission factor (G_{ef}) equal to 107 and 3, respectively.

The emissions of greenhouse gases due to wildfires were estimated based on 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. 1. The combustion factor (C_f) used was 0.45 (Table 2.6, IPCC 2006), whereas emission factors for individual gases 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 129.3 kt in 2022. The most extreme year of the reporting period was 1997, when about 228 kt of biomass was burned due to wildfires in an area of almost 3.5 th. ha. In 1990 and 2022, the reported forest areas under wildfire were 168 and 1 715 ha, respectively. The burned area in 2022 includes the largest recorded wildfire in the country with 1060 ha of burned area that hit the Bohemian-Switzerland National Park (Kudláčková et al. 2023). During the reporting period since 1990, there has not been a single year without reported wildfire. The mean annual forest area affected by forest wildfires reached 619 ha in the period 1990 to 2022. The full time series of forest wildfires in terms of areal extent and number of fires per year is shown in Fig. 6-14. The associated emissions of non-CO_2 gases can be found in the corresponding CRF Tables.

There are no direct N_2O emissions from N fertilization on Forest Land, as there is no practice of nitrogen fertilization of forest stands in the Czech Republic. Similarly, non-CO_2 emissions related to the drainage of wet forest soils are not reported, as this activity is no longer in practice.

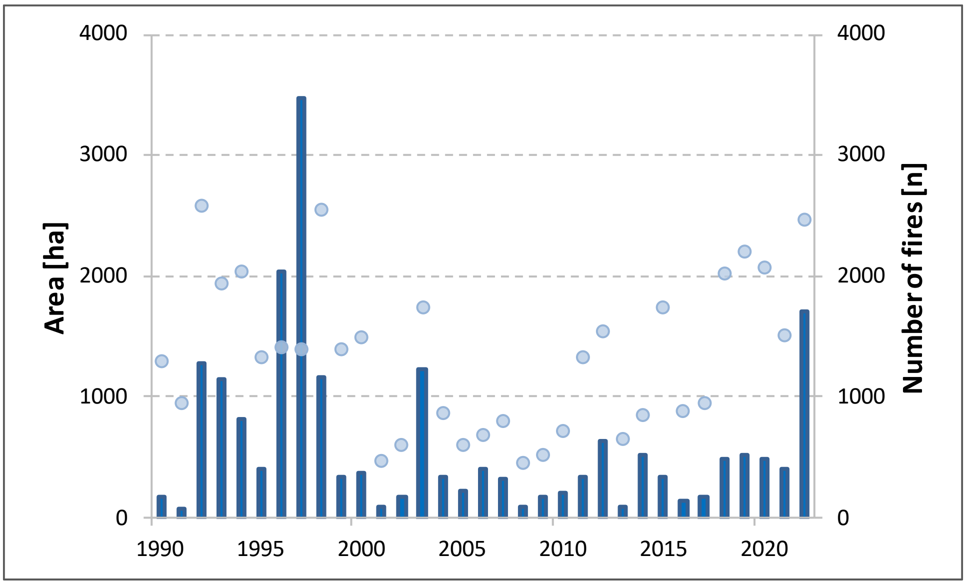

Fig. 6-14 Wildfires on forest land since 1990 – annual area (left; bars) and number of fires per year (right; filled symbol)

6.4.2.3 Land converted to Forest Land

The methods employed to estimate emissions in the 4.A.2 Land converted to Forest Land category are identical or coherent with those for the category 4.A.1 Forest Land remaining Forest Land (cf. Tab. A3 9 in Annex 3.6.1). The exception is mineral soil, which under 4.A.2 includes other land-use categories not covered by CBM, and the previously developed Tier 2 methodology based on soil carbon map layers is retained.

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 adopted methodology to identify land-use change (Section 6.2) provides areas of all conversion types updated annually, which are directly used by CBM. Land areas are under conversion for a period of 20 years, according to the default assumption of IPCC (2006). Under the conditions in this country, all newly afforested lands are considered as managed lands under the prescribed forest management rules as specified by the Czech Forestry Act.

The increment, as well as the entire CBM calibration routine, is fully applicable to age classes I and II (stand age up to 20 years, i.e., category 4.A.2) as estimated from the actual wood volumes and areas per major species groups, as described in detail in Annex 3.6.1. It should be noted that the CBM model uses a curve-smoothing algorithm to estimate above-ground biomass when there is little or no merchantable volume (see more in Kurz et al. 2009), which aids estimations for small-growth (young) stands.

Since the specific tree species composition of the newly converted land is unknown, the information of tree species share used for afforestation in category 4.A.2 in CBM utilized 40, 10 and 50% for beech, oak and spruce species groups, respectively. These proportions were identified iteratively to match the observed development of species composition for the reporting period (see more details in Annex 3.6.2).

Similarly, the carbon loss associated with biomass disturbance in terms of management and mortality in the category of Land converted to Forest Land was coherent with that applied for 4.A.1 as described elsewhere. Specifically for 4.A.2, turnover and transfer rates are applied identically as detailed in Annex 3.6.3, whereas the effect of management interventions is insignificant (zero) for the stand age until 20 years. 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 land that is newly converted to forest land. As is also apparent from the national statistics that 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) applicable to 4.A.2 were estimated in accordance with the guidance of the Tier 2 methods (IPCC 2006), using the CBM estimates of carbon stocks in DOM pool components (deadwood and litter) as reference values (Fig. 6-15). This approach assumes that deadwood and litter carbon pools increase linearly from zero to the reference values for the given country-specific conditions. For deadwood, a conservative value of the transition period for developing the deadwood carbon stock of 100 years was used, while for litter, the default (IPCC 2006) period of 20 years was used.

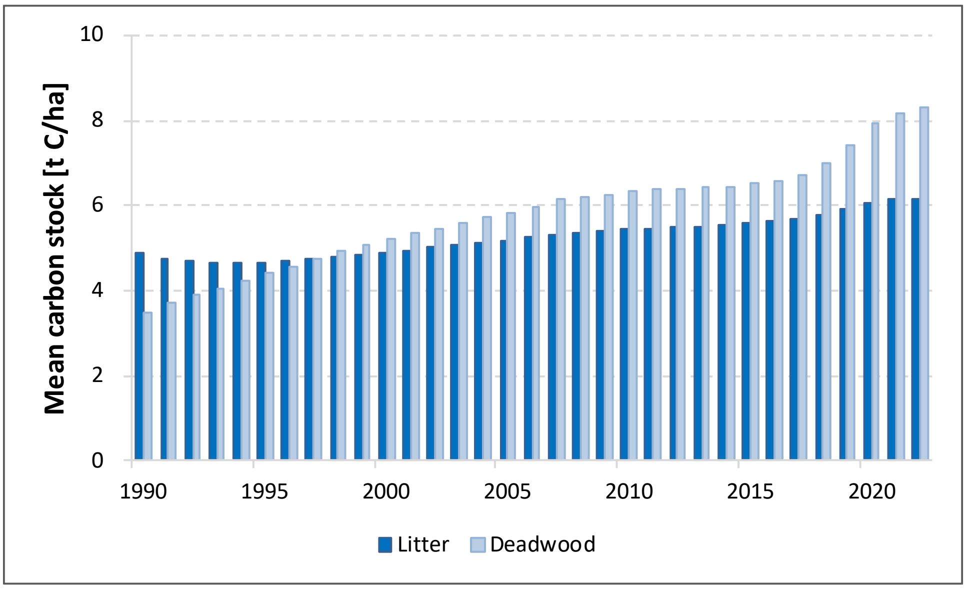

Fig. 6-15 Mean carbon stock (t C/ha) of DOM components litter and deadwood for the reporting period.

The net change of carbon stock in mineral soils was estimated using the country-specific Tier 2/Tier 3 method. This was based on a vector map of topsoil organic carbon contents (Macků et al. 2007, Šefrna and Janderková 2007, Vopravil and Khel 2020, see Fig. 6-16). The map constructed for forest soils utilized over six thousand soil samples, linking forest ecosystem units - stand site types and ecological series available in maps of 1:5 000 and 1:10 000, as used in the Czech system of forest typology (Macků et al. 2007, Marková et al. 2016). These represent the soil organic carbon contents to a reference depth of 30 cm, including the upper organic horizon.

Until the NIR submission 2020, the carbon content in agricultural soils was prepared to match the forest soil map in terms of reference depth and carbon content categories, although based on the interpretation of a coarser scale 1:50 000 and 1:500 000 soil maps (Šefrna and Janderková, 2007). Since NIR 2021, the activity data on soil carbon in agricultural soils were updated with a more detailed layer of soil organic carbon estimates, but with the same reference depth of 30 cm. This layer was prepared by experts from the Research Institute for Soil and Water Conservation and detailed in Vopravil and Khel (2020).

The polygonal source maps were used to obtain the mean carbon content per individual cadastral unit (n = 13 076 in 2022), serving as reference levels of soil carbon stocks applicable to forest and agricultural soils. Since agricultural soils include both the Cropland and Grassland land-use categories, the bulk soil carbon contents obtained from the map were 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 an estimation of the soil carbon stock change among categories 4.A Forest Land, 4.B Cropland and 4.C Grassland, as well as 4.E Settlements (derived soil carbon content, see Section 6.8.2). The estimated quantities of carbon stock change at the level of 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 estimating the emissions and removals of CO_2.

In 2022, the area-weighted mean carbon stock in mineral soil per cadastral unit reached 65.3, 53.1 and 63.1 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 those that are drained (IPCC 2006).

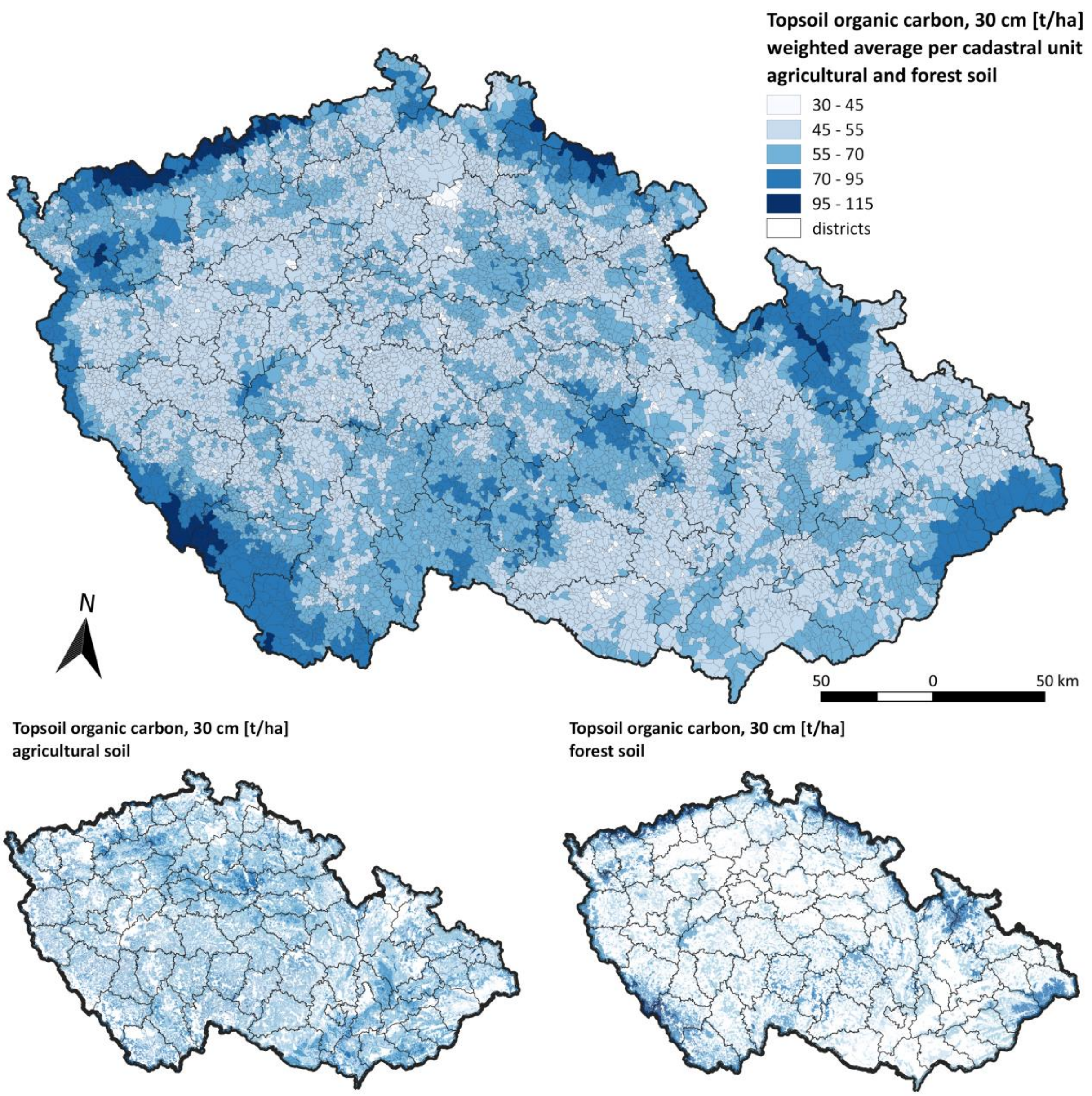

Fig. 6-16 Top - topsoil (30 cm) organic carbon content map adapted from Macků et al. (2007), Vopravil and Khel (2020) estimated as cadastral unit means from the source maps {bottom] –topsoil carbon content for agricultural (left) and forest (right). The unit (t/ha) and unit categories are identical for all the maps.

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 category in the country. The same applies to N_2O emissions from nitrogen fertilization, which is not carried out on forest land in this country.

The estimated emissions and removals for individual carbon pools for category 4.A.2 can be found in the corresponding reporting tables. For transparency, the estimated emissions by major pools are also displayed graphically in Fig. 6-17.

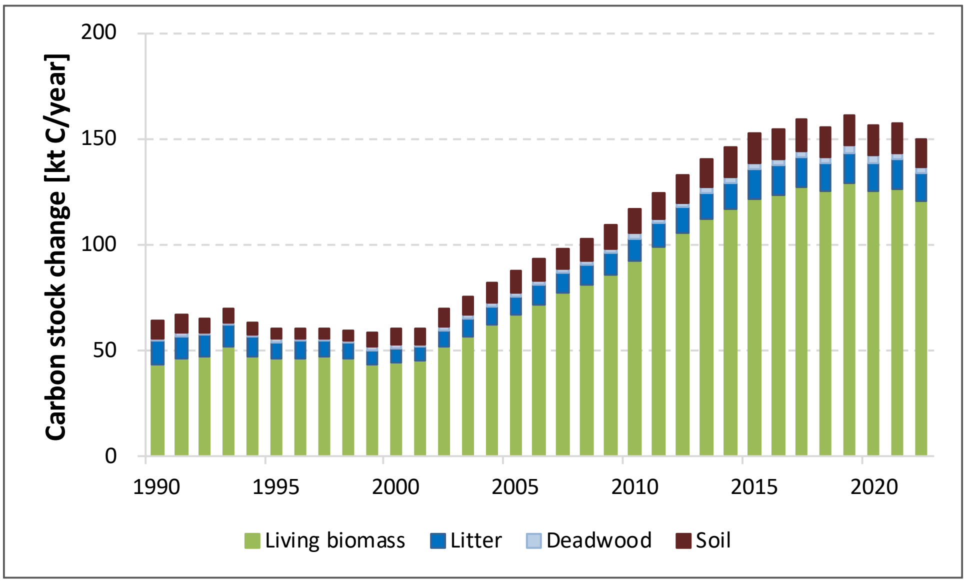

Fig. 6-17 Carbon stock changes estimated for the category 4.A.2 Land converted to Forest Land by major pools, namely living biomass, dead organic matter (litter and deadwood) and mineral soil.

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 2022.

The uncertainty estimation was guided by the Tier 1 methods outlined in IPCC 2006 Gl. (IPCC, 2006) employing the following equations:

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

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:

$$U_{total} = \frac{\sqrt{(U_1 * x_1)^2 + (U_2 * x_2)^2 + \ldots + (U_n * x_n)^2}}{|x_1 + x_2 + \ldots + x_n|} \quad (3)$$

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. 3 is not well applicable for the LULUCF sector. Summing negative (removals) and positive (emission) members (x_i) in the denominator of Eq. 3 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 to the resulting product of Eq. 3.

The adopted uncertainty values are listed below and/or under the corresponding subchapters of other land use categories. Since this inventory newly implemented Tier 3 modelling approach using CBM for several carbon pools, it makes the rigorous uncertainty estimation challenging. Most commonly, modelled estimates require the use of Monte Carlo analyses, conducting many model runs or repeated analyses with input parameters varied to represent the uncertainty in individual input data (Kurz et al. 2016). This has not been performed yet due to the time and capacity constraints. Hence, for this inventory, the interim uncertainty estimate is based on a conservative expert judgement and literature, including the recent NIR (2021) inventory submissions of Canada and Ireland, where CBM (CBM-CFS3) was also used. Specifically, we assume for the Tier 3 carbon stock change estimates for living biomass, DOM (both litter and deadwood) and mineral soil the overall uncertainty 25, 50 and 100%, respectively. Also, a more conservative value of 50% was used biomass carbon stock change estimates under land use conversions associated with forest land.

For all other (Tier 2) estimates, the source information for adjusted uncertainty values was obtained from the conducted CzechTerra statistical (sample-based) 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 combustion 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 logic of combining uncertainties on the level of the entire land use category or on the level of the entire LULUCF sector according to Eq. 3. This is calculated based on 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 2022, 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 32% and 24%, respectively. Correspondingly, the uncertainty for the entire 4.A Forest Land category reached 36%.

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 for quality should 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, IPCC 2006).

The input information and calculations are archived by the expert team and the coordinator of NIR. Hence, all the background data and calculations are verifiable.

Apart from the 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 the 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. This was required due to the minor rectifications in the input file related to the harvest input and proportions related to harvest residues (Ch. 6.4.1), and secondarily due to the related revisions in disturbance matrices (Annex 3.6.2.5) used for CBM-CFS3 model (Kurz et al. 2009, Kull et al. 2019). Finally, changes in activity data for prescribed burning affected non-CO_2 emissions (N_2O, CH_4). These changes affected the estimates in all carbon pools and non-CO_2 emissions in category 4.A. The overall effect of the implemented revisions was on average 14 % for the reporting period (except last year), as the estimated emissions for 4.A Forest land decreased relative those in the previous NIR submission. Practically all that difference was attributed to 4.A.1 subcategory, while the quantitative impact on 4.A.2 was about 1 % (decreased sink).

For transparency, the estimates for category 4.A Forest land are displayed graphically in Fig. 6-18, including the current (NIR 2024) and previous (NIR 2023) inventory submission.

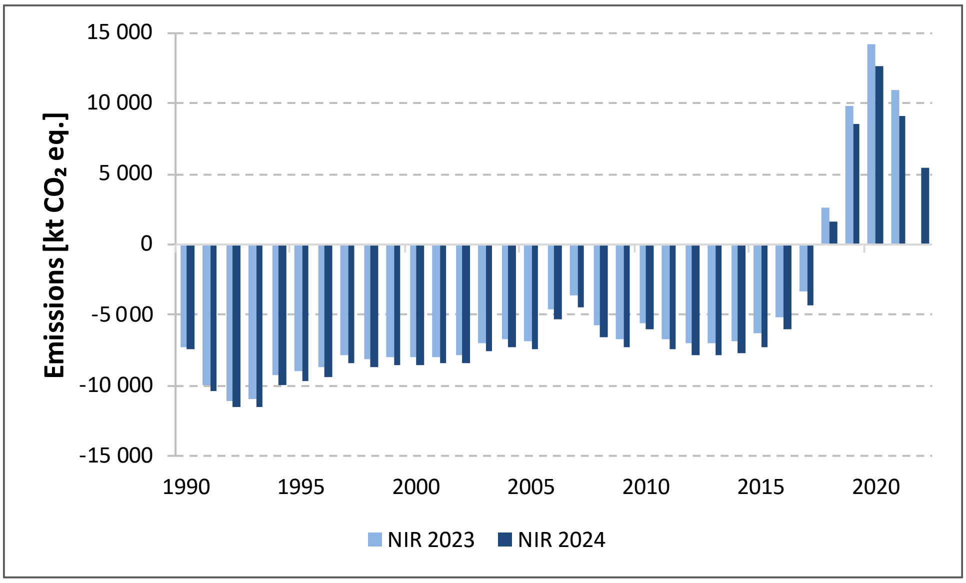

Fig. 6-18 Estimated emissions for category 4.A Forest land – the current (NIR 2024) and previous (NIR 2023) inventory submission.

With respect to the issues identified by the latest inventory review (ARR 2022) that concern 4.A Forest land, these were addressed in detail in the previous NIR (2023) submission. Although no new review was conducted in 2023, we have additional information with respect to the previously (ARR 2022) open issue L.3, while we retain the text from the previous inventory submission regarding the two remaining issues:

- L.3 - addressing consistency issue for estimates of additional harvest fraction: apart from the enhanced information on harvest activity data in Sections 6.4.1, 6.4.2, the harvest fractions representing additional harvest were modified in this inventory submission (Ch. 6.4.1). Currently, they represent on average a quantity of 0.41 Mm^3/year for the reporting period. The inventory team works on additional verification and validation of these estimates. Note, however, that its quantitative importance remains minor, in fact corresponding to its fraction of the base harvest, which is on average 2.6 % for the reporting period.

- L.10 – (text retained from the NIR 2023 submission) question on IEF for litter and verification analysis for carbon stock change in the litter and deadwood pools on 4.A.1 Land remaining Forest land. Apart from the information already provided in the NIR and to Expert Review Team in 2022 in response to this request, we state that carbon stock change (CSC) in the litter pool is driven both by input related to harvest quantities and respiration loss of the entire litter stock that is caused by respiration and accumulation over several years, hence the dynamics in CSC are not directly comparable with harvest quantities. For period prior to the current bark-beetle outbreak (not including recent exceptional years), there would be no significant relationship between CSC in the litter pool and harvest level since the respiration processes over accumulated litter stock would be decoupled from annual harvest volumes. This was checked by a linear regression analysis, which for the period 1990-2015 showed zero explained variability (R^2=0.0) and no significancy (p=0.908). With respect to the questioned absolute quantities of CSC in litter, please note that it does reflect the specific (and – at least within European countries - exceptional) trend of harvest due to the historically unprecedented dieback of coniferous stands due to drought-induced bark-beetle infestation – as described e.g. in Section 6.4.1. This can also be substantiated by the latest IEF for CSC in litter that dropped to 0.19 in 2021, i.e., 46 % of the all-time high observed in 2020 and matching the range of the observed values for other countries as noted by ERT in ARR 2022. This development of CSC in litter is also fully in accordance with the observed reversal of harvest trend and hence emissions for this category. As for the deadwood, there is no inconsistency with the pools that can be observed by statistical a forest inventory, such as the Czech NFI (Kučera and Adolt 2019) or Landscape inventory CzechTerra (Cienciala et al. 2016). However, no observation-based forest inventory can capture all carbon pools at the scale of the country. For this reason, the estimates facilitated by modelling tools such as CBM-CFS3 (Kurz et al. 2009, Kull et al. 2019) representing Tier 3 methods are the only approaches practically applicable at that scale and time resolution of individual years. They allow insight into carbon stock changes covering the entire ecosystem and changes in all pools involved (e.g., in CBM represented by 21 carbon compartments). Since the simulated ecosystem is fully constrained in the model, the independent verification provided for living biomass gives reasonably solid ground for trustable estimation of other carbon pools, based on the use of nationally and internationally verified decay rate constants, country-specific tree allometry, forest structure, increment rates and known harvest quantities. Since this explanation is rather technical, it is not integrated in the main text, but provided here for the reviews to come.

- L.11 – (text retained from the NIR 2023 submission) transparency issue (attributed to 4.A.2 Land converted to Forest land) on reference mean carbon stock values for litter and its development over time. Section 6.4.2 provides information on the only available empirical estimates from Landscape inventory CzechTerra that is quantitatively close to the estimates of CBM. However, in the absence of any repeated assessment in situ that would allow estimating CSC in litter, the adoption of Tier-3 approach facilitated by nationally calibrated CBM-CFS3 model is the only solution providing transparent estimation of CSC for the entire reporting period. The trend observed in CSC in litter corresponds to fluxes and processes that affect that pool – most prominently the applied tree species group-specific harvest intensity and decay rates. The estimates of the litter and deadwood carbon pools are fully coherent to those estimated in similar conditions of other countries (see e.g., Slovenia). The trends in the litter pool correspond to both growing stock development and harvest intensity changes. Finally, using other reference estimates for the litter poll in 4.A.2 than those assessed in 4.A.1 would simply be incoherent and hence not recommendable. Similarly as for issue L.10 above, this reasoning is not integrated in the main text, but provided here for the reviews to come.

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

CBM-CFS3 model (Kull et al. 2019) used for this inventory report will be further integrated in the national emission inventory. The inventory team plans to use a regionally specific (NUTS3) estimation for the recent years onwards (probably since 2018 or 2021) as illustrated in Annex 3.6 and used by Cienciala and Melichar (2024), with the assumed implementation for the NIR 2025 submission. The effort is initiated to provide a more complete verification of CBM estimates, in line with the latest available data such as the new NFI3 results that are gradually being released by FMI, Brandýs n. Labem (e.g., Máslo et al. 2023). Also associated with CBM use, the inventory team plans to elaborate more advanced uncertainty estimates based on Monte-Carlo approach.

The inventory team of IFER initiated a collaboration with the Forest Management Institute, Brandýs n. Labem, to revise the methodology for the category 4.A Forest land, so that it would fully utilize the sample based National Forest Inventory (NFI) and its recently conducted third campaign (NFI3, Máslo et al. 2023) These data would serve as a basis for a revised CBM-CFS calibration that is planned to be finalized for the NIR 2027 submission at the latest. While the current deployment of Tier 3 approaches by CBM based on the official data from CzSO and database of FMP adequately addressed the complexity of ecosystem carbon balance under the conditions of the recent forest decline in the country, more timely calibration and verification data from the ongoing NFI program are needed to increase robustness of the model estimates.

6.5 Cropland (CRF 4.B)

6.5.1 Source category description

In the Czech Republic, Cropland (Fig. 6-19) is predominantly represented by arable land (92.0% of the category in 2022), while the remaining area includes hop-fields, vineyards, gardens and orchards. These categories correspond to five of the six real estate categories for agricultural land from the database of “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC.

Cropland is spatially the largest land-use category in the country. At the same time, the area of Cropland has constantly been decreasing since the 1970s, with a particularly strong decreasing trend since 1990 (Fig. 6-19). While, in 1990, Cropland represented approx. 43.8% of the total area of the country, this share decreased to 40.1% in 2022. 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 area of mountainous regions. In addition, there is a growing demand for land for infrastructure and settlements.

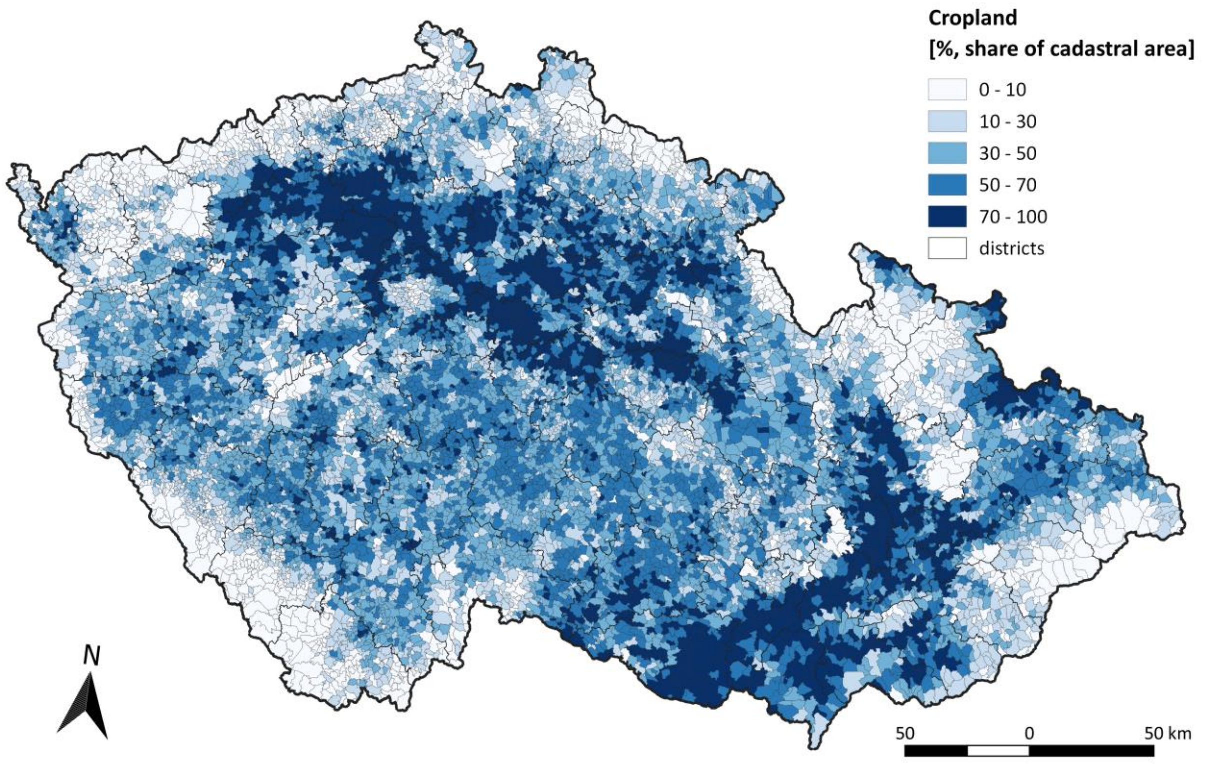

Fig. 6-19 Cropland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2022)

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. 6-20.

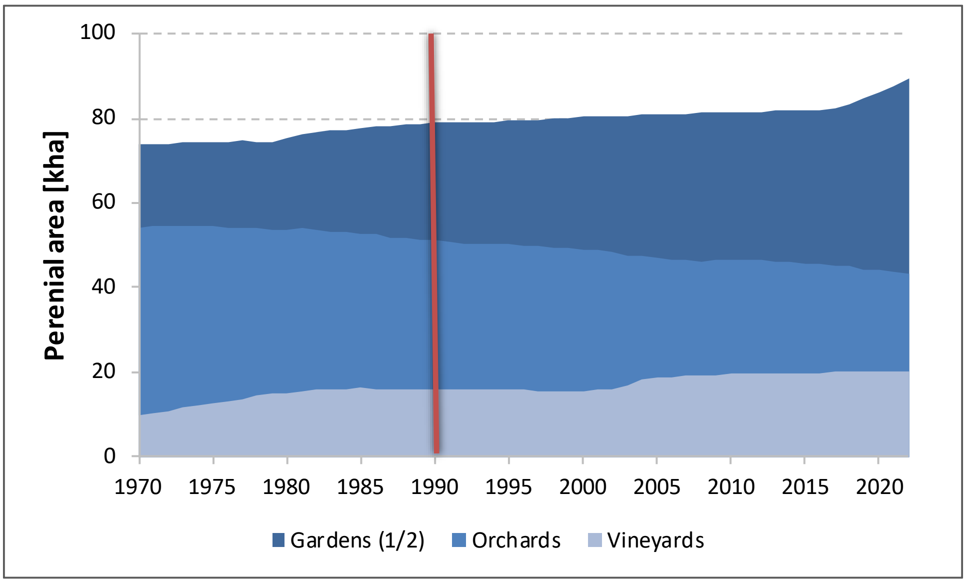

Fig. 6-20 Trend in perennial cropland area in the Czech Republic for the period 1970 to 2022

In NIR 2021, the estimation of emissions associated with biomass accumulation on Cropland was revised and updated according to the new biomass accumulation rates of 0.43 t C/ha/year for orchards and 0.28 t C/ha/year for vineyards as recommended by IPCC (2019). This also applies for maximum carbon stock at harvest (8.5 t C/ha for orchards and 5.5 t C/ha for vineyards, IPCC, 2019).

In NIR 2022 inventory report, the estimation procedure was also revised. While earlier the carbon stock change in perennial biomass was solved as a difference between consecutive years, it is newly estimated from the perennial cropland area 20 years ago. This respects the 20-year harvest cycle for orchards and vineyards (IPCC, 2019). The estimation can be written as:

Annual change of biomass = (remaining area of perennial cropland x annual carbon accumulation rate) – (remaining area of perennial cropland before 20 years x 1/20 (i.e., rate of area at end of rotation period) x biomass carbon stock at end of rotation period)

Overall, the perennial cropland area has an increasing trend (Fig. 6-20) for the period 1970-2022 (137 503 ha in 1970, 152 787 ha in 2022). Therefore, the carbon pool of living biomass within 4.B.1 represents a CO_2 sink for the entire period.

The carbon stock change of dead organic matter follows the Tier 1 method assumption of IPCC (2006) that dead wood and litter stocks are not present on Cropland or are at equilibrium. Hence, no change is assumed for this pool.

The carbon stock change in soil in the category Cropland remaining Cropland is given by changes in mineral and organic soils. Organic soils basically do not occur on Cropland; they occur as peatland in mountainous regions on Forest Land. In the NIR 2021 submission, estimation of emissions from agricultural soils was revised using a new soil carbon layer map with a reference depth of 30 cm.

Seven specific categories were defined for Cropland remaining Cropland (Tab. 6-10). They discern non-perennial and perennial vegetation categories and their specific subtypes and lead the choice of emission factors.

For the calculation of F_I, in addition to IPCC default values, published data from the experiments for different intensities of fertilization in the Czech Republic were also used (Kubat et al., 2006; Menšík et al., 2019 and Šimon et al., 2011). Then, a specific set of practices associated with input (e.g., share of residues, amount of mineral or organic fertilization, use of intercrops etc.) were attributed to each crop species, based on expert knowledge from Crop Research Institute (CRI). Since most crops deploy two or more practices with different F_I (usually a combination of default and specific factors), an activity weighted F_I for each crop was calculated. Finally, an average crop species area weighted F_I was defined. Similarly for the management factor (F_{MG}), a typical management approach for a given crop was defined by expert knowledge (CRI). To each group of defined tillage activities (e.g., types and frequency of tillage, soil preparation, etc.) an IPCC default F_{MG} was ascribed and calculated for a given crop. Finally, an average crop species area weighted F_{MG} was estimated and used for a given vegetation category. Other emission factors related to land use (F_{LU}) and input (F_I) correspond to the recommended values of Table 5.5 for the temperate moist region (IPCC 2006, 2019). These categories and 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 2022 shown)

Management activity by vegetation category	Land use F_{LU}	Tillage F_{MG}	Input F_I	Area in 1990 [kha]	Area in 2022 [kha]
I. Non-perennial, arable land, no fallow	0.70	1.04	1.01	2 961.9	2 856.1
II. Non-perennial, arable land, fallow	0.82	1.07	0.92	191.0	25.7
III. Non-perennial, gardens (1/2)	0.70	1.04	0.92	78.9	89.4
IV. Non-perennial, hop fields	0.70	1.04	0.92	11.3	8.8
V. Perennial, gardens (1/2)	1.00	1.09	0.92	78.9	89.4
VI. Perennial, orchards	1.00	1.09	0.92	51.1	43.0
VII. Perennial, vineyards	0.72	1.04	0.92	15.8	20.3

The emission estimation follows Eq. 2.25 assuming a 20-year default period for time dependence of stock change factors (D) and using the soil carbon layer in cropland mineral soils. 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. 6-10. The assumption was made on share of perennial and non-perennial gardens, 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 Surveys conducted in 2016, 2013, 2007, 2005, 2003 and Agricultural Census 2010. These surveys are conducted in the European Union member countries following the requirements of EU/EC legislation. In the Czech Republic, the survey is conducted based on 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.

Next, the detailed spatially-explicit land-use conversion data including cropland vegetation categories (Tab. 6-10) were made available from COSMC at the level of individual cadastral units for the period 2002-2022. This allowed spatially explicit identification of changes related to land management. This, together with geographical layer of soil organic carbon in agricultural land and emission factors expressing the applicable management facilitated estimation of the related soil carbon stock change.

For the period 1990 to 2001, the emission estimates used information on cropland vegetation categories only at the country level. To make this information consistent with the more recent detailed data since 2002, a post-calibration based on the data from the period 2002-2022 using linear regression (R^2=0.96, p<0.001, n=21) relationship that was applied on the former data estimates (period 1990-2001) to ensure methodological coherency for entire reporting period. This methodological improvement corrected the previous estimates. Specifically, the approach avoided possible double counting of emissions in categories 4.B.1 and 4.B.2.

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 lime application 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 mostly converted to Grassland. However, the adopted detailed system of land-use representation and land use change identification system can 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 IPCC (2006) and the recommended default values for the temperate zone.

Until the NIR 2022 submission, the estimation of the total carbon loss (L_{Def}) associated with wood removals under Forest land converted to Cropland, followed Eq. 2.14 (AFOLU 2006) applied as

$$L_{Def} = A_{Def} \times V_{ab} \times BCEF_{Def} \times (1 + R) \times CF \times fd \tag{4}$$

where A_{def} is the area (ha) of forest land converted to other land use (Cropland in this case), V_{ab} is the mean aboveground merchantable volume, $BCEF_{Def}$ represents the biomass expansion and conversion factor applicable to harvested volumes under deforestation, derived from national studies or regional compilations that include the data from the Czech Republic, representing species-specific volume-weighted mean of all age classes and individual dominant tree species, as the actual stand age of those harvested deforested volumes is unknown. The carbon fraction (*CF*) in woody currently used for broadleaved and coniferous tree species represented temperate forest categories as reported by Thomas and Martin (2012), volume weighted mean from the actual species composition. The ratio of below-ground biomass to above-ground 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). This formerly applied approach, activity data and emission factors are detailed in the previous (NIR 2022) submission.

Since previous (NIR 2023) inventory submission, for deforestation events represented by the Convention categories of Forest land converted to other land use categories (4.B.2.1, 4.C.2.1, 4.D.2.1, 4.E.2.1), loss of carbon in living biomass is quantified fully by CBM (Tier 3, Tab. 6-8) using the corresponding deforestation areas from annually updated Land use representation and land-use change identification system based on the data from COSMC (Sections 6.2 and 6.3). Since the species composition of deforested areas is unknown, these areas in the CBM runs were technically attributed to Spruce, the most represented tree species group. This makes estimation of deforestation impact somewhat more conservative in terms of carbon loss as compared to the previous Tier 2 estimates used for the corresponding land-use conversions earlier. This is because spruce forest type has the largest growing stock volume per hectare relative to other tree species groups, which = in somewhat different proportions – also applies for mean aboveground biomass and carbon held in it. The quantitative impact of these differences is included in the comparison of former and current NIR submissions (Section 6.5.5), while other details can be found in the corresponding CRF tables, including the applicable deforested areas in each year of the reporting period.

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 changes in dead organic matter pools concerns land use conversion from Forest Land. These were assessed as conservative loss of litter and aboveground deadwood using the Tier 3 CBM estimates of mean carbon stock in these DOM pool components (Fig. 6-21).

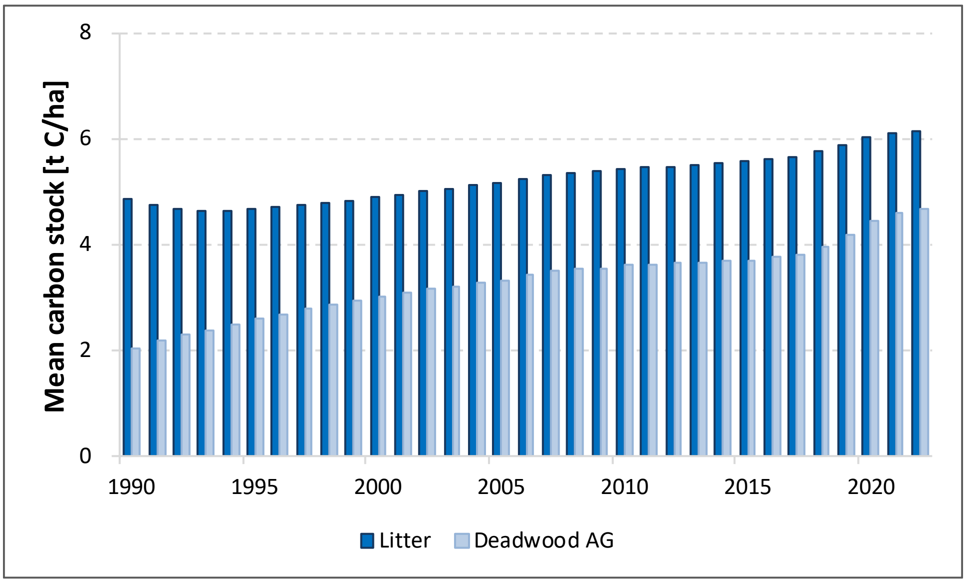

Fig. 6-21 Mean carbon stock (t C/ha) of DOM components litter and aboveground (AG) deadwood for the reporting period.

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, Grassland and Settlements 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 based on 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 2022, 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%, change in living biomass assessed by CBM 50% for deforestation events, stock change factor for land use 50%, stock change factor for management regime 5%. 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). 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 2022, using the above uncertainty values, the total estimated uncertainty for category 4.B.1 Cropland remaining Cropland was 30%. The corresponding uncertainty for category 4.B.2 Land converted to Cropland was 26%. The overall uncertainty for category 4.B Cropland was estimated to be 41% (noting the effect of combining positive and negative values of emission quantities estimated in the respective emission categories as discussed in Section 6.4.3).

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

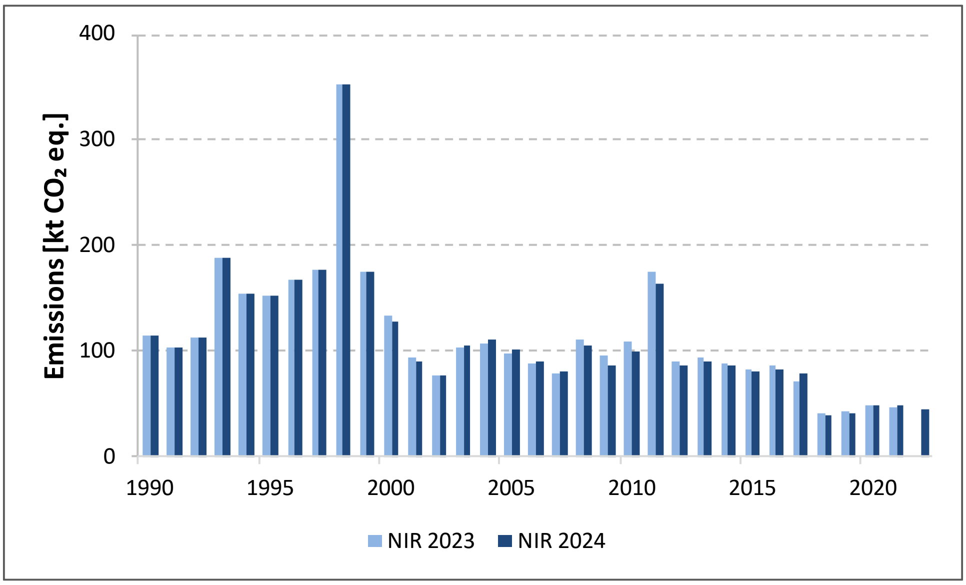

Fig. 6-22 Estimated emissions for category 4.B Cropland – the current (NIR 2024) and previous (NIR 2023) inventory submission.

Since the last submission, the emission estimates related to carbon stock changes were recalculated for both the categories 4.B.1 Cropland remaining Cropland and 4.B.2 Land converted to Cropland. This was due to the revised Tier 3 estimates aided by CBM for subcategory 4.B.2.1 involving conversion from Forest land, respectively.

Overall, the estimated emissions decreased by 1.1% for the entire category 4.B. In 4.B.1, the estimates remained practically identical relative to the previous values (Fig. 6-22), while the emission estimates decreased by 1% for 4.B.2 when comparing the identical period (1990-2021). These fragmental changes are attributed to estimates related to deforestation (subcategory Forest land converted to Cropland) that reflect improvements in model assessments aided by CBM.

None of the individual emission categories of Cropland qualifies among the key categories by quantity or trend in this inventory submission.

For transparency, the estimates for category 4.B Cropland are displayed graphically in Fig. 6-22, including the current (NIR 2023) and previous (NIR 2022) inventory submission.

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

The inventory will continue implementing spatially explicit expression of carbon stock changes emission estimates on the level of individual cadastral units. 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 and uncertainty estimates.

Since 2024, the team cooperates with the AdAgriF project "Advanced methods of greenhouse gases emission reduction and sequestration in agriculture and forest landscape for climate change mitigation", (CZ.02.01.01/00/22_008/0004635), funded by Ministry of Education and coordinated by GCRI (prof. Trnka). The aim of the cooperation is to gradually increase the methodological level of the estimates in the categories related to agricultural land (4B Cropland, 4C Grassland).

6.6 Grassland (CRF 4.C)

6.6.1 Source category description

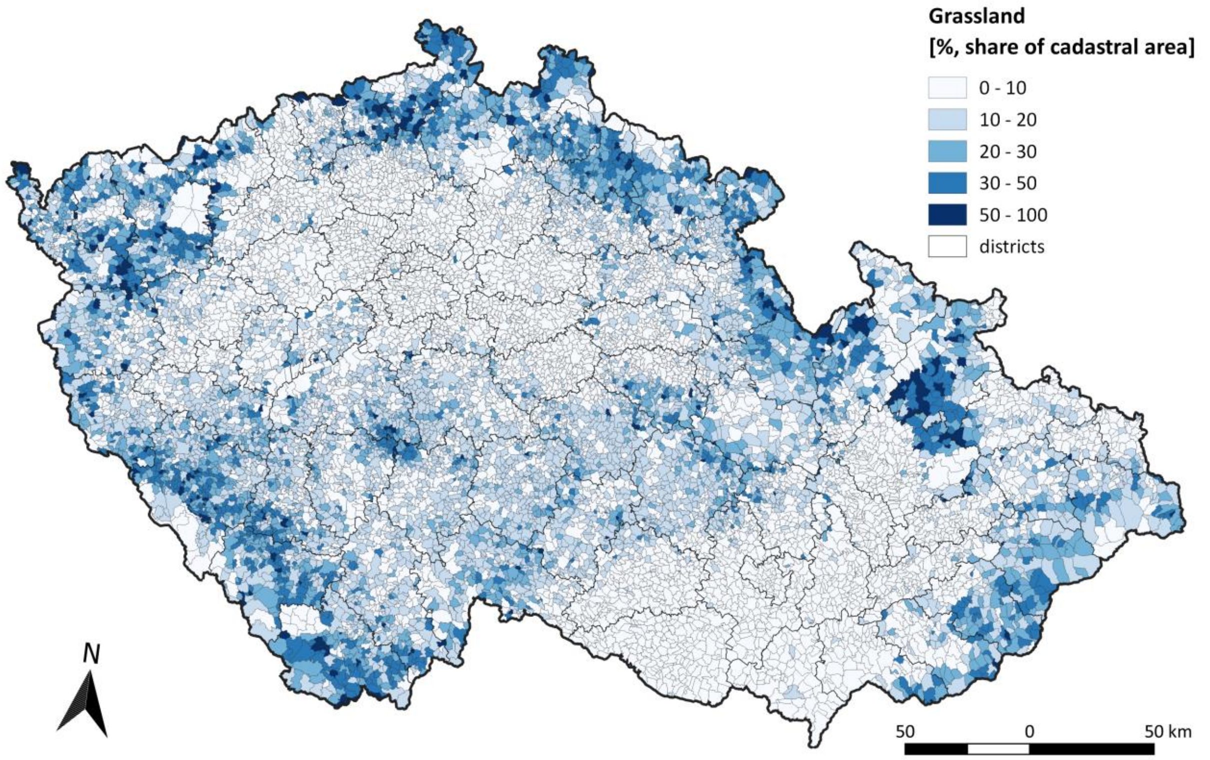

Fig. 6-23 Grassland in the Czech Republic – distribution calculated as a spatial share of the category within individual cadastral units (as of 2022)

Through its spatial share of 13.1% in 2022, 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. It is distinctively spread mostly in hilly parts of the country (Fig. 6-23).

The importance of Grassland gradually increases in this country, both for its role in production and for preserving biodiversity in the landscape. According to the national agricultural programs, the spatial share 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 since 1990, the area of Grassland has increased by 24% as of 2022.

6.6.2 Methodological issues

The emission inventory of 4.C Grassland concerns sub-categories 4.C.1 Grassland remaining Grassland and 4.C.2 Land converted to Grassland. The emission inventory of 4.C Grassland considers changes in living biomass, dead organic matter, and soil.

6.6.2.1 Grassland remaining Grassland

The assumption of no change in carbon stock held in living biomass was employed for category 4.C.1 Grassland remaining Grassland, in accordance with the Tier 1 approach of IPCC (2006). This is a safe assumption for the conditions in this country and any application of higher tier approaches would not be justified with respect to data requirements and the expected insignificant carbon stock changes.

Similarly as for living biomass, the carbon stocks associated with dead organic matter (DOM), including deadwood and litter, are considered to be at equilibrium, i.e., it is assumed that there are no changes in carbon stocks.

The emissions from changes in soil carbon stock were estimated for category 4.C.1 Grassland remaining Grassland. These are given by changes in mineral 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 the NIR 2021 submission using an improved layer of country-specific average carbon content on Grassland estimated and derived from the detailed soil carbon maps (Fig. 6-16). In the previous submission (NIR 2023), the area of grassland was newly stratified according to specific management activities that determine attribution of appropriate management and input stock change factors according to updated Table 6.2 of IPCC (2019). Three specific categories were defined for Grassland remaining Grassland. These categories and applicable relative stock change factors are summarized in Tab. 6-11.

Tab. 6-11 Categories of management activities by vegetation category on Grassland remaining Grassland, attributed land use, tillage (management) and input factors and corresponding areas (1990 and 2022 shown)

Management categories on grassland	Land use F_{LU}	Management F_{MG}	Input F_I	Area in 1990 (kha)	Area in 2022 (kha)
I. Grassland – high intensity grazing	1	0.90	-	749.2	611.9
II. Grassland – nominally managed	1	1.00	-	8.3	294.7
III. Grassland not used for production	1	0.70	-	8.0	17.2

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 (63.1 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. 6-11. Next, the share of high intensity grazing grassland, nominally managed (extensive) grassland and grassland not used for production was obtained from the periodic Farm Structure Surveys conducted in 2020, 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 based on 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. The emission factors used as listed in Tab. 6-11 correspond to the recommended values of updated Table 6.2 for grassland management (IPCC 2019). After 2013, the share of nominally managed grassland increased on account of intensively managed grassland. This results in increasing carbon sink in the category 4.C.1 Grassland remaining Grassland.

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 5.9; IPCC 2006). As for Forest Land converted to Cropland (category 4.C.2.1), loss of carbon in living biomass is quantified fully by CBM (Tier 3, Tab. 6-8) using the corresponding deforestation areas from annually updated Land use representation and land-use change identification system based on the data from COSMC (Sections 6.2 and 6.3). This was a new implementation for the previous (NIR 2023) inventory submission, enhancing the use of Tier 3 estimates facilitated by CBM (Tab. 6-8). More details relevant to this pool and category are given in Section 6.5.2.2 (Land converted to Cropland). The biomass carbon content immediately after the conversion (except for deforestation) 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, 4.B Cropland and 4.E Settlements 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 2022. 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%, carbon , average biomass stock in cropland and grassland prior conversion 75%, biomass carbon stock after land-use conversion 75%, change in living biomass assessed by CBM 50% for deforestation events, stock change factor for land use 50%, 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%.

For 2022, using the above uncertainty values, the total estimated uncertainty for category 4.C.1 Grassland remaining Grassland reached 41%. The corresponding uncertainty for category 4.C.2 Land converted to Grassland reached 55%. The overall combined uncertainty for category 4.C Grassland is 33%.

6.6.4 Source-specific QA/QC and verification

The emission estimates are based on the activity data taken from the official national sources and follow the recommendations of the adopted 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 explicit recalculation for made for 4.C.1, while the subcategory 4.C.2 Land converted to Grassland was recalculated due to the revised calibration of CBM model. This affected the estimates of deforestation, i.e., Forest land converted to Grassland. Hence, these changes resulted in marginally altered emissions for the entire category 4.C Grassland.

On average, the revised emission sink estimates in 4.C quantitatively differ by less than half a percent as compared to the previously reported estimates as assessed on the comparable period of 1990 to 2021. These changes represent a marginally decreased sink for this category. The subcategory 4.C.1 Grassland remaining Grassland qualified among the key categories by quantity and trend in this inventory submission with a contribution of 0.26 % to the total GHG emissions in the country in 2022 (Chapter 6.1.1).

For transparency, the estimates for category 4.C Grassland are displayed graphically in Fig. 6-24, including the current (NIR 2024) and previous (NIR 2023) inventory submission.

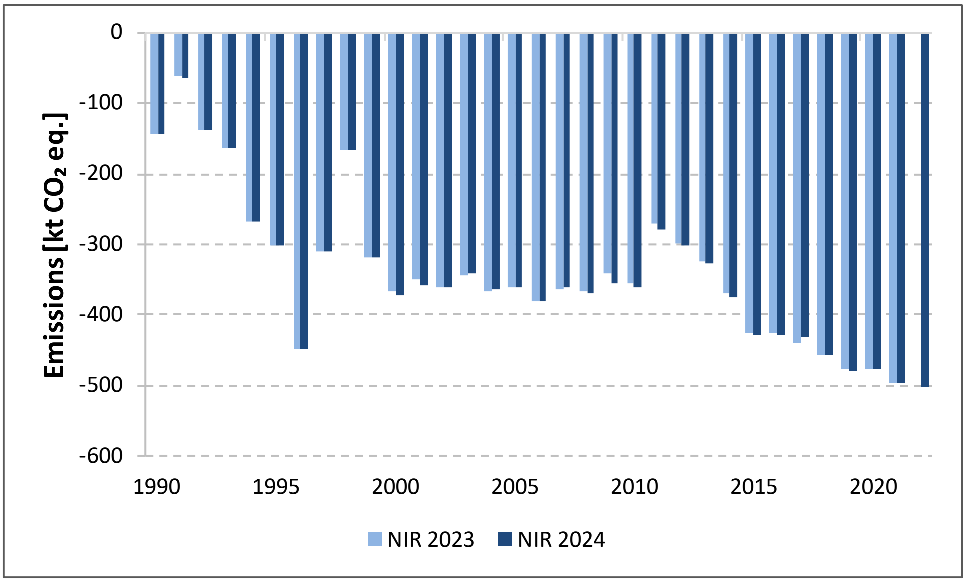

Fig. 6-24 Estimated emissions for category 4.C Grassland – the current (NIR 2024) and previous (NIR 2023) inventory submission.

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 improving 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 better substantiated emission factors. Most likely in 2024, the new activity data on reference soil carbon stock attributable to Grassland in the country will become available from Research Institute for Soil and Water Conservation (J. Vopravil, personal communication 2024). This will permit its implementation for the coming NIR submission.

Since 2024, the team cooperates with the AdAgriF project "Advanced methods of greenhouse gases emission reduction and sequestration in agriculture and forest landscape for climate change mitigation", (CZ.02.01.01/00/22_008/0004635), funded by Ministry of Education and coordinated by GCRI (prof. Trnka). The aim of the cooperation is to gradually increase the methodological level of the estimates in the categories related to agricultural land (4B Cropland, 4C Grassland).

6.7 Wetlands (CRF 4.D)

6.7.1 Source category description

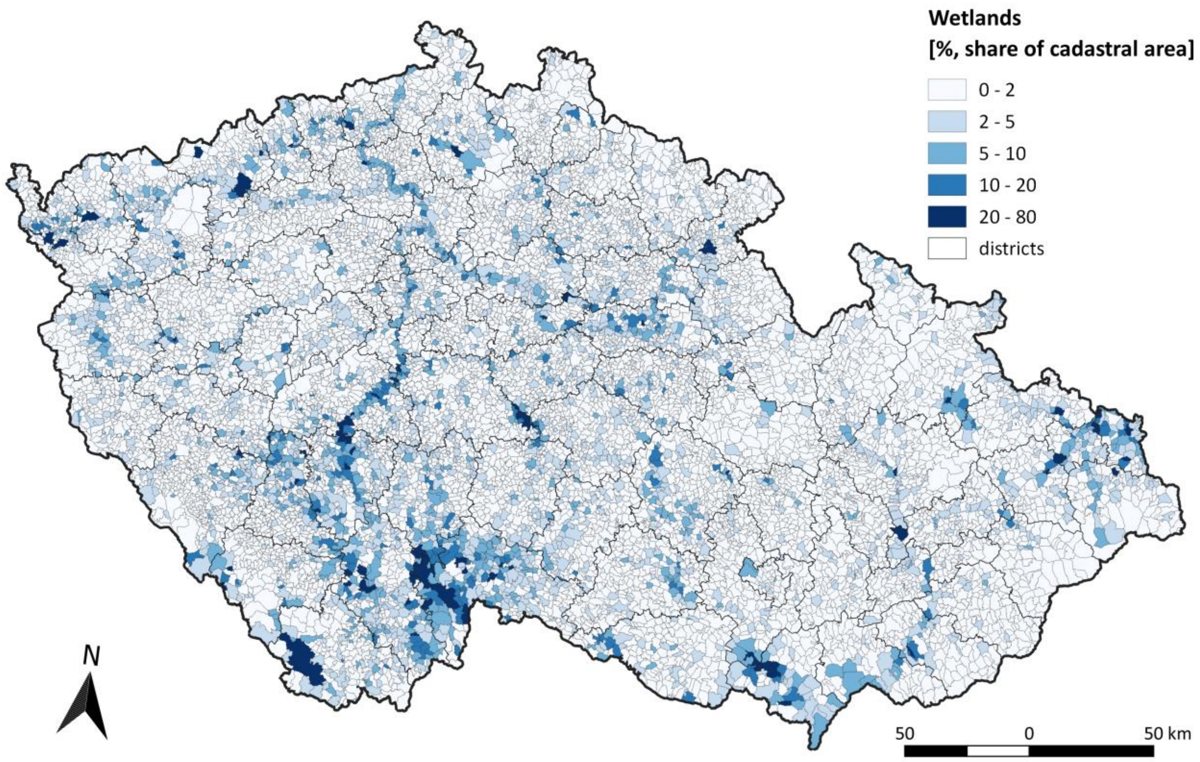

Fig. 6-25 Wetlands – distribution calculated as a spatial share of the category within individual cadastral units (as of 2022)

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 included under 4.D Wetlands (Tab. 6-5). 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. The inventory team makes no further alteration of the default categorization provided by COSMC. Accordingly, reporting 4.D Wetlands as defined above (in compliance with the national definition of wetland) resorts to subcategory Other wetlands (remaining or land converted to) in the CRF tables.

The area of 4.D Wetlands currently covers 2.2% of the total territory. It has been increasing steadily since 1990 (by 8.1% until 2022) with even a stronger trend earlier (Fig. 6-4). It can be expected that this trend will continue, and that the area of Wetlands would increase further. This is mainly due to programs aimed at increasing the water retention capacity of the landscape[5], 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).

[5] *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).*

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 peatland 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 the early 1990s following Act No. 114/92 on nature protection. Peat for industrial use relies on import, with exception of peat used in balneology. Hence, sub-category 4.D.1 Wetlands remaining Wetlands cannot be attributed to either flooded land or peat extraction lands. Hence, all wetland areas are reported under category 4.D.1.3 Other Wetlands remaining Other Wetlands. Correspondingly, the emissions for 4.D.1 Wetlands remaining Wetlands were not explicitly estimated for this sub-category.

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 litter and 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. As for Forest Land converted to Wetlands (category 4.D.2.1), loss of carbon in living biomass is quantified fully by CBM (Tier 3, Tab. 6-8) using the corresponding deforestation areas from annually updated Land use representation and land-use change identification system based on the data from COSMC (Sections 6.2 and 6.3). This was a new implementation since NIR 2023 inventory submission, enhancing the use of Tier 3 estimates facilitated by CBM (Tab. 6-8). More details relevant to this pool and category are given in Section 6.5.2.2 (Land converted to Cropland). The corresponding default values were employed: the biomass stock after conversion equaled 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 deadwood and litter components, 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 2022. 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%, change in living biomass assessed by CBM 50% for deforestation events.

Since the emission estimate concerns only category 4.D.2 Land converted to Wetlands, the uncertainty is estimated for this category. For 2022, the estimated uncertainty for category 4.D.2 was 40%.

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 Wetlands were recalculated in its subcategory 4.D.2. This was due to the changes implemented in 4.D.2.1 involving conversion from Forest land that rely on CBM-assisted Tier 3 estimates (Tab. 6-8). These changes decreased emissions for category 4.D (4.D.2) by 2% relative to the previous NIR submission, or by about 0.5 kt CO_2 eq./year, which is quantitatively negligible.

None of the individual emission categories of Wetlands qualifies among the key categories by quantity or trend in this inventory submission.

For transparency, the estimates for category 4.D Wetlands are displayed graphically in Fig. 6-26, including the current (NIR 2024) and previous (NIR 2023) inventory submission.

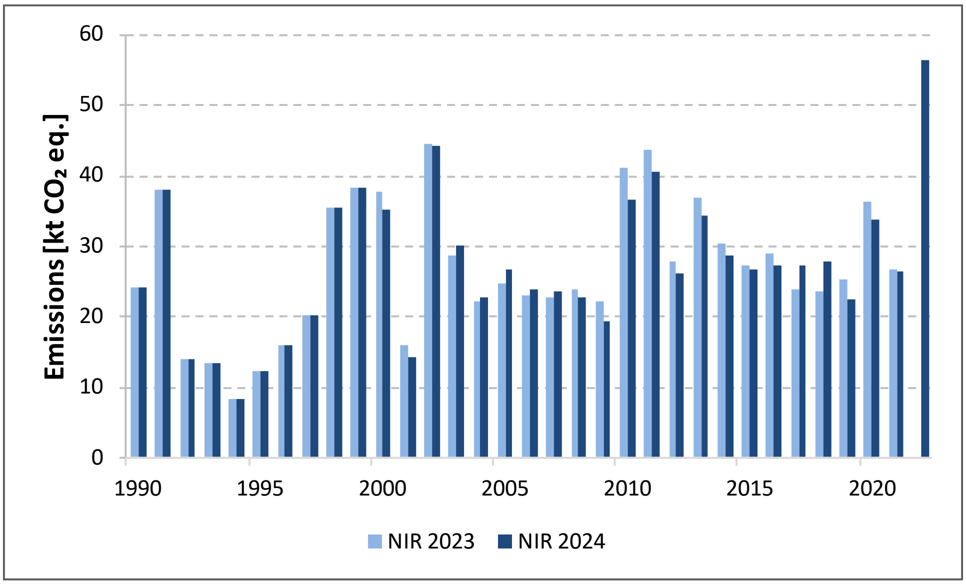

Fig. 6-26 Estimated emissions for category 4.D Wetlands – the current (NIR 2024) and previous (NIR 2023) inventory submission.

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

Depending on capacities, more transparent wetlands classification will be worked on to increase transparency of the reporting.

6.8 Settlements (CRF 4.E)

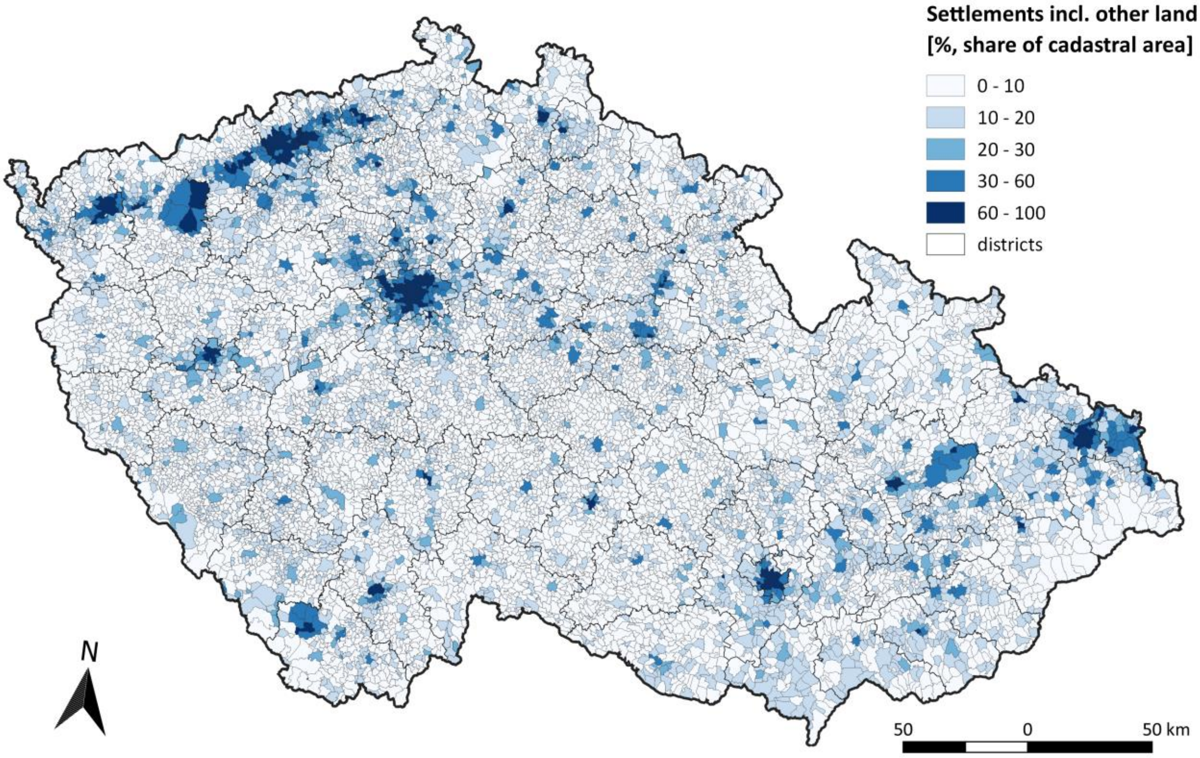

Fig. 6-27 Settlements, incl. other land – distribution calculated as a spatial share of the category within individual cadastral units (as of 2022)

6.8.1 Source category description

Category 4.E Settlements is defined by IPCC (2006) as all developed land, including transportation infrastructure and human settlements. The area definition under category 4.E Settlements was revised previously for the NIR 2013 submission to better match the IPCC (2006) default definition. Next, the NIR inventory submission of 2018 incorporated an additional change to this category, namely merging the land areas previously attributed under category 4.F Other land. 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-country 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. 6-5). 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 2022) represents 10.6% of the area of the country. The area of this category has increased since 1990 by about 3%, especially during the most recent years (see Fig. 6-4).

6.8.2 Methodological issues

Following Tier 1 assumption of IPCC (2006), the carbon stocks in biomass, dead organic matter (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 was first included in the NIR 2019 inventory submission. The reference value of carbon stock pool in Settlements was derived based on the data from the Landscape 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 remaining part assumes 20% soil carbon loss for paved over areas in line with the 2006 IPCC Guidelines (vol. 4, chap. 8, p.8.24). The resulting reference carbon stock applicable to Settlements has its area-weighted mean of 54.0 t C/ha, ranging from 30.3 to 90.4 t/ha for individual cadastral areas. This approach allows 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 similarly as for other land use conversion types.

The corresponding values were employed for emission estimates due to land use conversion: the biomass stock after conversion equaled 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 dead organic matter components, that were treated 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). As for Forest Land converted to Settlements (category 4.E.2.1), loss of carbon in living biomass is quantified fully by CBM (Tier 3, Tab. 6-8) using the corresponding deforestation areas from annually updated Land use representation and land-use change identification system based on the data from COSMC (Sections 6.2 and 6.3). This was a new implementation since NIR 2023 inventory submission, enhancing the use of Tier 3 estimates facilitated by CBM (Tab. 6-8). More details relevant to this pool and category are given in Section 6.5.2.2 (Land converted to Cropland). The latter section also describes the estimation of emissions related to deadwood and litter components, which was applied identically in this land use category. Finally, soil carbon pool estimates applicable for land use conversions to Settlements used the spatially-specific carbon pool values 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 2022. 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: land use areas 3%, reference biomass carbon stock prior and after land-use conversion 75%, change in living biomass assessed by CBM 50% for deforestation events.

The emission estimate concerns only category 4.E.2 Land converted to Settlements; therefore, the uncertainty is estimated only for this category. For 2022, the estimated uncertainty for category 4.E.2 was 42%.

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

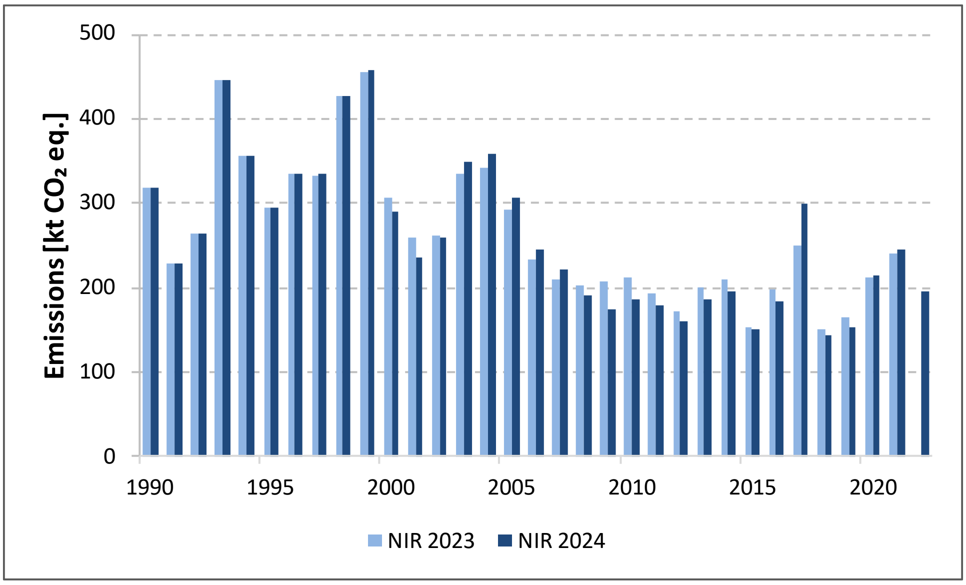

Fig. 6-28 Estimated emissions for category 4.E Settlements– the current (NIR 2024) and previous (NIR 2023) inventory submission.

The emission estimates for the category 4.E Settlements were recalculated in its subcategory 4.E.2. This was due to the changes implemented in 4.E.2.1 involving conversion from Forest land that rely on CBM-assisted Tier 3 estimates (Tab. 6-8). These changes decreased emission estimates for category 4.E (4.E.2) by 1% relative to the previous NIR submission.

None of the individual emission categories of Settlements qualifies among the key categories by quantity or trend in this inventory submission.

For transparency, the estimates for category 4.E Settlements are displayed graphically in Fig. 6-28, including the current (NIR 2024) and previous (NIR 2023) inventory submission.

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 intends to verify the activity data needed for verifying carbon stock change estimates in living biomass and mineral soils for this category.

6.9 Other Land (CRF 4.F)

6.9.1 Source category description

Since the NIR 2018 inventory submission, the IPCC category 4.F Other land is not represented by any land use category within the Czech conditions and the national system of land use representation and land use change identification. Prior to this submission, category 4.F Other Land represented unmanaged (unmanageable) land areas, matching the IPCC (2006) default definition. These areas were assessed from the database of “Aggregate areas of cadastral land categories” (AACLC), collected and administered by COSMC. It 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 issues 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 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 earlier (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.F Other land within category 4.E Settlements, which improves reporting consistency and transparency, while enhancing the ability to track land-use conversions. No other improvements are planned for category 4.F Other land.

6.10 Harvested Wood Products (CRF 4.G)

6.10.1 Source category description

The contribution of Harvested wood products (HWP), mandatorily included by Decision 2/CMP7 in emission inventories under UNFCCC and KP since the 2015 inventory submission, is also estimated for the Czech emission inventory. Changes in the pool of HWP may represent CO_2 emissions or removals, which are included within the LULUCF sector as a specific category (CRF 4.G) in addition to the six IPCC land use categories. The HWP pool considers primary woody products generated from wood produced in 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). Since the FAO database have recently become updated with a larger time delay, the input data were crosschecked with the Czech colleagues at the Czech Ministry of Agriculture and Forest Management Institute (Michal Synek, personal communication, Jan. 2023). Based on that, some of the recent activity data were revised – specifically, these revisions concern all major HWP categories (except wood pulp) for the most recent two or three years. The adopted national activity data are reported in the CRF tables (4.Gs2) for the period 1961 to 2022. Eventually, the identical data will become available at the FAO database for the country, but with a considerable delay.

The fraction corresponding to source material originating from deforested land was estimated based on deforested areas as reported under Activity 3.3 Deforestation of the former Kyoto protocol. Although quantitatively insignificant (0.016% in both 1990 and 2022, respectively), the HWP contribution of this fraction was estimated using instantaneous oxidation, which was the formal requirement of the IPCC guidelines (IPCC 2014b) for estimation of HWP contribution under the former Kyoto Protocol. This conservative approach remains adopted for the HWP estimates under the Convention, too.

Tab. 6-12 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

Country / HWP category	Production		Import		Export	
	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 2022 are shown in Tab. 6-2. The emissions fluctuated during the reporting period, where the mean contribution reached -1 166 kt CO_2/year. The estimated HWP contribution reached -1 680 and -1 946 kt CO_2 in 1990 and 2022, 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 2022.

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 recalculation was made for the category 4.G HWP except the most recent years due to slightly changed activity data at FAO database on wood production and trade, the primary source of the activity data used for estimation of HWP emission contribution for the entire reporting period. These activity data were crosschecked and rectified based on the discussion with the country correspondents for reporting to FAO (see section 6.10.2 above). These affected the estimates of HWP contribution for 2021. Hence, the estimates differ between the current and the previous submission only marginally, namely by -0.2% (decreased sink).

For transparency, the estimates for category 4.G HWP are displayed graphically in Fig. 6-29, including the current (NIR 2024) and previous (NIR 2023) inventory submission.

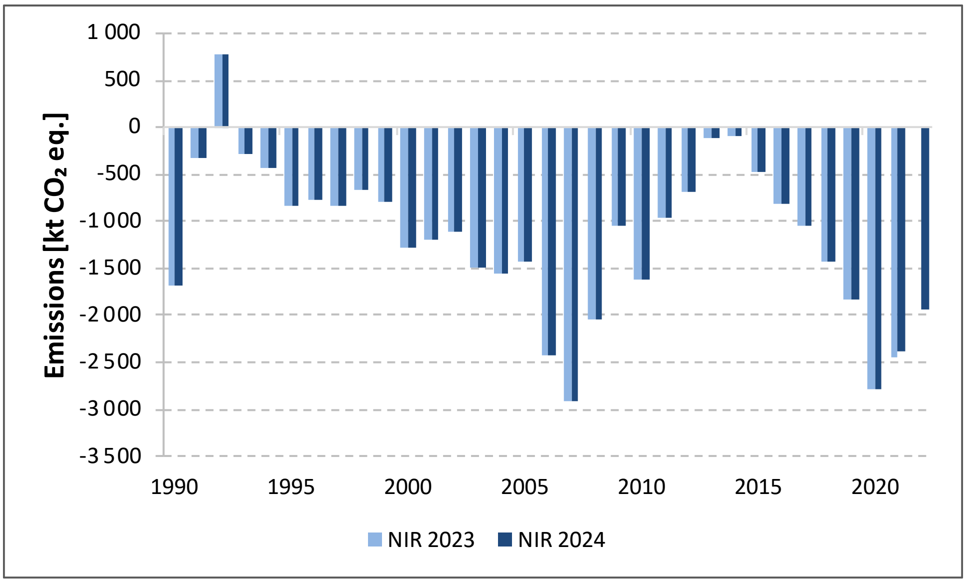

Fig. 6-29 Estimated emissions for category 4.G HWP – the current (NIR 2024) and previous (NIR 2023) inventory submission.

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.

6.11 Acknowledgement

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7 Waste (CRF sector 5)

7.1 Overview of sector

The waste sector comprises emissions from human activities associated with waste management in general. Most human and economic activities result in the production of waste; therefore, performance of this sector is closely connected with population and the economic state of the country. Most processes in the sector originate in biological or biochemical processes and therefore it takes longer for changes in management practices to be reflected in emissions. An overview of the whole sector is shown on Fig. 7-1.

Unfortunately in this submission data for the reference year 2021 are reported, because it was not possible to obtain the 2022 data needed to calculate emissions. The situation is caused by deployment of a new information system for waste management, which unfortunately is not completed yet in terms of development. The reference year 2022 will be reported in the next submission.

This sector encompasses several categories. In 2022, the total GHG emissions from the Waste sector in the Czech Republic were about 5 700 kt CO_2 eq. and approximately 94% of these emissions accounted for CH_4. The main source category of this sector is 5.A - Solid Waste Disposal. In 2022, this category emitted approximately 133 kt of CH_4 (see Fig. 7-2), equalling 3 725 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 biological treatment of waste (5.B) and from waste incineration and open burning of waste (5.C). 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.i 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 2022, there is a slightly increasing trend in emissions from landfilling. Almost 90% of all wastes produced are used (recycled, used for energy purposes etc.). However, it is partly caused by huge amount of building and demolition waste which influences the whole waste statistics. Talking about another categories such as municipal solid waste (MSW), there is recovered approximately only one half of it. In recent years, the amount of waste composted increased because of new legislation. The technology of anaerobic

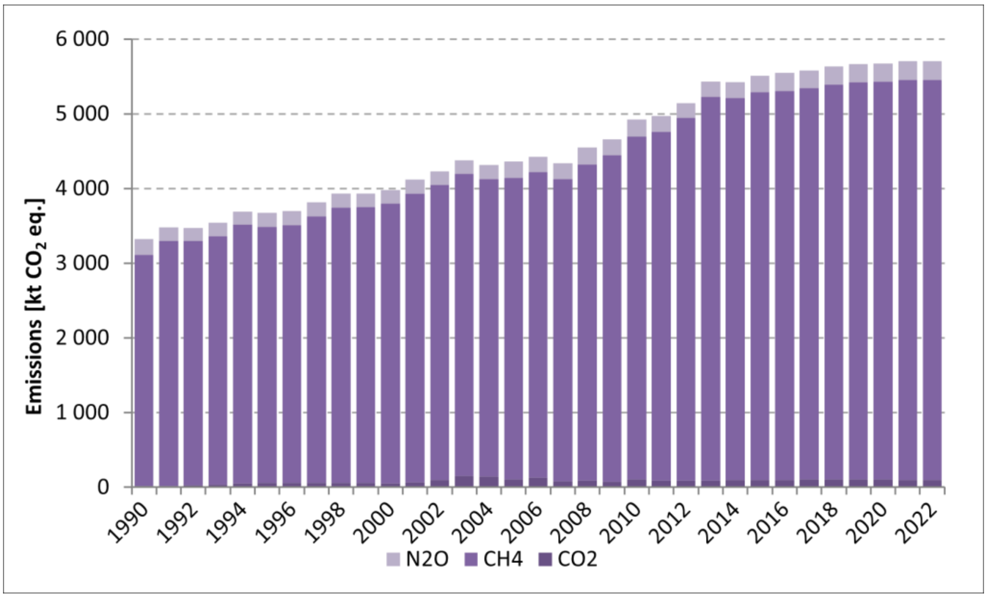

Fig. 7-1 The development of gas emissions from the Waste sector, 1990-2022

digestion is being widely adopted due to subsidies on biogas production and was another growing source category. In recent years the growth stopped and the biogas production is stable. In the Czech Republic, there are still efforts to increase energy use of waste instead of landfilling or burning without energy use. Emissions from industrial wastewater were steadily increasing till 2019. 2020 is the first year when both municipal and industrial wastewater emissions decreased. In 2022 the emissions from industrial wastewater slightly increased while municipal ones decreased. In general the emissions from wastewater treatment and discharge insignificantly decreased. Significant categories in this sector are shown in Tab. 7-1. Since 2019, the Waste sector is quantified and managed by Czech Environmental Information Agency (CENIA) (previously by CUEC, Charles University Environmental Center).

Tab. 7-1 The overview of significant source categories in the Waste sector (2022)

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	CH_4	LA, TA	LA, TA	Yes	Yes	Yes	Yes	3.09	3.18
5.D Wastewater treatment and discharge	CH_4	LA	LA, TA	Yes	Yes	Yes	Yes	0.74	0.76
5.B Biological treatment of solid waste	CH_4	LA, TA	LA, TA	Yes	Yes	Yes	Yes	0.61	0.63

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 the land use change and forestry. The CH_4 emissions are much more important. Methane is released in the case of decomposition without the presence of oxygen. In some solid waste disposal sites (SWDS) the arising methane (as a part of landfill gas) is caught by piping in the body of the landfill and then collected. This gas can be (and in the Czech Republic is in some cases) used for energy recovery.

This source category might also produce emissions of other micropollutants, such as non-methane volatile organic compounds (NMVOCs), as well as smaller amounts of nitrous oxide (N_2O), nitrogen oxides (NO_X) and carbon monoxide (CO). In line with the IPCC 2006 Guidelines (IPCC, 2006), only CH_4 is addressed in this chapter. An overview of this category is shown in Fig. 7-2.

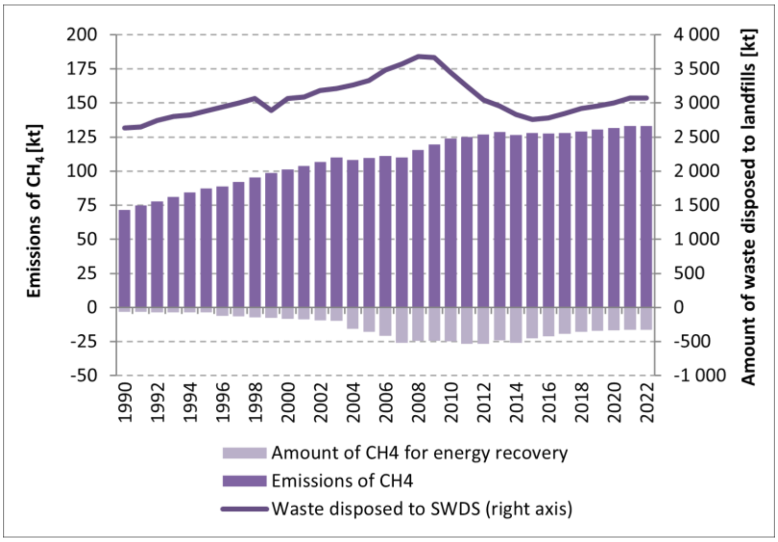

Fig. 7-2 Development of emissions from SWDS and total amount of waste disposed to SWDS 1990-2022

7.2.1.2 Methodological issues

Waste disposal to Solid Waste Disposal Sites (SWDS)

The key activity data for methane quantification from 5.A.1.a is the amount of waste disposed in landfills. The annual disposal is given in Tab. 7-2. The data for the annual disposal are obtained from mixed sources, since the application of the FOD (first-order decay) model requires data from 1950 to the present day. These historical data are not available in the country, therefore assumptions about the past had to be

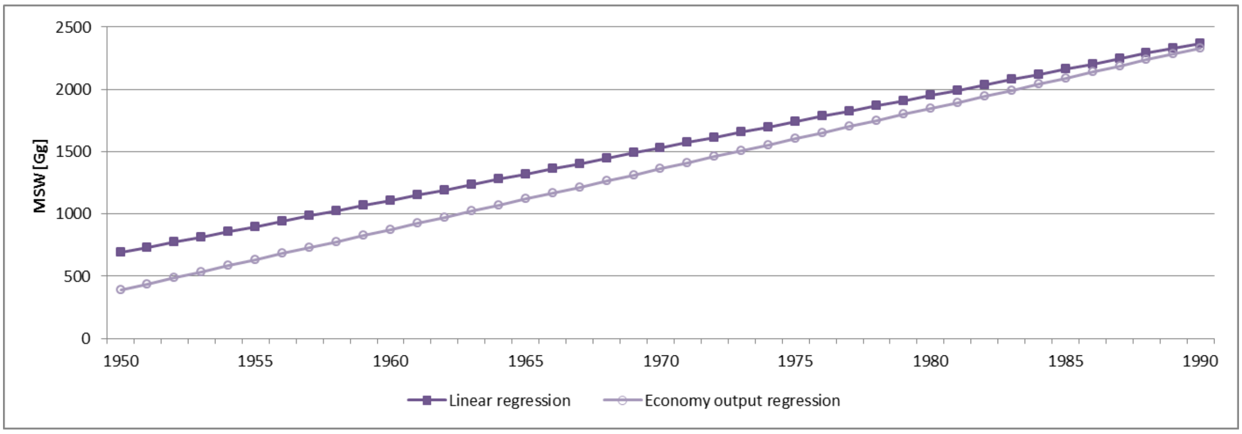

Fig. 7-3 Disposal of Municipal Solid Waste (MSW) to SWDS and GDP, Czech Republic, 1950-1990

used. These assumptions are described in the working paper (Havránek, 2007), but the method can be simply described as interpolation and extrapolation between points in time; correlation of the waste production with the social product (predecessor of the current GDP, gross domestic product) as a test method was performed (Fig. 7-3). The trends look similar. The higher of the two estimates was used in the quantification.

Tab. 7-2 MSW and IW (municipal solid waste + industrial waste) disposal to SWDS in the Czech Republic [kt], 1990–2022

Year	Waste disposed to SWDS	Year	Waste disposed to SWDS	Year	Waste disposed to SWDS	Year	Waste disposed to SWDS
1990	2 631	**1999**	2 892	**2008**	3 684	**2017**	2 843
1991	2 648	**2000**	3 063	**2009**	3 666	**2018**	2 918
1992	2 744	**2001**	3 086	**2010**	3 445	**2019**	2 956

1993	2 803	**2002**	3 180	**2011**	3 241	**2020**	2 997
1994	2 821	**2003**	3 212	**2012**	3 046	**2021**	3 073
1995	2 881	**2004**	3 260	**2013**	2 952	**2022**	3 073
1996	2 943	**2005**	3 330	**2014**	2 830		
1997	2 999	**2006**	3 481	**2015**	2 759		
1998	3 064	**2007**	3 574	**2016**	2 783		

Since 2009, the waste deposited to landfills has decreased slightly, but nowadays there is still percieved growth. A decrease in landfilled waste is a long term target of the Czech national environmental policy.

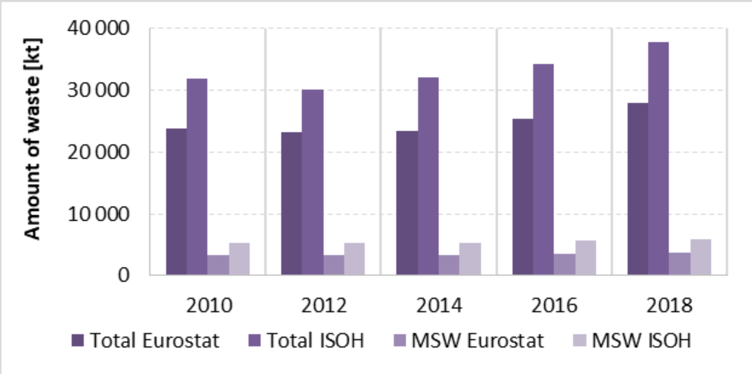

Fig. 7-4 Amount of waste produced in the Czech Republic - comparison of data from Eurostat and ISOH, 2010-2018

The data used for present years are based on annual report of indicators to Plan of waste management – a strategic document about waste management in the Czech Republic. Similar values can be found in public information system (database) of waste management in the Czech Republic (VISOH) and its non public version (ISOH - information system on waste management), both managed by Czech Environmental Information Agency (CENIA). Values of the indicators are calculated based on the ISOH database. The ISOH system contains bottom up data from around 60 000 respondents, where reporting obligation to this system is based on the national legislation and it is controlled by Czech Environmental Inspectorate, regional authorities and municipalities. There also exist statistics about waste developed by Czech Statistical Office (CzSO) that are subsequently reported to Eurostat. For the purpose of the inventory we use ISOH data because they are evidence-based and verified by CENIA during reporting procedure. In 2018, CENIA runned a cross comparison on SWDS data from ISOH and CzSO and ISOH data fit better on fees and levies gathered in the waste management sector and hence are percieved more accurate. Fig. 7-4 and Fig. 7-5 show the differences between data from Eurostat and ISOH for the production of waste and the amount of waste disposed to SWDS in years 2010 – 2018, both for total amount of waste and for municipal solid waste. Eurostat reports two kinds of data from households. One is called Household and similar wastes and the second is Municipal waste. For the comparison in Submission 2020 there was used the Household and similar wastes database. Deeper comparison was made and the Municipal waste database was found out more suitable because the definition of waste and waste categories are similar to the Czech definition. However, the big differences between ISOH and Eurostat did not change much.

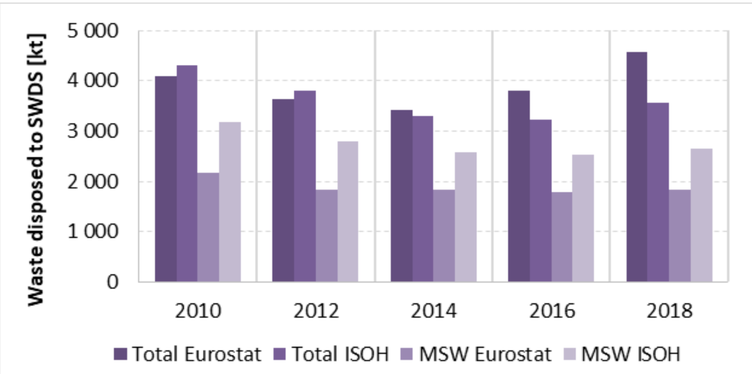

Fig. 7-5 Amount of waste disposed to SWDS in the Czech Republic - comparison of data from Eurostat and ISOH, 2010-2018

As can be seen, the production of waste is always higher from ISOH. The data on the amount of waste disposed to solid waste disposal sites are for MSW in all four years higher from ISOH, but in case of the total this trend is not apparent.

The difference between data from Eurostat and ISOH is given by different ways of data collection and another methodological approaches. ISOH is the official waste database of Ministry of the Environment (MoE) (administrated by CENIA). ISOH gets data straight from waste producers who are required to report their amount of waste produced or treated into this database. So there should be all data on waste management in the Czech Republic. Eurostat gets data from the Czech Statistical Office (CzSO) which uses statistical methods – data collected from a smaller amount of waste producers and the total amount is then counted, based on the collected data. Both of these data sources are official and long-term discussion is made about decreasing the differences between the data from these two sources. Recently, management of waste section of CzSO changed their methods, too. Since the reference year 2021 CzSO has access to the same database as CENIA, so the base source is same for both institutions. Also the definition of the waste streams which are statistically determined were more aligned. It seems that CENIA and CzSO waste data will finally fit better.

National legislation on landfill management is based on the European legislation. There were also legislative regulations before Czech membership in EU but the transition into the European legislation brought more detailed approach to waste management practices and their evidence. In general, it sets conditions on how landfilling can be done, specifies the relevant actors and state bodies responsible for the administration and control, duties and obligation of all the stakeholders. The main regulations in this area before the membership in EU were Act 238/1991 Coll. "Act on waste" and newer act on waste Act 185/2001 Coll. The Act on waste from 2001 was replaced by new Act 541/2020 Coll. just in the end of year 2020. The main directive relevant for the landfilling was in case of Act 185/2001 Coll., Decree 294/2005 Coll. "Decree on the conditions for depositing waste in landfills and its use on the surface of the ground" and Decree 383/2001 Coll. "Decree on details on waste treatment practices" that are now novelised to Decree 273/2021 Coll. Management of waste is complicated and the full regulative framework can be found on the website of the Ministry of the Environment.

Industrial waste, sludge and dual data

The category 5.A distinguishes diverse categories of waste. Some of them are not included as a special category in ISOH, for example there is no category "industrial waste" (IW). Based on suggestion from Annual Review Report (ARR) the data sources on waste are hybridized in the way that we still use ISOH data which do contain IW data (but do not discern them as such) but we adjust them by residual factor from CzSO based on their IW statistics.

The method used for estimation of methane emissions from this source category is the Tier 1 FOD approach (first-order decay model). The first-order decay model assumes gradual decomposition of waste disposed in landfills. The GHG (greenhouse gas) emissions were calculated from the IPCC Spreadsheet for Estimating Methane Emissions from Solid Waste Disposal Sites, which is a part of the 2006 Guidelines (IPCC, 2006) referred further to the IPCC model (IPCC, 2006).

Waste composition, sludge, k-rate and Degradable Organic Carbon (DOC)

Waste composition is crucial for emission estimations from SWDS. Several attempts have been made to obtain country-specific data about waste composition (Tab. 7-3). The data for the 1990 – 1995 period are based on the IPCC default values for Eastern Europe, while the data for the 1996 – 2000 and 2002 – 2004 periods are based on interpolation 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. For the period 2012 – 2020 data from company EKO-KOM are available. EKO-KOM makes every even year a survey on MSW composition. For 2012, 2014, 2016, 2018 and 2020 EKO-KOM values were used and the odd years are made as average between the two years around. For the reference year 2022, the composition was taken from the 2020 EKO-KOM analysis, same as for the reference year 2021.

Tab. 7-3 MSW composition for the Czech Republic used in the quantification (fractions of total, 1950-2022)

	Paper	Food	Textile	Wood and straw	DOC (calculated)
k-*rate*	0.06	0.185	0.06	0.03	
DOC (default)	0.4	0.15	0.24	0.43	
			Share of particular waste streams		

	Paper	Food	Textile	Wood and straw	DOC (calculated)
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
2009-2011	0.16	0.35	0.08	0.13	0.194
2012	0.14	0.30	0.08	0.18	0.198
2013	0.13	0.30	0.06	0.20	0.197
2014	0.12	0.30	0.04	0.22	0.197
2015	0.12	0.27	0.04	0.26	0.207
2016	0.11	0.25	0.03	0.30	0.217
2017	0.10	0.28	0.03	0.30	0.220
2018	0.10	0.32	0.03	0.30	0.223
2019	0.10	0.32	0.02	0.31	0.224
2020	0.10	0.31	0.02	0.31	0.226
2021	0.10	0.31	0.02	0.31	0.226
2022	0.10	0.31	0.02	0.31	0.226

As can be seen, the table does not include all possible waste streams which might be deposited in a landfill. The missing item is for example the sludge. This is because the projects from which the expert derived the waste composition did not include any sludge as a part of the waste mixture because sludge is not a part of MSW. 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. This means that the emissions should not be underestimated because the mass deposited in landfills does include sludge (the data are bottom-up total mass data for landfills) and the average DOC obtained using the current waste mixture is larger than the default DOC for sludge. However, more detailed insight into this issue is planned in upcoming years.

The table also contains the methane generation rate (k-rate) employed. This rate is closely related to the composition of a particular substance and the available moisture. The IPCC default k-rates for a wet temperate climate were used (the average temperature of the Czech Republic is around 8 °C and the annual precipitation is in long-term average 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.

Methane correction factor

The methane correction factor (MCF) is a value expressing the overall management of landfills in the country. Better-managed and deeper landfills have higher MCF value. Shallow SWDS ensure that far more oxygen penetrates into the body of the landfill to aerobically decompose DOC, so that the MCF is lower. 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 the data for recent years (1992+) and expert judgement in the early years of the timeline. In recent years only managed anaerobic SWDS are considered to occur in the Czech Republic.

Tab. 7-4 Methane correction factor 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, 1950-2022

	MCF
1950 – 1959	0.6
1960 – 1969	0.6
1970 – 1979	0.8
1980 – 1989	0.9
1990 – 2022	1.0

Oxidation factor

As methane moves from the anaerobic zone to the semi-aerobic and 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), who mentions a non-zero oxidation factor, but these figures seem to be site-specific and have very high values compared to the default value, perhaps due to specific practices at the site. Therefore, they cannot be used as representative for the whole country. However, the methodology (IPCC, 2006) suggests that an oxidation factor greater than 0.1 should not be used if no site measurements are available (a larger value adds uncertainty). The author used the recommended oxidation factor of 0.1 in the report.

Delay time

When waste is disposed to 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 the deposition, which is equivalent to an average delay time of six months before decay to methane commences. It is good practice to assume an average delay of two to six months. If a value greater than six months is chosen, evidence to support this must be provided. The Czech Republic has no representative country-specific value for the delay time, so the author used a default value of 6 months.

Fraction of methane

Fraction of methane (F) is a parameter that 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) and value 0.55 was used in recent years. The 0.61 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 Ministry of Industry and Trade (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 was therefore used in the quantification till the 2020 NIR. Nevertheless, the F value has been changed in this report from the country specific 0.55 to IPCC default 0.5. This was recommended by the review team which have not found the origin of the 0.55 factor right. In the 2021 submission, value 0.5 was used and the whole timeline was recalculated. Since then the application of the value 0.5 continued, however, a more detailed research on the LFG composition in the Czech Republic and factor F is addressed in upcoming years.

Recovered methane

The landfill gas is in most cases collected by a LFG collecting system in the body of the landfill and then used for energy purposes. Based on 2006 IPCC Guidelines (IPCC, 2006), this methane (from LFG), that is being converted to CO_2 and has biogenic origin, is not considered to constitute GHG emissions and hence recovered methane (R) is subtracted from the total emissions. There is no default value for R, so country estimates were used, based on various sources, which all originate from the Ministry of Industry and Trade. The data on LFG volume and the number of landfills capturing LFG are official and can be found on the official websites (Ministry of Industry and Trade, 2021). The data on the energy obtained from the recovered LFG are individually requested, the Ministry of Industry and Trade does not publish them. 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. 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 interpolation of recovered methane was used for the period between 1996 and 2003. In 2022, almost 70 facilities were recovering LFG in the country. We also encountered a decrease in recovered amount of CH_4 in recent years. We assume that it might be correlated with decreasing trend in landfilling in past years and 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 Havránek (2007). The following Tab. 7-6 lists methane emissions from this category.

Tab. 7-6 Methane from SWDS [kt], 1990–2022

	CH_4 generation	CH_4 recovery	CH_4 emission
1990	82.93	3.25	71.71
1991	86.58	3.25	75.00
1992	89.97	3.45	77.87
1993	93.52	3.45	81.06
1994	97.03	3.45	84.22
1995	100.31	3.45	87.17
1996	104.71	6.03	88.81
1997	109.02	6.58	92.19
1998	113.24	7.12	95.50
1999	117.45	7.67	98.80
2000	120.54	8.22	101.09
2001	124.28	8.76	103.97
2002	127.93	9.31	106.76
2003	131.94	9.86	109.87
2004	135.92	15.58	108.31
2005	139.92	18.00	109.73
2006	144.00	20.58	111.08
2007	148.16	25.93	110.01
2008	152.92	24.58	115.50
2009	157.30	24.50	119.52
2010	162.31	24.66	123.89
2011	165.63	26.59	125.14
2012	167.57	26.56	126.90
2013	167.11	24.20	128.26
2014	166.23	25.72	126.47
2015	164.86	22.72	127.93
2016	163.11	21.30	127.63
2017	161.51	19.38	127.92
2018	161.20	17.82	129.04
2019	162.07	17.09	130.48
2020	163.06	16.67	131.75
2021	164.19	16.37	133.03
2022	164.19	16.37	133.03

7.2.1.3 Uncertainties and time-series consistency

Overall quantification of the uncertainity for this category is incomplete. This is considered as 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 – 2022 and therefore it cannot be correctly quantified by simple analysis. Combined uncertainty was estimated by the expert judgement based on default factors and activity data uncertainties that are shown in 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

No recalculations were made in this subsector.

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

In upcoming years there is planned a project on review of 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 and also to investigate more the LFG systems on the landfills. A nationally specific methodology for determining the share of methane in LFG was prepared this year and now it is in the certification process. We plan to continue with improving the approach on determination of MSW composition.

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: 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 is a process deliberately leading into generation of methane (as a part of biogas). However, it is a controlled process mainly directed towards capturing the produced biogas and thus the emissions from this source category are also relatively small. Anaerobic digestion has greatly increased in recent years. An overall survey of this source category is shown in Fig. 7-6.

7.3.1 Composting (CRF 5.B.1)

7.3.1.1 Source category description

This category quantifies emissions from industrial composting facilities. Emissions from household compost heaps are not estimated because there are no available data on household composting in the Czech Republic. We consider these emissions to be negligible because the compost heaps are usually smaller than the industrial and the amount of biowaste deposited is also small. Nevetheless, they are taken into account and a new methodology is planned to be used, although all these factors will introduce high levels of uncertainty in the results.

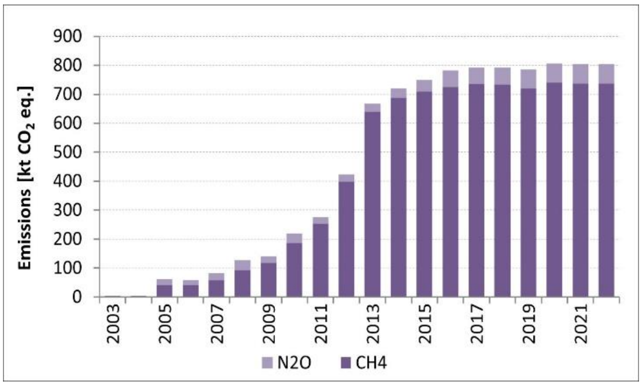

Fig. 7-6 The development of emissions from biological treatment of solid waste, 2003-2022 (2003 and 2004 only anaerobic digestion)

7.3.1.2 Methodological issues

This source category quantifies emissions from composting based on data on the waste management. The composting data are obtained from ISOH system (for more details about ISOH, see source category 5.A).

In accordance with IPCC 2006 Gl., composted waste was split into two groups – municipal solid waste (MSW) and other waste. Municipal solid waste is waste from households and corporate waste similar to the household waste. Composted other waste means all waste except the municipal. Both categories use identical emission factor (EF). Fresh (wet) weight data and default EF from IPCC 2006 Gl. are used. No data are available for either category before 2005, so further research has been launched to determine the reasons for this. The amount of composted MSW is gradually increasing, especially from the year 2016. Since 2016 all municipalities are obligated to ensure their inhabitants the collection of biowaste. To compost more 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 (and related parameters) from composting, 2005-2022

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MSW [kt]	48.8	61.5	79.8	114.4	134.6	144.1	181.9	153.5	202.8	303.1
Other waste [kt]	288.8	222.7	296.4	428.7	221.3	358.2	190.1	228.3	247.0	217.2
CH_4 emission factor [kg CH_4/t]	4									
N_2O emission factor [kg N_2O/t]	0.24									
Total Composting emissions CH_4 [kt]	1.35	1.14	1.50	2.17	1.42	2.01	1.49	1.53	1.80	2.08
Total Composting emissions N_2O [kt]	0.08	0.07	0.09	0.13	0.09	0.12	0.09	0.09	0.11	0.12
Total composting GHG [kt CO_2 eq.]	59.3	49.9	66.1	95.4	62.5	88.2	65.3	67.0	79.0	91.4
	2015	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**		
MSW [kt]	374.0	583.5	615.1	639.8	721.7	751	760.4	760.4		
Other waste [kt]	249.4	305.9	283.3	278.9	305.0	289.0	280.2	280.2		
CH_4 emission factor [kg CH_4/t]	4									
N_2O emission factor [kg N_2O/t]	0.24									
Total Composting emissions CH_4 [kt]	2.49	3.56	3.59	3.67	4.11	4.16	4.16	4.16		
Total Composting emissions N_2O [kt]	0.15	0.21	0.22	0.22	0.25	0.25	0.25	0.25		
Total composting GHG [kt CO_2 eq.]	109,5	156,2	157,8	161,3	180,3	182,6	182,7	182,7		

7.3.1.3 Uncertainties and time-series consistency

This category has default uncertainty, as only default factors are used. The uncertainty of the reported activity data is estimated to be small (+/- 5%); however, the largest source of uncertainty is not captured by the official data – the uncertainty in household composting.

Time series consistency is ensured as the inventory approaches concerned are employed identically across the whole reporting period from the base year 1990 to 2022. However, the data for composting of waste are available from the year 2005.

7.3.1.4 Source-specific QA/QC and verification

The QA/QC plan for the sector was updated during the year 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.

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 recalculations were made in this subsector.

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

In 2019, a proposal for a project to develop the methodology for estimation of household composting was submitted. The methodology is already developed, but was not used for this submission yet because of the overall delay with the avalability of data on the whole waste sector. Research was initiated to obtain data on composting before 2005, too. However, we are sceptical that credible data exist.

7.3.2 Anaerobic Digestion at Biogas Facilities (CRF 5.B.2)

7.3.2.1 Source category description

Anaerobic digestion (AD) is a process of transformation biowaste into gas (biogas). However, emissions from this category are not the amount of the gas produced (see *Methodological issues*). AD in the Czech Republic has increased from 86 digesting facilities in 2009 to 400 facilities in 2022. However, the year 2009 is after the start of the boom in building biogas plants. In 2005 it was only 5 AD facilities in the whole Czech Republic. This rapid increase was fuelled by the increasing availability of the technology and governmental subsidies for energy from biogas produced using AD. The number of AD facilities is almost the same in last nine years.

7.3.2.2 Methodological issues

Default emission factors were used for the estimation of the emissions from AD. Since production of the biogas from AD facilities is carefully monitored (thanks to government subsidies) the data about biogas production were used as activity data. The Ministry of Industry and Trade monitors the amount of biogas and additional data, such as calorific value of the produced gas, the energy produced and the total volume of gas. The heating value of methane was used to convert the above-mentioned values to mass units of produced methane. Production does not necessarily mean emission of biogas. IPCC 2006 Gl. states that there could be some leakages but they are usually 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. It is planned to create a country specific value for the leakages in upcoming years.

Since the data on 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 Czech definition (e.g. agricultural residues, industrial by-products etc.) but they still generate the biogas and it is logical to involve them. An overview of the sector is shown in Tab. 7-9.

Tab. 7-9 Emissions and related parameters from Anaerobic digestion facilities, 2003-2022

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Number of biogas stations	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
Conversion [TJ/kt]	50.009									
Activity data – R CH_4 [kt]	2.84	2.44	2.40	6.50	11.78	22.58	56.13	93.18	150.91	254.37
Emissions CH_4 (default 5%) [kt]	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**	**2018**	**2019**	**2020**	**2021**	**2022**
Number of biogas stations	388	404	403	404	404	404	402	398	400	400
Energy [TJ]	21 040	22 472	22 870	22 357	22 669	22 544	21 652	22 297	22 181	22 181
Conversion [TJ/kt]	50.009									
Activity data – R CH_4 [kt]	420.72	449.36	457.32	447.06	453.30	450.80	432.96	445.86	443.55	443.55
Emissions CH_4 (default 5%) [kt]	21.04	22.47	22.87	22.35	22.66	22.54	21.65	22.29	22.18	22.18

7.3.2.3 Uncertainties and time-series consistency

The time series are consistent (2003 - 2022), since the same method, factors and the data source are used. Uncertainty in this source category is given by the emission factor (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 recalculations were made in this subsector.

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 estimating leakages, which is crucial for the whole quantification. This improvement is of moderate priority and has already started to be solved as a part of the same project as improving the methodology for estimating the emissions from the household composting. The result is planned to be incorporated in NIR 2025. (As mentioned in chapter 7.3.1.6, we are sceptical that credible data on biogas production in previous years could be found, too.)

7.4 Incineration and Open Burning of Waste (CRF 5.C)

In the Czech Republic there are some incineration plants incinerating waste without energy recovery. There are incineration plants recovering the energy, too, but these plants and the wastes used as a fuel are included in the Energy sector in category 1.A.1.a.i. This chapter includes only waste that is disposed by incineration or is open burned, what is an illegal activity in the Czech Republic but it sometimes happens eg. unintentional (or sometimes deliberate) landfill or waste bin fire. The chapter and values on open burning of waste were reported for the first time two years ago.

7.4.1 Waste incineration (CRF 5.C.1)

This category contains emissions from waste incineration in the Czech Republic. Waste incineration is defined as the combustion of waste in controlled incineration facilities. Modern waste incinerators have tall stacks and specially designed combustion chambers, that ensure high combustion temperatures, long residence times, and efficient waste agitation, while introducing air for more complete combustion.

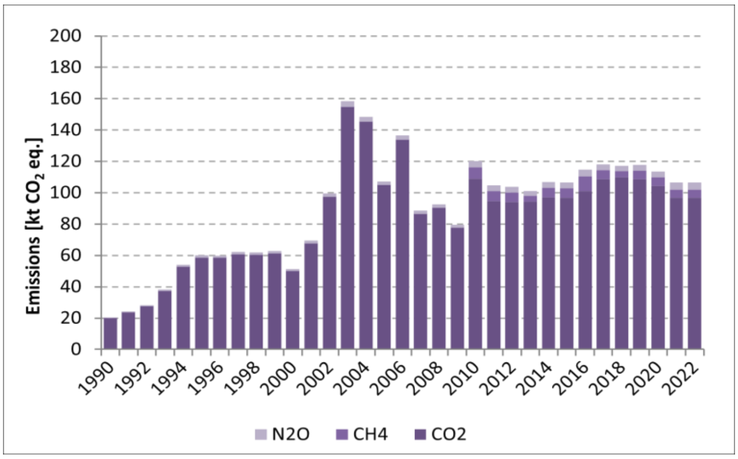

Fig. 7-7 Development of emissions from waste incineration, 1990-2022

The types of solid wastes incinerated include: industrial, hazardous, clinical waste, MSW and sewage sludge (IPCC, 2006). However, in the Czech legislation it is not easy to distinguish these categories, some of them are parts of another categories and for example no special category called “Industrial waste” exist. Category 5.C.1 (Waste incineration) includes emissions of CO_2, CH_4 and N_2O from these practices. However, almost all emissions are caused by CO_2. Development of the category is shown in Fig. 7-7.

7.4.1.1 Source category description

There are tens of facilities incinerating or co-incinerating different kinds of wastes (mostly not MSW) without energy use. Their emissions are presented in this category.

7.4.1.2 Methodological issues

In this source category only CO_2 emissions resulting from oxidation of the fraction of fossil (non-biogenic) carbon in the waste (e.g. plastics, rubber, liquid solvents, and waste oil) during incineration are considered in the net emissions and are included in the national CO_2 emissions estimates. In addition, incineration plants produce small amounts of methane and nitrous oxide. All the emissions are reported in this category 5.C.1. The 5.C.1 category is from 2021 divided by four waste streams: MSW, clinical waste, sewage sludge, industrial waste (with residual waste). No category *Hazardous waste* is reported because in the Czech legislation the hazardous waste is a part of all of these four categories. Some sludges are hazardous, some parts of MSW are hazardous and even not all the clinical waste is hazardous, it has its hazardous and non-hazardous parts. As mentioned earlier there is also no category *Industrial waste* and therefore the IPCC category *Industrial waste* is filled in with residual data – the incinerated waste that does not fall into the category of MSW, clinical and sewage sludge. However, this “Industrial waste” is actually mostly composed by wastes from industry, so it can be considered as industrial waste (this category also includes hazardous and non-hazardous wastes). The four subcategories mentioned above are reported as biological part and non-biological part for all the emissions. However, the CO_2 emissions of biogenic origin are described as an information item and are not included in the national totals. The whole timeline was divided into these four waste subcategories but the total amount of combusted waste didn’t change.

Estimations of CO_2 emissions are based on the Tier 1 approach (IPCC, 2006). For measurement of emissions from MSW, the MSW composition is needed. In this case 2006 IPCC Guidelines composition was not used because the MSW composistion is being used in category 5.A and this category doesn’t use the IPCC default values but newer country specific values. MSW composition is necessary for calculating MSW emission factors which are not given as one value but only separately for every MSW component (type). MSW total EFs (presented in Tab. 7-12) are calculated by multiplying these unique EFs for each type of MSW by the MSW composition (final EF is weighted mean). In case of sewage sludge we use IPCC 2019 Refinement to the 2006 Guidelines values because sewage sludge is the only item that the Refinement had changed. However, sewage sludge is considered to contain only biogenic carbon so only biogenic CO_2 emissions are impacted by usage of 2019 Refinement and are very low. All used parameters with their origin are written in the Tab. 7-11.

The calculation method 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 lack of country-specific data for the necessary parameters, the default data for the calculations were taken from IPCC guidlines, only the combustion efficiency doesn’t reach the default value and is decreased to country specific (CS) value of 0.995. It is suggested that the default factor is 1.0, but this is contradictory to the evidence found in literature and in the bottom ash measurement, where the share of unburnt carbon can be measured, yielding a contradictory oxidation factor implying that all the carbon in the fuel is incinerated. The literature supporting this assumption is reviewed in annex A5.4. The impact on the inventory is negligible; however, a factor of less than 100% is easier to manage in assessing the uncertainty.

Tab. 7-11 Parameters of incineration used for each type of waste and their origin

	MSW		Clinical		Sewage sludge		Industrial (+ residues)	
Total carbon content	**0.4**	Tab. 2.4 + MSW composition	**0.6**	Tab. 5.2	**0.3**	Tab. 5.2*	**0.5**	Tab. 5.2

	MSW		Clinical		Sewage sludge		Industrial (+ residues)	
Fossil carbon fraction	**0.3**	Tab. 2.4 + MSW composition	**0.4**	Tab. 5.2	**0**	Tab. 5.2	**0.9**	Tab. 5.2
Combustion efficiency	**0.995**	CS	**0.995**	CS	**0.995**	CS	**0.995**	CS
C-CO_2 ratio	**3.7**	Eq. 5.1	**3.7**	Eq. 5.1	**3.7**	Eq. 5.1	**3.7**	Eq. 5.1
Dry matter content	**0.7**	Tab. 2.4 + MSW composition	**0.65**	Tab. 2.6 (from water content)	**0.1**	Chap. 2.3.2	**0.9**	Tab. 2.5 (from water content - “Other”)
CH_4 emission factor [kt CH_4/kt wet waste]	**2.0E-07**	Tab. 5.3	**2.0E-07**	Tab. 5.3	**9.7E-06**	Chap. 5.4.2	**2.0E-07**	Tab. 5.3
N_2O emission factor [kt N_2O/kt wet waste]	**5.0E-05**	Tab. 5.6	**1.0E-04**	Tab. 5.6 (as industrial)	**9.0E-04**	Tab. 5.6	**1.0E-04**	Tab. 5.6

*Tab. = Table (and its number) in 2006 IPCC Guidelines (IPCC, 2006), Eq. = Equation (and its number) from 2006 IPCC Guidelines (IPCC, 2006), Chap. = Chapter (and its number) from 2006 IPCC Guidelines where the value is written in text (IPCC,2006), * = values from 2019 Refinement (IPCC, 2019), MSW composition used for the Czech Republic*

The activity data (amount of waste incinerated in each category) are based on the ISOH database. The system uses categorization of waste management activities and this source category is listed under code D10 – incineration on land. The problem is that the database does not contain data before 2002 and incineration data in 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. These derived data are for the total amount of waste incinerated. The separation of total waste into the four categories prior to 2005 was done by extrapolation of share of categories in the timeline 2005-2022. The waste data are presented in Tab. 7-12. All waste data that are used for the calculation are in wet weight. Correction factors for dry matter content are used for CO_2 emissions. Methane and nitrous oxide emission factors are for wet waste, hence no correction is applied. Emissions for every GHG are divided into biogenic and non-biogenic part. To save room in Tab. 7-133, where GHG emissions from waste incineration for each type of waste 1990–2022 are presented, the results are divided into biogenic and non-biogenic waste fractions only for the important gas – CO_2. Furthermore, only the non-biogenic (fossil) part is counted to the total. 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.

Tab. 7-12 Waste incinerated [kt] by types 1990–2022 (2005-2022 data from ISOH, prior to 2005 extrapolation)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
MSW	0.01	0.03	0.05	0.11	0.21	0.31	0.38	0.47	0.54	0.63	0.58
Clinical waste	0.28	0.54	0.86	1.50	2.59	3.42	3.95	4.68	5.24	5.91	5.33
Sewage sludge	0.40	0.47	0.53	0.71	0.97	1.06	1.03	1.04	1.01	1.00	0.79
Industrial (+ residual)	13.40	15.85	18.37	24.73	34.58	38.28	37.94	39.18	38.79	39.04	31.70
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
MSW	0.88	1.21	1.76	2.32	1.74	2.13	2.55	2.01	2.06	2.33	2.25
Clinical waste	7.91	11.76	13.82	13.53	14.91	17.39	18.39	20.04	21.72	20.46	22.85
Sewage sludge	1.04	1.52	2.26	1.41	0.82	0.81	1.10	1.41	1.23	1.22	1.20
Industrial (+ residual)	42.64	61.07	99.15	92.66	64.87	83.41	50.70	52.96	43.69	60.43	50.36
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
MSW	2.11	2.84	3.95	3.71	3.15	3.50	3.93	3.68	4.43	3.47	3.47
Clinical waste	24.27	24.56	25.46	27.03	28.12	28.97	29.55	27.53	28.76	33.99	33.99
Sewage sludge	1.12	1.00	0.69	0.46	0.58	0.42	0.39	0.50	0.44	0.43	0.43
Industrial (+ residual)	48.78	50.84	50.14	49.46	48.93	57.39	59.69	58.55	55.13	48.18	48.18

Tab. 7-13 GHG emissions from waste incineration for each type of waste 1990–2022

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
MSW CO_2 emissions – Fossil [kt]	0.00	0.01	0.01	0.03	0.06	0.09	0.12	0.14	0.17	0.19	0.18
MSW CO_2 emissions - Biogenic [kt]	0.01	0.02	0.03	0.08	0.15	0.22	0.27	0.33	0.39	0.45	0.41
MSW CH_4 emissions [kt]	3E-09	5E-09	9E-09	2E-08	4E-08	6E-08	8E-08	9E-08	1E-07	1E-07	1E-07
MSW N_2O emissions [kt]	7E-07	1E-06	2E-06	5E-06	1E-05	2E-05	2E-05	2E-05	3E-05	3E-05	3E-05
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
MSW CO_2 emissions – Fossil [kt]	0.27	0.37	0.54	0.71	0.53	0.65	0.78	0.62	0.63	0.72	0.69
MSW CO_2 emissions - Biogenic [kt]	0.63	0.86	1.26	1.66	1.25	1.52	1.82	1.44	1.47	1.67	1.61
MSW CH_4 emissions [kt]	2E-07	2E-07	4E-07	5E-07	3E-07	4E-07	5E-07	4E-07	4E-07	5E-07	4E-07
MSW N_2O emissions [kt]	4E-05	6E-05	9E-05	1E-04	9E-05	1E-04	1E-04	1E-04	1E-04	1E-04	1E-04
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
MSW CO_2 emissions – Fossil [kt]	0.65	0.87	1.21	1.14	0.96	1.07	1.20	1.13	1.36	1.06	1.06
MSW CO_2 emissions - Biogenic [kt]	1.51	2.03	2.82	2.65	2.25	2.50	2.81	2.63	3.17	2.48	2.48
MSW CH_4 emissions [kt]	4E-07	6E-07	8E-07	7E-07	6E-07	7E-07	8E-07	7E-07	9E-07	7E-07	7E-07
MSW N_2O emissions [kt]	1E-04	1E-04	2E-04	2E-04	2E-04	2E-04	2E-04	2E-04	2E-04	2E-04	2E-04
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Clinical waste CO_2 emissions – Fossil [kt]	0.16	0.30	0.49	0.85	1.47	1.94	2.25	2.66	2.98	3.36	3.03
Clinical waste CO_2 emissions -Biogenic [kt]	0.24	0.46	0.74	1.28	2.21	2.92	3.37	3.99	4.48	5.05	4.55
Clinical waste CH_4 emissions [kt]	6E-08	1E-07	2E-07	3E-07	5E-07	7E-07	8E-07	9E-07	1E-06	1E-06	1E-06
Clinical waste N_2O emissions [kt]	3E-05	5E-05	9E-05	2E-04	3E-04	3E-04	4E-04	5E-04	5E-04	6E-04	5E-04
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Clinical waste CO_2 emissions – Fossil [kt]	4.50	6.69	7.86	7.70	8.49	9.90	10.77	11.40	12.36	11.65	13.00
Clinical waste CO_2 emissions -Biogenic [kt]	6.75	10.04	11.80	11.55	12.73	14.85	16.16	17.11	18.55	17.47	19.50
Clinical waste CH_4 emissions [kt]	2E-06	2E-06	3E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	5E-06
Clinical waste N_2O emissions [kt]	8E-04	1E-03	1E-03	1E-03	1E-03	2E-03	2E-03	2E-03	2E-03	2E-03	2E-03
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Clinical waste CO_2 emissions – Fossil [kt]	13.81	13.98	14.49	15.38	16.00	16.49	16.82	15.67	16.37	19.35	19.35
Clinical waste CO_2 emissions -Biogenic [kt]	20.72	20.96	21.74	23.07	24.00	24.73	25.23	23.50	24.55	29.02	29.02

Clinical waste CH_4 emissions [kt]	5E-06	5E-06	5E-06	5E-06	6E-06	6E-06	6E-06	6E-06	6E-06	7E-06	7E-06
Clinical waste N_2O emissions [kt]	2E-03	2E-03	3E-03	3E-03	3E-03	3E-03	3E-03	3E-03	3E-03	3E-03	3E-03

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Sewage sludge CO_2 emissions – Fossil [kt]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sewage sludge CO_2 emissions -Biogenic [kt]	0.04	0.05	0.06	0.08	0.11	0.12	0.11	0.11	0.11	0.11	0.09
Sewage sludge CH_4 emissions [kt]	4E-06	5E-06	5E-06	7E-06	9E-06	1E-05	1E-05	1E-05	1E-05	1E-05	8E-06
Sewage sludge N_2O emissions [kt]	4E-04	4E-04	5E-04	6E-04	9E-04	1E-03	9E-04	9E-04	9E-04	9E-04	7E-04

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Sewage sludge CO_2 emissions – Fossil [kt]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sewage sludge CO_2 emissions -Biogenic [kt]	0.11	0.17	0.25	0.15	0.09	0.09	0.12	0.15	0.14	0.13	0.13
Sewage sludge CH_4 emissions [kt]	1E-05	2E-05	1E-05	8E-06	8E-06	1E-05	1E-05	1E-05	1E-05	1E-05	1E-05
Sewage sludge N_2O emissions [kt]	1E-03	2E-03	1E-03	7E-04	7E-04	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Sewage sludge CO_2 emissions – Fossil [kt]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sewage sludge CO_2 emissions -Biogenic [kt]	0.12	0.11	0.08	0.05	0.06	0.05	0.04	0.06	0.05	0.05	0.05
Sewage sludge CH_4 emissions [kt]	1E-05	1E-05	7E-06	5E-06	6E-06	4E-06	4E-06	5E-06	4E-06	4E-06	4E-06
Sewage sludge N_2O emissions [kt]	1E-03	9E-04	6E-04	4E-04	5E-04	4E-04	4E-04	5E-04	4E-04	4E-04	4E-04

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Industrial waste CO_2 emissions – Fossil [kt]	19.80	23.42	27.14	36.55	51.10	56.57	56.05	57.89	57.32	57.68	46.83
Industrial waste CO_2 emissions -Biogenic [kt]	2.20	2.60	3.02	4.06	5.68	6.29	6.23	6.43	6.37	6.41	5.20
Industrial waste CH_4 emissions [kt]	3E-06	3E-06	4E-06	5E-06	7E-06	8E-06	8E-06	8E-06	8E-06	8E-06	6E-06
Industrial waste N_2O emissions [kt]	1E-03	2E-03	2E-03	2E-03	3E-03	4E-03	4E-03	4E-03	4E-03	4E-03	3E-03

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Industrial waste CO_2 emissions – Fossil [kt]	63.00	90.23	145.0	136.91	95.85	123.24	74.91	78.26	64.56	89.29	74.42
Industrial waste CO_2 emissions -Biogenic [kt]	7.00	10.03	16.28	15.21	10.65	13.69	8.32	8.70	7.17	9.92	8.27
Industrial waste CH_4 emissions [kt]	9E-06	1E-05	2E-05	2E-05	1E-05	2E-05	1E-05	1E-05	9E-06	1E-05	1E-05

Industrial waste N_2O emissions [kt]	4E-03	6E-03	1E-02	9E-03	6E-03	8E-03	5E-03	5E-03	4E-03	6E-03	5E-03
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Industrial waste CO_2 emissions – Fossil [kt]	72.07	75.12	74.09	73.09	72.30	84.80	88.19	86.52	81.45	71.19	71.19
Industrial waste CO_2 emissions -Biogenic [kt]	8.01	8.35	8.23	8.12	8.03	9.42	9.80	9.61	9.05	7.91	7.91
Industrial waste CH_4 emissions [kt]	1E-05	1E-05	1E-05	1E-05	1E-05	1E-05	1E-05	1E-05	1E-05	1E-05	1E-05
Industrial waste N_2O emissions [kt]	5E-03	5E-03	5E-03	5E-03	5E-03	6E-03	6E-03	6E-03	6E-03	5E-03	5E-03

Tab. 7-13 shows the emissions for the whole category 5.C.1. As can be seen, almost all emissions are caused by the incineration of industrial and there is a significant amount of clinical waste, too. Categories MSW and sewage sludge are negligible (non-biogenic emissions from sewage sludge are 0 at all because the fossil carbon fraction is considered to be 0 (Tab. 7-11). In comparison to the Tab. 7-12, more emissions comes from 1 kt of industrial waste than from the second biggest source – clinical waste (eg. year 2021: industrial waste incinerated 48.18 kt, clinical 33.99 kt). It is mainly caused by the emission factors, especialy the fossil carbon fraction which is for industrial 0.9 but for the clinical only 0.4. Whilst the amount of the clinical waste incinerated is approximately half of the industrial waste incinerated, the emissions from clinical waste are much lower then one half of the industrial emissions. In conclusion, the total amount of incinerated waste didn't change much but the total emissions did. They decreased by units up to tens of kt CO_2 eq.

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 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 on waste incineration in the future.

Tab. 7-14 Uncertainty estimates for 5.C.1 category

Gas	Category	AD uncertainity [%]	EF uncertainity [%]	Origin of the parameters
CO_2	5.C.1 Waste incineration	15	50	AD Expert judgement M. Havránek; EF IPCC default + expert judgement
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 ISOH were 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 recalculations were made in the subcategory 5.C.1.

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

This category could be improved by deeper study of data and information about waste incineration prior to 2005. However, we do not know if there exist any better data or wider information than MIT has. Thus at this moment, this issue is not a priority for us. We also try to investigate more the situation of fossil liquid waste in the Czech Republic.

7.4.2 Open Burning of Waste (CRF 5.C.2)

Open burning of waste is an illegal activity in the Czech Republic. Inhabitants are not allowed to burn their wastes except some garden residues. There exists an evidence of accidental landfill and bin or container fires. A research on these phenomena was launched and a country specific methodology for calculating the GHG emissions was finilised in 2021. In 2022 we brought the results of emissions from open burning of waste since the year 2010. We consider these emissions negligible so the methodology was not used for all the years, nor for the reference year 2022. Further application of this method will only take place once every few years to check if the situation hasn't changed dramatically.

7.4.2.1 Source category description

This subcategory consists of accidental fires of wastes or fires that should be accidental because (as it is written in the paragraph before) it is illegal to burn waste. In the Czech Republic there occur thousands of fires connected with wastes per year. About 1000 of them are landfill fires where larger amount of waste is burned. These fires last longer than for example fires of bins because the affected area is usually larger, the terrain of a landfill is demanding for the firefighters and they are in a risk as the landfill is completely not a safe place. The duration of fire is prolonged by landfill gas which donates the fire with a fuel – methane. Fires of dumps or another places with cumulated wastes are included, too. However, not burning of waste in households.

7.4.2.2 Methodological issues

In this source category CO_2, CH_4 and N_2O emissions are estimated. CH_4 and N_2O emissions are more important than in 5.C.1 because open burning is definitely much more imperfect combustion than incineration in plants and emissions of wider range of gases arise. The category is divided into biological and non-biological part, too. The category also should be differentiated to more subcategories (like MSW, industrial etc.) but we report only one category, because the amount of waste open burned is really small and uncertain.

The data used for this category come from various sources. The first source is database ISOH and its waste part and also part where register of waste management facilities is placed and facilities described. Another source are data on fires from the firefighters where every single fire, where waste was burning, is described. And finally some physical-chemical tables on substances or materials properties which are used for the calculation.

In the firefighters' database there is information about the place, time and substances (in major) that were burning. These data are used for calculating the amount of waste that burned on the landfill. The amount (mass) is crucial for the emission estimate and is than inserted to IPCC equations (2006 IPCC Gl.) for emissions from incineration and open burning of waste. As the amount of waste open burned is small but has great uncertainty the values of burned waste on landfills are not subtracted from values of landfilled waste in 5.A.

We use default emission factors for the emission calculation. However, wastes that are burned are of various kinds and we want to include the variability to emission factors, too. In order to do so, we calculated and will calculate in future the emission factors for every year. Basic data are connected with 5.A category and its MSW composition because some parameters (as was said in 5.C.1) don't exist for MSW as one category but only for subcategories of MSW. We take the MSW composition and the default factors and make weighed means. The final emission factors are placed in Tab. 7-15.

Tab. 7-15 Emission factors for open burning of waste for each year

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Carbon fraction	0.42	0.42	0.43	0.42	0.42	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Fosil carbon fraction	0.29	0.29	0.32	0.32	0.33	0.32	0.32	0.29	0.26	0.26	0.26	0.26	0.26
Dry matter content	0.72	0.72	0.75	0.75	0.75	0.76	0.77	0.75	0.74	0.74	0.74	0.74	0.74
Oxidation factor (combustion efficiency)	0.58												
C-CO_2 ratio	3.7												
CH_4 emission factor [kt/kt waste]	6.5E-03												
N_2O emission factor [kt/kt waste]	1.5E-04												

The calculated emissions and the amount of waste open burned in last ten years are placed in Tab. 7-16. These emissions are not divided into biological and non-biological part for all three gases as it is in CRF, only for CO_2 like in 5.C.1. Emissions are calculated for years 2010, 2013, 2016 and 2018. For the rest of the years only interpolation is used as the methodology is very time-consuming, complicated and the emissions are not huge.

Tab. 7-16 Amount of waste open burned and generated emissions 2010-2022

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Waste open burned [kt]	39.36	35.01	34.41	20.01	33.23	32.63	51.49	31.45	21.45	30.26	29.67	29.10	29.10
Emissions of CO_2 - Fossil [kt]	7.39	6.58	7.42	4.38	7.38	7.33	11.70	6.32	3.78	5.33	5.22	5.12	5.12
Emissions of CO_2 - Biogenic [kt]	18.10	16.10	15.90	9.17	15.10	15.28	24.84	15.40	10.63	15.09	14.87	14.59	14.59
Total emissions of CH_4 [kt]	0.26	0.23	0.22	0.13	0.22	0.21	0.33	0.20	0.14	0.20	0.19	0.19	0.19
Total emissions of N_2O [kt]	0.005	0.005	0.005	0.003	0.005	0.005	0.008	0.005	0.003	0.005	0.004	0.004	0.004

We plan to continue with calculating the emissions every two or three years from the activity data and the rest of years interpolate. A huge disadvantage is that the number and intensity of the fires are various in years and depend for example on meteorological conditions or the origin (cause) of fire. Sometimes a huge fire can produce as much emissions as hundreds of another smaller fires in the same year.

7.4.2.3 Uncertainties and time-series consistency

As it was written, the uncertainty is huge and occurs in many parts of the calculation. The data from firefighters are more uncertain than the ISOH data and we consider really small uncertainty in data from physical-chemical tables. However, we see the whole uncertainty as significant and we make an effort to decrease it. Time-series consistency is dependent on the data providers. We suppose that the ISOH database is a stable source for the future but we cannot be sure about it in case of data from firefighters because they are not obligatory to share the data with us.

Tab. 7-17 Uncertainty estimates for 5.C.2 category

Gas	Category	AD uncertainity [%]	EF uncetrainity [%]	Origin of the parameters
CO_2	5.C.2 Open burning of waste	70	30	AD Expert judgement J. Esterlová; EF IPCC default + expert judgement
N_2O	5.C.2 Open burning of waste	70	40	AD Expert judgement J. Esterlová; EF IPCC default
CH_4	5.C.2 Open burning of waste	70	40	AD Expert judgement J. Esterlová; EF IPCC default

7.4.2.4 Source-specific QA/QC and verification

For this particular subcategory, bottom-up data provided by the official sources were used. However, the inaccuracy or uncertainty of this data is not quantified but is estimated by expert judgment. The compiler didn't cross-check the data on open burning of waste with data from other sources because it was not possible to do it. The national methodology on estimating the emissions from open burning of waste was certified and reviewed by the NIS QA/QC coordinator.

7.4.2.5 Source-specific recalculations, including changes made in response to the review process

This subcategory was estimated for the first time two years ago. No recalculations were made.

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

We plan to check the methodology again as it is completely new and try to define the weaknesses of it and improve them. If it is needed we can calculate the years that are now interpolated, too, but we prefer not to do it as the category is not too important but the time spent on calculating should be important for other activities.

7.5 Wastewater Treatment and Discharge (CRF 5.D)

This source category consists of two subcategories: 5.D.1. emissions from domestic wastewater treatment and 5.D.2 emissions from industrial wastewater treatment. Overall development of emissions from this source category is shown in Fig. 7-8. Emissions of CH_4 and N_2O are presented. The main drivers of the emissions are population size, industrial production growth and the share of the particular treatment options.

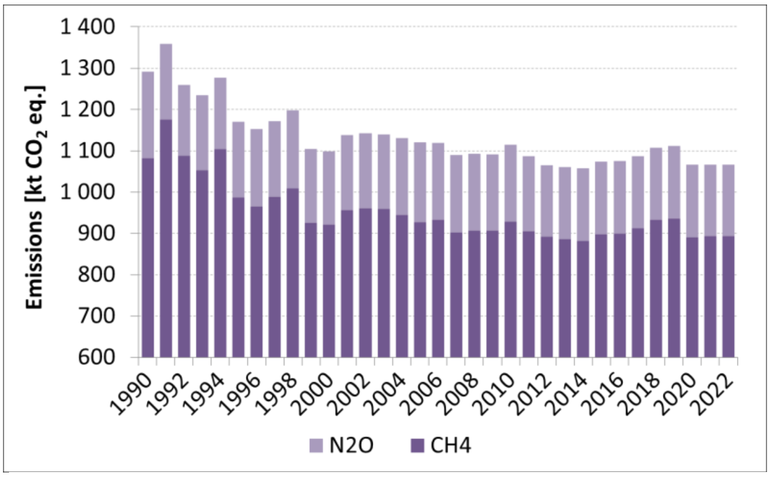

Fig. 7-8 Development of GHG emissions from wastewater treatment and discharge, 1990-2022

7.5.1 Domestic Wastewater Treatment (CRF 5.D.1)

7.5.1.1 Source category description

Treatment of domestic wastewater in the Czech Republic is mostly centralised and more than 87 % of the population is connected to the 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 (WWTP) treat 97.5% of all the collected water. Anaerobic technology is being increasingly used to produce biogass from sludge.

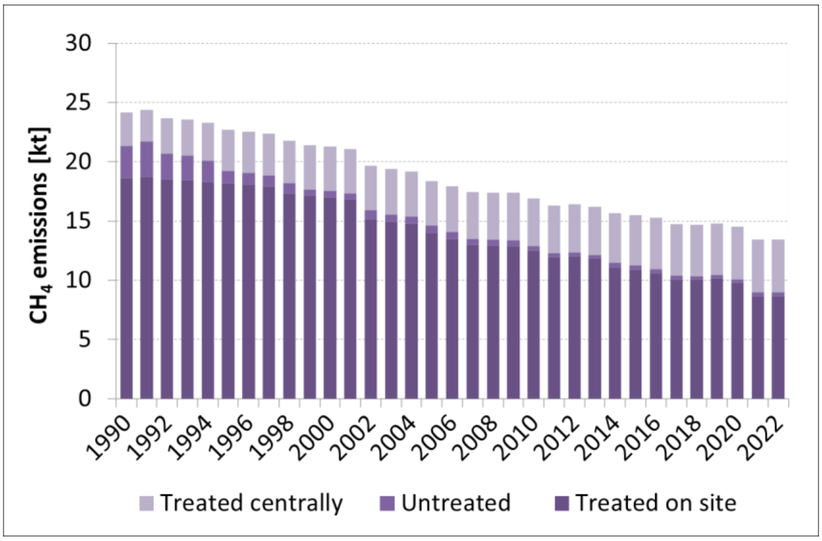

Fig. 7-9 Development of 5.D.1 emission of CH_4 by types of treatment, 1990-2022

This category was recalculated in past years to fully reflect the complexity and pathways that are used to treat wastewater in this country, effectively replacing Tier 1. Development of 5.D.1 emission of CH_4 by types of treatment represents Fig. 7-9.

7.5.1.2 Methodological issues

The content of organic pollution in the water is the basic factor for determining methane emissions from wastewater management. The content of organic pollution in municipal wastewater and sludge is given as BOD_5 (the Biochemical Oxygen Demand).

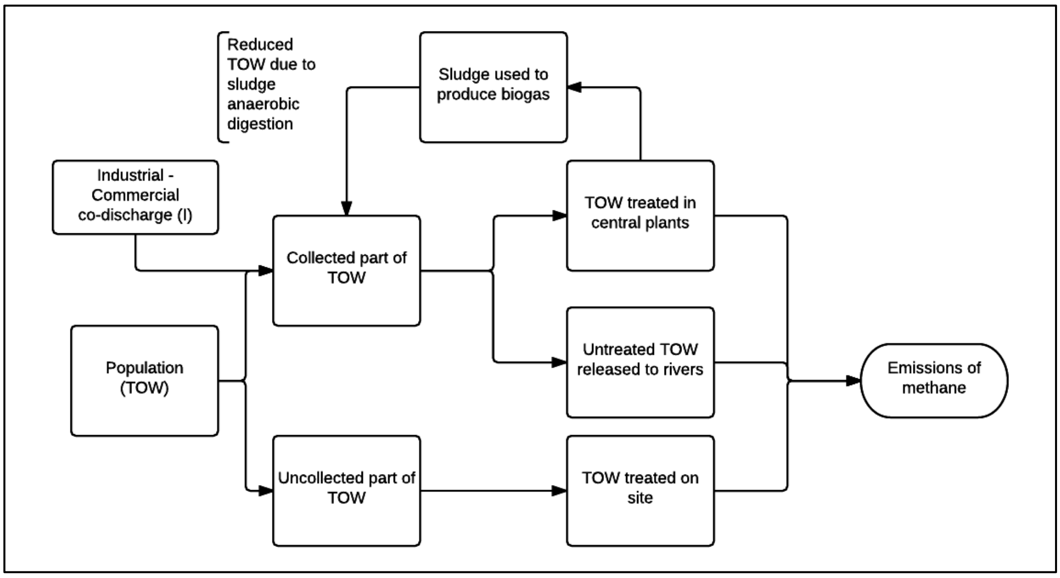

Fig. 7-10 The scheme of total organic waste flow in 5.D.1

The current IPCC methodology employs BOD for evaluation of municipal wastewater and sludge and Chemical Oxygen Demand (COD) for industrial wastewater. The new method is based on default Tier 1 where sludge treatment is not considered; however available data on biogas production from sludge treatment are used to reduce TOW (Total Organic Waste). A scheme of TOW flow is given in the folowing figure (Fig. 7-10).

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. 7-18 to Tab. 7-20.

- The number of inhabitants (source: Czech Statistical Office, CzSO).
- 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 WWTP (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.
- Biogas produced by WWTP is converted to the TOW required to produce this biogas and is subtracted from collected TOW.
- Collected TOW is divided into two streams treated TOW and untreated TOW.

- Treated TOW is treated by well managed central treatment plants (default factors) resulting in methane emissions.
- Untreated TOW is discharged into watersheds resulting in methane emissions.
- Methane emissions from all three sources are summed up resulting in emissions from this source category.

Tab. 7-18 Activity data used for 5.D.1 category, 1990–2022

	Total population [thous. pers.]	Sewer connection [%]	Water treated [%]		Total population [thous. pers.]	Sewer connection [%]	Water treated [%]
1990	10 362	72.60	72.60	**2007**	10 323	80.80	95.80
1991	10 308	72.30	69.60	**2008**	10 429	81.11	95.32
1992	10 317	72.70	77.80	**2009**	10 492	81.30	95.25
1993	10 331	72.80	78.90	**2010**	10 517	81.90	96.20
1994	10 336	73.00	82.20	**2011**	10 497	82.62	96.83
1995	10 331	73.20	89.50	**2012**	10 509	82.54	97.08
1996	10 315	73.30	90.30	**2013**	10 511	82.82	97.39
1997	10 304	73.50	90.90	**2014**	10 525	83.90	96.90
1998	10 295	74.40	91.30	**2015**	10 543	84.20	97.00
1999	10 283	74.60	95.00	**2016**	10 565	84.70	97.30
2000	10 273	74.80	94.80	**2017**	10 590	85.50	97.50
2001	10 224	74.90	95.50	**2018**	10 626	85.50	97.60
2002	10 201	77.40	92.60	**2019**	10 669	85.50	97.70
2003	10 202	77.70	94.49	**2020**	10 700	86.10	97.50
2004	10 207	77.90	94.44	**2021**	10 500	87.40	97.50
2005	10 234	79.10	94.60	**2022**	10 500	87.40	97.50
2006	10 267	80.00	94.16				

Tab. 7-19 Parameters used for 5.D.1 category, 1990–2022

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. 7-20 Methane emissions from 5.D.1 category, 1990–2022

	Uncollected TOW emissions CH_4 [kt]	Untreated TOW emissions CH_4 [kt]	Treated TOW emissions CH_4 [kt]	Biogas reduction (fraction of treated TOW)	Total CH_4emissions [kt]
MCF	**0.5**	**0.1**	**0.039**		
1990	18.65	2.71	2.80	0.20	24.16
1991	18.76	2.98	2.66	0.20	24.40
1992	18.51	2.19	2.99	0.20	23.68
1993	18.46	2.09	3.04	0.20	23.59
1994	18.34	1.76	3.18	0.20	23.28
1995	18.19	1.04	3.47	0.20	22.70
1996	18.10	0.96	3.50	0.20	22.56
1997	17.94	0.91	3.53	0.20	22.37
1998	17.32	0.88	3.58	0.20	21.77
1999	17.16	0.50	3.73	0.20	21.40
2000	17.01	0.53	3.73	0.20	21.27
2001	16.86	0.45	3.75	0.20	21.06
2002	15.15	0.77	3.75	0.20	19.66
2003	14.95	0.58	3.87	0.19	19.40
2004	14.82	0.57	3.78	0.21	19.17

	Uncollected TOW emissions CH_4 [kt]	Untreated TOW emissions CH_4 [kt]	Treated TOW emissions CH_4 [kt]	Biogas reduction (fraction of treated TOW)	Total CH_4emissions [kt]
MCF	**0.5**	**0.1**	**0.039**		
2005	14.05	0.55	3.76	0.23	18.37
2006	13.49	0.61	3.81	0.23	17.91
2007	13.02	0.45	3.97	0.22	17.44
2008	12.95	0.50	3.93	0.24	17.38
2009	12.89	0.51	3.99	0.23	17.39
2010	12.51	0.40	3.99	0.25	16.91
2011	11.99	0.33	3.98	0.26	16.30
2012	12.06	0.31	4.06	0.25	16.42
2013	11.86	0.28	4.07	0.25	16.22
2014	11.13	0.34	4.19	0.24	15.66
2015	10.91	0.34	4.26	0.23	15.52
2016	10.65	0.30	4.30	0.23	15.26
2017	10.10	0.28	4.38	0.23	14.76
2018	10.10	0.27	4.32	0.24	14.69
2019	10.18	0.27	4.35	0.24	14.80
2020	9.79	0.29	4.44	0.23	14.52
2021	8.69	0.29	4.46	0.22	13.45
2022	8.69	0.29	4.46	0.22	13.45

The MCF in the category "uncollected TOW" is 0.5, because this value is the default MCF in 2006 IPCC GLs, vol. 5, ch. 6, table 6.3 for septic systems, which are the most common option for uncollected waste water treated on site. For the category “untreated TOW” the used MCF value is 0,1, which is the default value in 2006 IPCC GLs, vol. 5, ch. 6, table 6.3 for sea, river and lake discharge, as the untreated waste water ends mostly in rivers. The MFC value for “treated TOW” is derived from 2016 values for the WWTP, where 87% were not overloading and 13% were overloading, and 13% result in an average MCF for WWTP of 0.039. The information source for this determination is an overview of CZ WWTP, which gives details of every individual WWTP and indicate whether they comply with existing legislation (European Commission, 2016).

Determination of the N_2O emissions from municipal wastewater is a 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 subcategory are shown in Tab. 7-21.

Tab. 7-21 Indirect N_2O emissions [kt] from 5.D.1 and 5.D.2, 1990–2022

	Proteins [g/capita/day*]	Population [number, thous. pers.]	Fnpr [kg N/kg protein]	Fnon-con**	Find-com**	N efluent [kg N/yr]	EF [kg N_2O/kg N]	Emissions N_2O [kt]
1990	105.77	10 362	0.16	1.25	1.25	100 016 115	0.005	0.79
1991	92.98	10 308				87 463 239		0.69
1992	87.37	10 317				82 258 845		0.65
1993	92.75	10 331				87 432 447		0.69
1994	88.36	10 336				83 338 924		0.65
1995	93.14	10 331				87 801 379		0.69
1996	95.59	10 315				89 976 569		0.71
1997	93.31	10 304				87 730 746		0.69
1998	96.91	10 295				91 038 567		0.72

	Proteins [g/capita/day*]	Population [number, thous. pers.]	Fnpr [kg N/kg protein]	Fnon-con**	Find-com**	N efluent [kg N/yr]	EF [kg N_2O/kg N]	Emissions N_2O [kt]
1999	91.40	10 283				85 760 989		0.67
2000	90.29	10 273				84 634 767		0.66
2001	92.84	10 224				86 615 776		0.68
2002	92.97	10 201				86 538 394		0.68
2003	92.99	10 202				86 564 452		0.68
2004	96.08	10 207				89 487 156		0.70
2005	99.33	10 234				92 760 403		0.73
2006	95.26	10 267				89 242 564		0.70
2007	95.06	10 323				89 541 327		0.70
2008	93.79	10 429				89 260 824		0.70
2009	92.58	10 492				88 631 338		0.70
2010	92.80	10 517				89 060 048		0.70
2011	90.82	10 497				86 989 332		0.68
2012	86.86	10 509				83 296 338		0.65
2013	87.47	10 511				83 892 749		0.66
2014	87.30	10 525				83 841 737		0.66
2015	87.70	10 543				84 371 211		0.66
2016	87.00	10 565				84 875 148		0.66
2017	86.70	10 590				83 777 711		0.66
2018	86.70	10 626				84 069 673		0.66
2019	86.70	10 669				84 409 023		0.66
2020	86.70	10 700				84 652 939		0.67
2021	86.70	10 500				83 067 950		0.65
2022	86.70	10 500				83 067 950		0.65

** The latest available data is used for 2017; data for Czechoslovakia are used for 1990-1992.*
*** Fnpr - Fraction of Nitrogen in Protein*
Fnon-con - Factor for Non-consumed Protein Added to the Wastewater
Find-com - Factor for Industrial and Commercial Co-discharged Protein into the Sewer System

The values of the factors in the table are the default factors. Factor Fnon-con is the average between 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 activity data about the population were obtained from the Czech Statistical Office and the amount of proteins consumed in the Czech Republic was derived from the nutrition statistics of FAO (Faostat, 2021).

7.5.1.3 Uncertainties and time-series consistency

The uncertainty in this category is high because the data on organic pollution are based on the population alone and the science behind the formation of N_2O is also not robust and varies significantly.

Tab. 7-22 Uncertainty estimates for 5.D.1 category

Gas	Category	AD uncertainity [%]	EF uncertainity [%]	Origin of the parameters
CH_4	5.D.1 Domestic wastewater	21	50	Combined uncertainty of quantification parameters Expert judgement M. Havránek
N_2O	5.D.1 Domestic wastewater	26	50	AD Expert judgement M. Havránek; EF IPCC default

7.5.1.4 Source-specific QA/QC and verification

Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. Activity data used for this sector are approved by the data producer, who verifies them before they are used for calculation.

Because the waste sector is fairly small, an external subject is not used to provide QC; instead, QC is performed by a NIS coordinator and the results are communicated to the sectoral expert.

Activity data from national agencies and ministries are the subjects of internal QA/QC mechanisms and the NIS team has only limited insights into them. Processes are in place on all state agencies and ministries to ensure that state agencies produce the correct data.

7.5.1.5 Source-specific recalculations, including changes made in response to the review process

No recalculations were made in this subsector.

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

It is planned to quantify the uncertainity range in a similar way as in category 5.D.2 using the upper and lower margins of the esimates to estimate the uncertainty in more quantitative terms. This aspect is of moderate importance. We also plan to review so far used factors.

7.5.2 Industrial Wastewater (CRF 5.D.2)

7.5.2.1 Source category description

This source category deals with emissions from the treatment of industrial wastewaters. Most of the industries in the country have their own wastewater treatment systems; however, a significant fraction of industries are part of municipal sewage systems. This does not create a problem, as both categories 5.D.1 and 5.D.2 are based on production statistics not on collection systems. Industrial waste water (IWW) treatment at bigger companies in the country is mostly managed on spot, utilizing aerobic techniques to treat the water. Anaerobic treatment of sludge is being increasingly used. There is no double counting with the category 5.B, as the data allow division between waste AD and water treatment digestion (and are sufficiently precise to allow division between domestic wastewater and IWW). Separated sludge that is not used for biogas production is treated by a mixture of aerobic treatment options.

Development of the category is shown in Fig. 7-11.

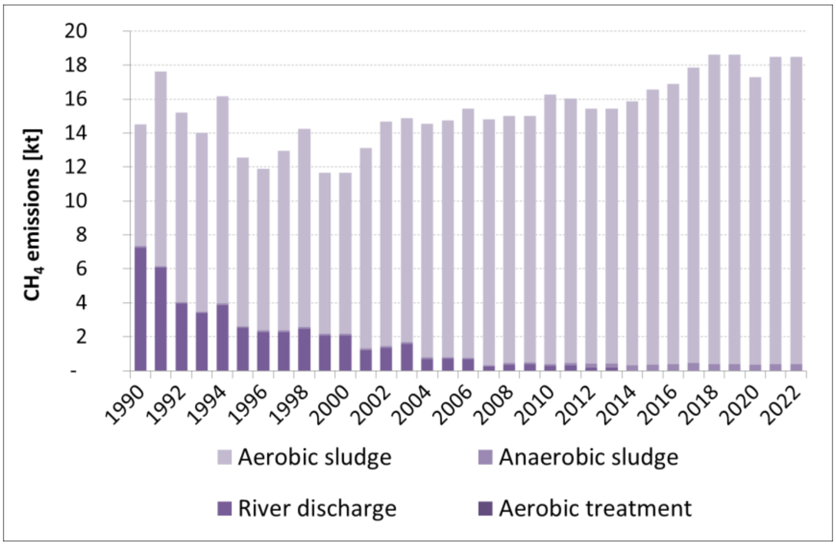

Fig. 7-11 Development of emissions from 5.D.2 by types of emission sources

7.5.2.2 Methodological issues

This entire category was recalculated in recent years. The recalculation method was based on Tier 1 of the methodology; however, we used country-specific data to ensure that it was based more on the available statistics. The main activity data for estimation of the methane emissions from this subcategory is determination of the amount of degradable pollution in industrial wastewaters. This part is identical with the previous calculation and was not changed. Specific production of pollution – the amount of pollution per production unit – kg COD/kg product is used in this source category. This value is then multiplied by the production or the value obtained from the overall amounts of industrial wastewater and from a qualified estimate of their concentrations (in kg COD/m^3). The approach used is based on the IPCC 2006 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. 7-23. The fraction of industrial water treated by a particular technology is based on CzSO data on industrial wastewater treatment. Wastewater is divided into two big groups – untreated, which is water that is released into the watershed without treatment (now almost non-existent) and treated water. Treated water is managed in well-maintained aerobic facilities. Sludge separated from IWW is treated aerobically or anaerobically for methane production. Since sludge data is generally unavailable in the country we reverse use of R – recovered methane. Based on R we estimate necessary amount of sludge COD which is subtracted from the total. The effect on the total emissions is identical, but we keep treatment streams separated. Data on R have been obtained on an annual basis from MIT renewable statistics since 2003; data on R prior to 2003 are based on expert estimates. The detailed flow of quantification is shown in Fig. 7-12.

Tab. 7-23 Industrial production data and used water generation and COD content factors, 1990–2022

	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

	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
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	2.34	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	2.18	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	2.26	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	2.12	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	2.17	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	2.20	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	2.21	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	2.24	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	2.24	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	2.20	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	2.20	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	2.34	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	2.46	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	2.46	0.65	0.20	3.54	0.82	0.67	0.06	0.07	0.52	0.10	0.13	0.09
2004	0.04	0.98	2.54	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	2.54	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	2.31	0.67	0.16	-	-	0.75	0.03	0.07	0.49	0.10	0.09	0.08
2007	0.06	1.12	2.36	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	3.28	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	3.28	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	3.28	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	3.28	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	3.28	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	3.28	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	2.76	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	2.88	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	2.97	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	3.16	0.37	0.18	-	1.43	1.01	0.02	0.09	0.64	0.14	0.14	0.07
2018	0.02	1.40	3.26	0.38	0.18	-	1.47	1.04	0.02	0.10	0.66	0.15	0.14	0.07
2019	0.02	1.40	3.25	0.38	0.18	-	1.47	1.04	0.02	0.10	0.66	0.15	0.14	0.07
2020	0.02	1.30	3.02	0.36	0.17	-	1.36	0.96	0.02	0.09	0.61	0.13	0.13	0.07
2021	0.02	1.40	3.22	0.38	0.18	-	1.46	1.03	0.02	0.10	0.65	0.14	0.14	0.07
2022	0.02	1.40	3.22	0.38	0.18	-	1.46	1.03	0.02	0.10	0.65	0.14	0.14	0.07

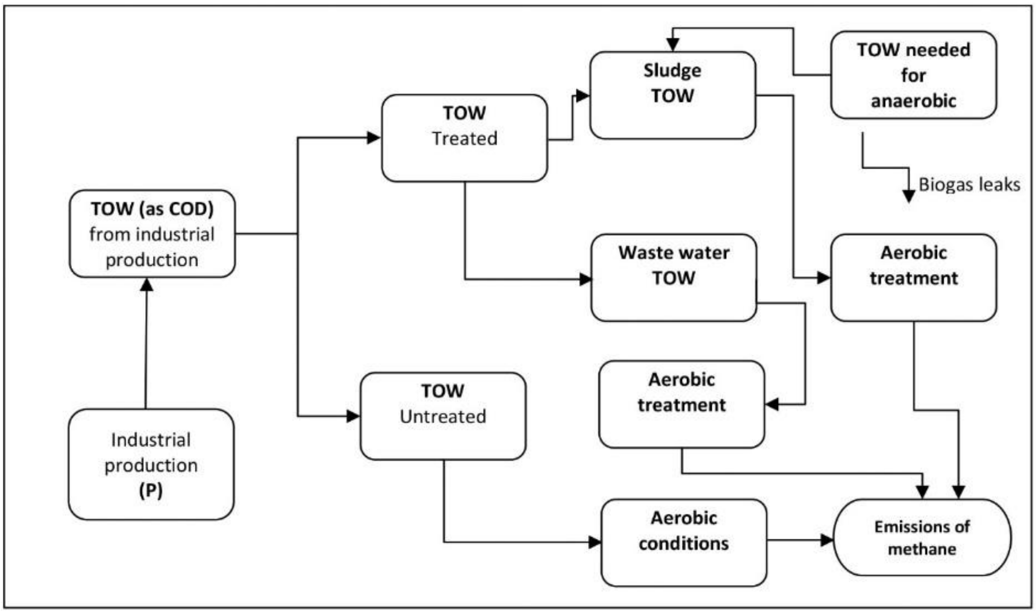

Fig. 7-12 The outline of the total organic waste flow in 5.D.2

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. 7-24.

Tab. 7-24 Used MCF for Industrial waste water treatment

	Sea, river and lake discharge	Aerobic treatment plant (well managed)	Aerobic treatment plant (ill managed)	Anaerobic digester for sludge	Anaerobic reactor	Anaerobic shallow lagoon	Anaerobic deep lagoon
Lower bound	0	0	0.2	0.8	0.8	0	0.8
Default MCF	0.1	0	0.3	0.8	0.8	0.2	0.8
Upper bound	0.2	0.1	0.4	1	1	0.3	1

For the quantification we assume that wastewater, that is treated in WWTP (i.e. not released into the watershed), is separated to a wastewater and sludge. Wastewater is treated aerobically. Because the default MCF values were used, this treatment option does not produce any emissions. The sludge is divided into two parts. One is treated anaerobically producing methane (that is recovered) and emissions. The second part of the sludge is treated aerobically resulting also in emissions.

Tab. 7-25 Emissions of CH_4 [kt] from 5.D.2, 1990–2022

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CH_4 emission	14.5	17.6	15.2	14.0	16.2	12.6	11.9	13.0	14.3	11.7	11.7	13.1	14.7
Recovered CH_4	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
CH_4 emission	14.9	14.6	14.7	15.4	14.8	15.0	15.0	16.3	16.0	15.4	15.4	15.9	16.6
Recovered CH_4	1.8	1.7	1.5	1.2	1.5	1.7	2.0	2.1	2.4	4.7	4.6	6.6	7.0
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**						
CH_4 emission	16.9	17.9	18.6	18.6	17.3	18.5	18.5						
Recovered CH_4	8.0	9.2	8.3	8.0	7.5	8.0	8.0						

7.5.2.3 Uncertainties and time-series consistency

The uncertainty in most of the factors (default IPCC values) is determined according to the IPCC 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. 7-26. During recalculation, all the variables were inserted in the equation as a parameters with lower and upper ranges and central (default where appliable) values. Based on this parametrisation, we were able to estimate the upper and lower boundaries of the emission estimate for this source category, as is shown in Fig. 7-13 (please note log scale in graph as there is three orders difference). The range now corresponds to the full scale of the uncertainity assesment, and indicates the minimum and maximum obtainable values by the distribution of the parameters used in the emission estimates; we foresee that running parametrized Monte Carlo simulation will lower the uncertainity range.

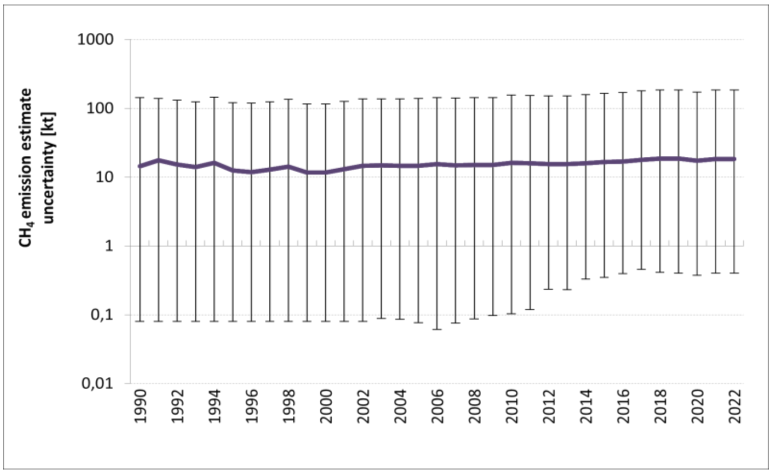

Fig. 7-13 Maximum uncertainty range for 5.D.2, 1990-2022 (log scale)

Tab. 7-26 Uncertainty estimates for 5.D.2 category

Gas	Category	AD uncertainty [%]	EF uncetrainty [%]	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

7.5.2.4 Source-specific QA/QC and verification

Quality assurance entails structured checklists of activities, which are dated and signed by the sector reporter and verified by external control of the activity data. Activity data taken for this sector are approved by the data producer, who verifies them before they are used for calculation.

Because the waste sector is fairly small, we do not use an external subject to provide QC; instead, QC is performed by a NIS coordinator and its results are communicated to the sectoral expert.

Activity data from national agencies and ministries are the subjects of internal QA/QC mechanisms but the NIS team has only limited insights into them.

7.5.2.5 Source-specific recalculations, including changes made in response to the review process

No recalculations were made in this subsector.

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

It is planned to verify the factor TOW derived from production statistics by comparison with real world data as the high uncertainty of this category and scarce data could mean that the top-down and bottom-up approaches will not match. Completing Monte-Carlo analysis of uncertainty in this category is another planned improvement. This activity has moderate priority.

7.6 Other (CRF 5.E)

This category is not relevant for the Czech Republic.

7.7 Long-term storage of carbon (CRF 5.F)

The long-term stored carbon in SWDS is reported as an information item in the Waste sector. Fossil and non-degradable biogenic carbon disposed in SWDS remains stored underground and does not contribute to anthropogenic climate change. The amount of carbon stored in SWDS is estimated by using the FOD model described in 5.A.1 using the same data described there. The results are shown in Tab. 7-27. Reporting format of this category in NIR was harmonised with CRF which requires reporting of kt of CO_2 rather than kt of C.

Tab. 7-27 Long-term stored carbon, 1990–2022, Czech Republic

	Long-term stored carbon [kt CO_2]	Accumulated long-term stored carbon (since 1950) [kt 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
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	1081.46	38634.43
2013	1045.85	39680.28
2014	1000.30	40680.58
2015	1019.08	41699.66
2016	1073.12	42772.78
2017	1111.37	43884.15
2018	1156.17	45040.32
2019	1181.10	46221.42

	Long-term stored carbon [kt CO_2]	Accumulated long-term stored carbon (since 1950) [kt CO_2]
2020	1207.55	47428.97
2021	1239.00	48667.97
2022	1239.00	48667.97

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, precursor gases are reported from all sectors, but indirect emissions are estimated from sectors Energy, IPPU and Waste. Emissions from Agriculture are considered biogenic. Tab. 9-1 presents a summary of emissions estimates for precursors, SO_x and NH_3 for the period from 1990 to 2022 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 have been met by 2010 by Parties to the UNECE / CLRTAP Convention signed this Protocol.

Emissions of precursor gases decreased in the period from 1990 to 2022 for NMVOC by 65.8%, for CO by 64.2% and for NO_x by 79.1%. SO_x (reported as SO_2) emissions decreased by 93.6% compared to 1990 level. NH_3 decreased by 69.3% in 2022 compared to the year 1990 (estimated data).

Tab. 9-1 Precursor emissions and their trends from 1990 – 2022

	NO_x	NO_x w/o LULUCF	CO	CO w/o LULUCF	NMVOC	SO_x	NH_3
1990	762.65	762.21	2936.17	2920.43	834.97	1753.81	10.00
1991	723.26	722.94	2858.47	2847.23	765.26	1649.74	9.34
1992	679.16	678.67	2847.24	2829.63	736.74	1381.96	8.76
1993	553.05	552.50	2609.87	2590.43	694.58	1302.42	8.37
1994	458.26	457.75	1640.10	1621.78	427.02	1158.97	10.56
1995	392.13	391.71	2306.71	2291.75	601.37	1058.82	5.34
1996	374.58	373.85	2453.24	2427.08	620.00	914.32	3.75
1997	346.72	345.72	2263.33	2227.60	580.11	694.36	3.96
1998	330.10	329.53	1801.25	1780.72	495.03	425.31	3.64
1999	305.41	304.99	1557.06	1542.05	451.83	231.87	3.49
2000	314.05	313.65	1526.77	1512.58	444.98	233.69	3.20
2001	311.36	311.16	1495.11	1488.28	437.66	228.68	3.05
2002	304.97	304.75	1419.47	1411.57	418.47	223.37	2.98
2003	309.49	309.02	1444.75	1428.21	414.98	218.36	3.01
2004	310.52	310.24	1411.24	1401.25	403.33	215.08	2.77
2005	308.20	307.95	1261.95	1253.02	379.13	208.47	3.25
2006	299.26	298.93	1269.07	1257.28	381.65	206.76	3.15
2007	298.28	297.91	1256.43	1243.14	370.07	212.07	3.21
2008	280.74	280.47	1183.24	1173.82	362.58	170.10	3.25
2009	264.18	263.94	1213.36	1204.52	365.89	168.77	3.19
2010	260.29	260.03	1273.92	1264.45	375.01	163.88	3.13
2011	247.61	247.50	1255.04	1251.10	365.97	167.51	3.22
2012	235.63	235.46	1230.09	1223.79	361.64	160.20	3.32
2013	222.69	222.64	1256.88	1254.82	364.25	145.25	3.33
2014	218.42	218.26	1188.17	1182.60	350.41	134.49	3.21
2015	211.71	211.59	1192.56	1188.23	356.20	129.86	3.18
2016	202.98	202.89	1177.53	1174.63	348.48	115.63	3.34

	NO_X	NO_X w/o LULUCF	CO	CO w/o LULUCF	NMVOC	SO_X	NH_3
2017	197.74	197.64	1166.22	1162.82	343.75	109.73	3.25
2018	189.71	189.50	1140.15	1133.00	334.88	96.58	3.37
2019	176.84	176.60	1076.80	1068.42	315.76	79.09	3.22
2020	162.25	162.01	1086.68	1078.20	304.44	67.15	3.15
2021	166.17	165.97	1124.25	1117.27	302.45	61.55	3.25
2022	159.28	158.81	1051.25	1034.59	285.69	64.65	3.07
Trend %	**-79.11**	**-79.16**	**-64.20**	**-64.57**	**-65.78**	**-93.61**	**-69.34**
NEC	**286**		**-**		**220**	**265**	**101**

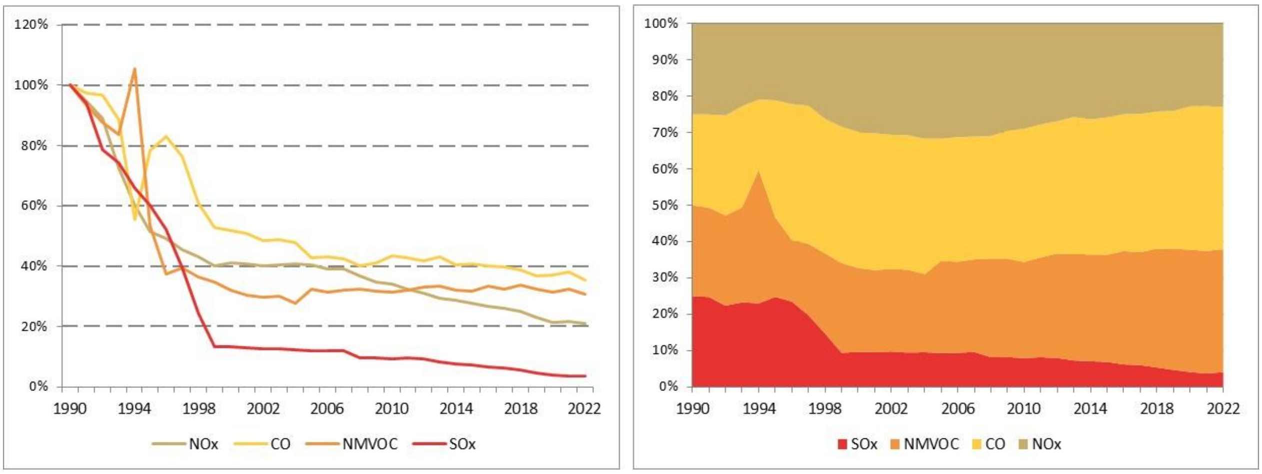

Fig. 9-1 Indexed emissions of precursor gases for 1990–2022 (1990 =100%), [%] (left); Overall trend in percentual share of precursor gases (right)

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 emissions in sectors of origin for 2022

	NO_X [kt]	CO [kt]	NMVOC [kt]	SO_X [kt]	NH_3 [kt]
Total emissions	159.28	1,051.25	285.69	64.65	3.07
1. Energy	136.03	947.20	186.24	61.75	1.69
1.A Fuel combustion	135.53	947.11	180.70	58.47	1.68
1.A.1 Energy Industries	32.44	12.18	4.92	26.22	0.06
1.A.2 Manufacturing industries and construction	18.82	101.60	1.85	12.09	0.32
1.A.3 Transport	52.12	61.79	11.80	0.17	0.80
1.A.4 Other sectors	32.09	771.46	162.12	19.98	0.50
1.A.5 Other	0.05	0.08	0.02	0.01	0.00
1.B Fugitive emissions from fuels	0.50	0.10	5.54	3.28	0.01
2. Industrial processes and product use	2.23	79.51	59.13	2.88	0.27
2.A Mineral industry	-	-	0.05	0.11	0.11
2.B Chemical industry	1.16	0.10	1.56	2.16	0.05
2.C Metal industry	0.99	78.19	1.17	0.55	0.00
2.D Non-energy products from fuels and solvent use	-	-	52.95	-	0.00

	NO_X [kt]	CO [kt]	NMVOC [kt]	SO_X [kt]	NH_3 [kt]
2.G Other product manufacture and use	0.07	1.22	3.39	0.04	0.11
3. Agriculture	20.07	-	38.01	-	-
4. LULUCF	0.47	16.67	-	-	-
5.Waste	0.48	7.88	2.31	0.02	1.11

9.2 Production of indirect emissions from precursor gases

Following precursor and indirect emission estimates are from sectors Energy, IPPU and Waste. Emissions from Agriculture are considered biogenic. Agriculture and LULUCF indirect emissions are not reported here, but under their own category according the 2006 IPCC guidelines.

9.2.1 Indirect N_2O emissions from nitrogen oxides

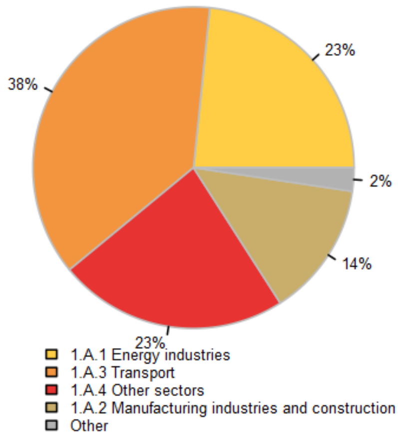

Fig. 9-2 Indirect N_2O emissions from NOx emissions in 2022

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 730.4kt to 138.7kt during the period 1990 - 2022. In 2022, NO_X emissions were 81.0% below the 1990 level. Slightly less than 98% of total NO_X emissions originate from 1.A Fuel combustion, mainly subsectors 1.A.1 Energy industries (23.4%), with subsector 1.A.1a Public electricity and heat production (19.9%); 1.A.3 Transport (37.6%), with 1.A.3.b Road transportation (30.0%), 1.A.4 Other sectors (23.1%), mainly from 1.A.4.c Agriculture/Forestry/Fishing (9.4%) and 1.A.2 Manufacturing industries and construction (13.6%) (Fig.9-2). Hence the indirect N_2O emissions from NOx correspondingly decreased from 3.5 kt to 0.7 kt from 1990 to 2022, which is 81.0% less than 1990.

9.2.2 Indirect N_2O from ammonia

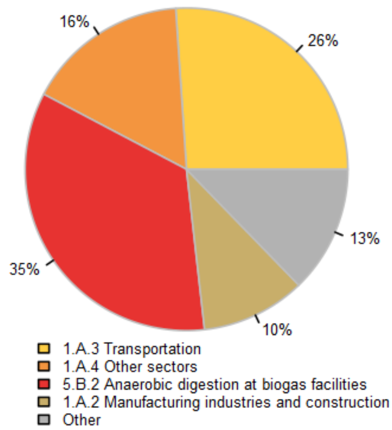

Fig. 9-3 Indirect N_2O emissions from NH_3 emissions in 2022

Emissions of anthropogenic NH_3 for 2022 are mainly produced from categories; 5.B.2 Anaerobic Digestion at Biogas Facilities (34.5%), 1.A.4 Other sectors (16.2%), 1.A.3 Transport (26.1%) and 1.A.2 Manufacturing industries and construction (10.5%)). The other (12.7%) includes sectors 1.A.1 Energy Industries (2.0%), 5.D Wastewater Treatment and Discharge (1.7%), 1.B Fugitive emissions from fuels (0.2%) and 2. Industrial processes and product use (8.9%) (Fig. 9-3). In 2022, emissions of NH_3 were 3.1 kt. The overall trend is decreasing from 1990 to 2022. Total indirect N_2O emissions from NH_3 in 2022 are 0.04 kt, which is 69.3% less than 1990.

9.2.3 Indirect CO_2 from carbon monoxide

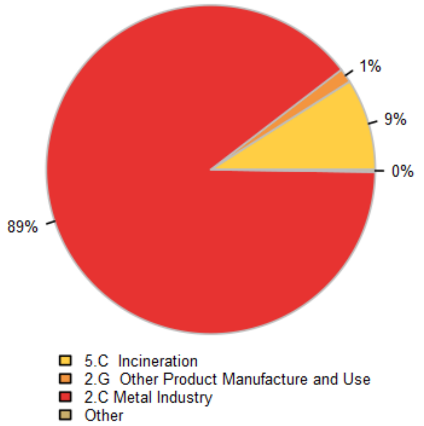

Fig. 9-4 Indirect CO_2 emissions from CO emissions in 2022

Emissions of CO are produced during the combustion of carbon-containing fuels at low temperatures and by insufficient amount of combustion air. In 2022, emissions of CO were 87.5 kt with increasing trend from 1990. Reason for increasing trend is growth of metal industry production in Czechia. CO emissions for 2022 are mainly produced from categories; 2.C Metal Industry (89.4%), 5.C Incineration (9.0%) and 2.G Other Product Manufacture and Use (1.4%) (Fig.9-4). Total indirect CO_2 emissions from CO in 2022 are 137.5 kt.

9.2.4 Indirect CO_2 from non-methane volatile organic compounds

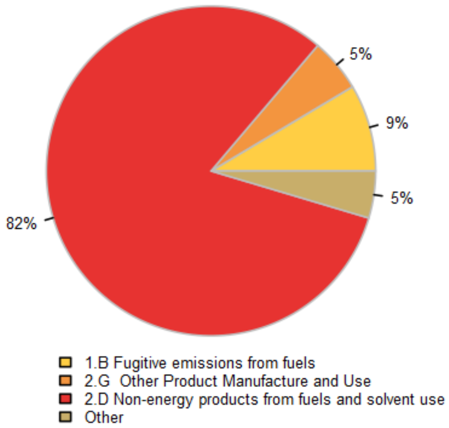

Fig. 9-5 Indirect CO_2 emissions from NMVOC emissions in 2022

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. Emissions from NMVOC decreased from 228.7 kt to 64.9 kt during the period between 1990 and 2022. In 2022, NMVOC emissions were 70.1% below the 1990 level. The main emission source category is 2.D Non-energy products from fuels and solvent use (81.6%) followed by 1.B Fugitive emissions from fuels (8.5%) and 2.G Other Product Manufacture and Use (5.2%). The rest consist of sector 5. Waste (0.3%), 2.B Chemical Industry (2.4%), 2.C Metal Industry (1.8%) and 2.A Mineral Industry (0.1%). Total indirect emissions of CO_2 from NMVOC in 2022 are 142.9 kt, which is 70.1% less than 1990.

9.2.4.1 Indirect CO_2 from 2.D Non-energy products from fuels and solvent use

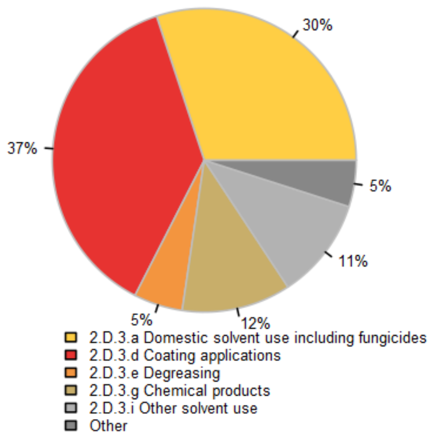

Fig. 9-6 Indirect CO_2 emissions from 2.D Non-energy products from fuels and solvent use in 2022

In 2022, 19.1% of all indirect CO_2 emissions originated from NMVOC emissions from 2.D Non-energy products from fuels and solvent use. The same sector produced 81.6% of indirect CO_2 emissions from all NMVOC. The main NMVOC source categories in 2.D Non-energy products from fuels and solvent use are; 2.D.3.d Coating applications (37.3%), 2.D.3.g Chemical products (11.6%), 2.D.3.a Domestic solvent use including fungicides (30.0%), 2.D.3.e Degreasing (5.2%) and 2.D.3.i Other solvent use (10.8%) (Fig. 9-6). The rest (Other) are 2.D.3.h Printing, 2.D.3.f Dry cleaning, 2.D.3.b Road paving with asphalt and 2.D.3.c Asphalt roofing together (5.1%). Total indirect emissions of CO_2 from 2.D Non-energy products from fuels and solvent use in 2022 are 116.7 kt.

9.2.5 Indirect CO_2 from methane

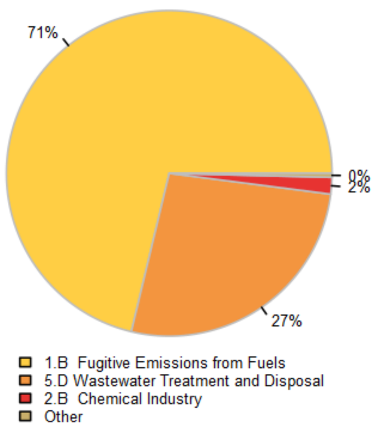

Fig. 9-7 Indirect CO_2 emissions from methane in 2022

In 2022, 54.1% of all indirect CO_2 emissions originated from methane. CH_4 emissions, used for the calculation of indirect CO_2 emissions are mainly produced from categories 1.B Fugitive emissions from fuels (71.3%); 1.B.1 Solid fuels (56.0%), 1.B.2 Oil and natural gas and other emissions from energy production (15.3%) and 5.D Wastewater treatment and discharge (26.5%) (Fig. 9-7). For more information on CH_4 emissions, consult respective chapters. Total indirect CO_2 emissions from CH_4 produced in 2022 are 330.8kt, which is 68.3% 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 1990 – 2022

	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	1369.82	3.50	437.29	0.09	119.73	0.03	1926.85	3.62
1991	1263.27	3.33	356.34	0.09	128.85	0.03	1748.46	3.44
1992	1163.88	3.13	345.89	0.09	120.21	0.03	1629.97	3.25
1993	1200.65	2.55	331.70	0.08	116.65	0.02	1649.01	2.65
1994	1133.09	2.15	329.62	0.08	121.66	0.02	1584.36	2.26
1995	1115.92	1.78	308.49	0.05	110.18	0.02	1534.59	1.85
1996	1120.71	1.69	294.11	0.03	107.87	0.02	1522.70	1.74
1997	1085.40	1.56	287.53	0.02	110.27	0.02	1483.20	1.61
1998	1035.80	1.49	281.79	0.02	112.20	0.02	1429.79	1.53
1999	934.31	1.38	284.68	0.02	104.02	0.02	1323.01	1.42
2000	843.29	1.42	303.24	0.02	103.62	0.02	1250.15	1.45
2001	769.07	1.40	299.65	0.02	107.07	0.02	1175.79	1.43
2002	741.63	1.37	292.19	0.02	107.50	0.01	1141.32	1.40
2003	727.15	1.39	286.64	0.02	107.30	0.01	1121.09	1.42
2004	695.22	1.40	278.63	0.02	105.78	0.01	1079.63	1.42
2005	748.80	1.39	275.41	0.02	104.05	0.01	1128.25	1.42
2006	772.44	1.35	295.45	0.02	104.70	0.01	1172.60	1.38
2007	722.52	1.35	296.08	0.02	101.67	0.01	1120.26	1.37
2008	711.02	1.26	278.32	0.02	102.07	0.01	1091.41	1.29
2009	628.93	1.19	251.31	0.01	102.03	0.01	982.27	1.21
2010	632.82	1.17	250.27	0.02	104.89	0.01	987.98	1.19
2011	628.55	1.10	236.16	0.01	102.51	0.01	967.22	1.13
2012	602.49	1.04	219.64	0.02	101.12	0.01	923.26	1.07
2013	503.46	0.97	223.55	0.01	100.33	0.02	827.34	1.00
2014	502.25	0.94	230.34	0.01	100.18	0.02	832.78	0.97
2015	485.95	0.91	228.20	0.01	101.70	0.02	815.85	0.94
2016	438.69	0.86	229.99	0.02	102.22	0.02	770.90	0.89
2017	402.26	0.84	224.97	0.01	103.10	0.02	730.33	0.87
2018	375.46	0.81	228.81	0.01	104.84	0.02	709.11	0.84
2019	336.15	0.75	215.73	0.01	105.39	0.02	657.26	0.78
2020	262.53	0.68	284.31	0.01	100.87	0.02	647.72	0.71
2021	261.19	0.70	286.04	0.02	101.16	0.02	648.39	0.73
2022	248.04	0.67	261.98	0.01	101.14	0.02	611.15	0.70
Trend %	**-81.89**	**-80.80**	**-40.09**	**-84.67**	**-15.53**	**-39.65**	**-68.28**	**-80.59**

All sectors have a decreasing trend in indirect emissions. Recalculation and inclusion of NH_3 emissions from 5.B.2 Anaerobic digestion at biogas facilities to the NFR corrected the N_2O trend in the GHG Waste sector, which is decreasing 39.7.3% compared to 1990. Total CO_2 indirect emissions are decreasing 68.3% and total N_2O indirect emissions are decreasing 80.6% to the 1990 level.

In the Fig. 9-8 is visually presented percentual division of indirect emissions of CO_2 and N_2O between the examined sectors.

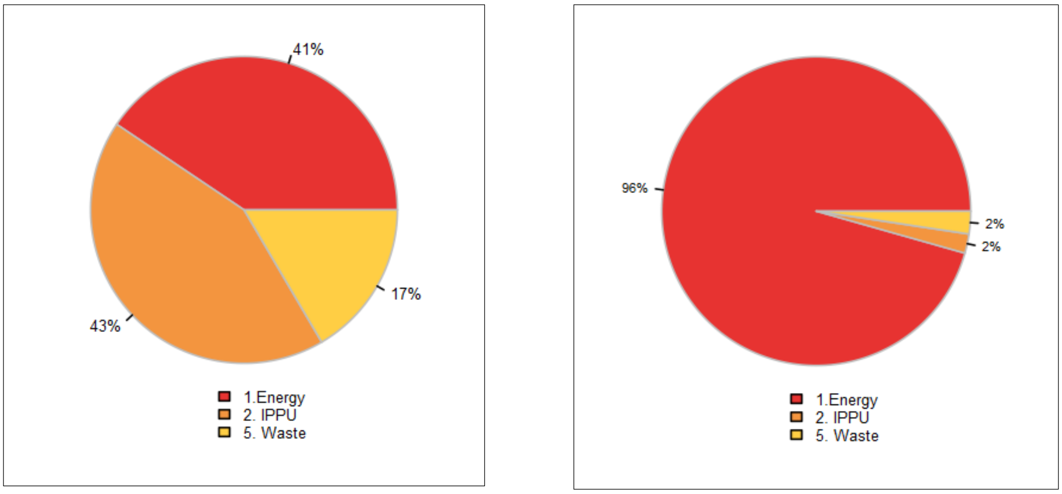

Fig. 9-8 Division of indirect emission of CO_2 (left) and N_2O (right) between the producing sectors for 2022 (in %)

Energy sector covers 41.6% of the total production of indirect CO_2 and 95.6% of the total production of indirect N_2O. 99.6% of the indirect N_2O emissions from Energy are from 1.A Fuel combustion; (38.8%) 1.A.3 Transport, 1A.4 Other sectors (23.9%) and followed by 1.A.1 Energy industries (23.3%). 71.3% of indirect CO_2 emissions from Energy are from 1.B Fugitive Emissions from Fuels.

IPPU sector covers 42.9% of the total production of indirect CO_2 and for the indirect N_2O the share is 2.0%. The two main subcategories producing indirect CO_2 in the IPPU sector are 2.C Metal industry (48.4%), with its CO production, and 2.D Non-energy products from fuels and solvent use (44.5%), with its NMVOC production. Indirect N_2O emissions from IPPU are divided between four categories: 2.B Chemical industry (43.9%), 2.C Metal industry (33.6%), 2.G Other product manufacture and use (12.7%) and 2.A Mineral industry (9.8%).

Waste sector covers 16.6% of the total production of indirect CO_2 and only 2.4% of the total production of indirect N_2O. Most of the indirect CO_2 emissions from the Waste sector are emitted from category 5.D Wastewater Treatment and Discharge (86.8%) followed by 5.C Incineration and Open Burning of Waste (13.1%) and 5.E Other (0.1%). Most of the N_2O is emitted from the category 5.B Biological Treatment of Solid Waste (82.1%) and the rest are from the category 5.C Incineration and Open Burning of Waste (13.9%) and the category 5.D Wastewater Treatment and Discharge (4.0%).

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.

Precursor gases from Agriculture were added to the CRF in 2024 for the completeness, but as they are considered biogenic, no indirect emissions are estimated. The CRF reporter tables have no place for NOx in 3B2 causing difference of 0.7kt in 2024 for the NOx between the NFR and CRF Czechia data.

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 1990–2021 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 2021 (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 NH3 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. Automated QC sumtests follow the data from the NFR files to the indirect emission calculation file with comparison to resulting CRF values. Therefore the reported emissions can be tracked correctly to the source. In 2022, CRF reporter failed to produce totals and sub totals correctly to the summary tables for multiple sectors for the Czechia inventory. This was also the case with precursor gases causing precursor gas totals having 0 - 0.02Kt rounding errors in the Energy sector summary tables. Rounding error has no effect on the GHG emissions or indirect emissions.

The Czech IIR team exchanges information about precursor data with the person responsible of the chapter 9 in the Czech NIR ensuring correct transfer of NFR data into the CRF.

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 2021. The main trends are that indirect CO_2 changes are higher in the early early years and indirect N_2O changes are higher in the current years. The highest kt differences compared to the previous submission are for the years 1990 – 1991 and 2015 for the indirect CO_2 emissions and 2015 – 2021 for the indirect N_2O emissions. The trend of the indirect CO_2 emissions difference is fluctuating from -1.3% in 1990 until peaking 1.2% in 2015.The trend of the indirect N_2O emissions recalculation has increasing higher fluctuations from 1990 (-1.5%) to 2021 (-5.7%) while peaking in 2019 (-7.5%).

Change to AR5 GWP has no effect in shown recalculations. The shown impact is from changes in the activity data in the NFR. The most significant change affecting indirect N_2O_2 emissions recalculation for the whole time serieswas recalculation of NH_3 in the NFR. The main change affecting the indirect CO_2 emissions is +57.3% recalculation of CO in sector 1A4 Other for year 2021. Global pandemic was creating special circumstances in year 2020, which can be observed as a slight slump in estimattions in 2020. The trends and impacts can be observed in the **Chyba! Chybný odkaz na záložku.**.

Tab. 9-4 Recalculation of indirect CO_2 and N_2O total emissions between 1990–2021

Submission	2022		2023		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	1952.21	3.68	1926.85	3.62	-25.37	-0.05	-1.30	-1.49
1991	1769.34	3.50	1748.46	3.44	-20.88	-0.05	-1.18	-1.55
1992	1637.76	3.30	1629.97	3.25	-7.79	-0.05	-0.48	-1.64
1993	1655.25	2.71	1649.01	2.65	-6.24	-0.05	-0.38	-1.89
1994	1584.36	2.26	1584.36	2.26	0.01	0.00	0.00	0.00
1995	1542.16	1.89	1534.59	1.85	-7.57	-0.04	-0.49	-2.36
1996	1527.63	1.78	1522.70	1.74	-4.93	-0.05	-0.32	-2.57
1997	1487.03	1.65	1483.20	1.61	-3.83	-0.05	-0.26	-2.75
1998	1433.94	1.57	1429.79	1.53	-4.15	-0.04	-0.29	-2.33
1999	1325.88	1.45	1323.01	1.42	-2.87	-0.04	-0.22	-2.63
2000	1253.23	1.49	1250.15	1.45	-3.08	-0.04	-0.25	-2.45
2001	1177.29	1.47	1175.79	1.43	-1.49	-0.04	-0.13	-2.53
2002	1142.12	1.43	1141.32	1.40	-0.80	-0.03	-0.07	-2.40
2003	1121.78	1.45	1121.09	1.42	-0.69	-0.03	-0.06	-1.86
2004	1080.43	1.45	1079.63	1.42	-0.80	-0.02	-0.07	-1.71
2005	1129.02	1.44	1128.25	1.42	-0.77	-0.02	-0.07	-1.51
2006	1173.45	1.40	1172.60	1.38	-0.86	-0.03	-0.07	-1.86
2007	1121.13	1.40	1120.26	1.37	-0.86	-0.02	-0.08	-1.70
2008	1092.15	1.32	1091.41	1.29	-0.75	-0.03	-0.07	-2.03
2009	982.77	1.24	982.27	1.21	-0.50	-0.03	-0.05	-2.26
2010	988.43	1.23	987.98	1.19	-0.46	-0.03	-0.05	-2.81
2011	967.68	1.16	967.22	1.13	-0.46	-0.03	-0.05	-2.94
2012	923.72	1.11	923.26	1.07	-0.46	-0.04	-0.05	-3.38
2013	827.66	1.04	827.34	1.00	-0.32	-0.04	-0.04	-3.87
2014	833.10	1.01	832.78	0.97	-0.32	-0.04	-0.04	-3.97
2015	805.83	0.98	815.85	0.94	10.02	-0.04	1.24	-4.29
2016	771.03	0.94	770.90	0.89	-0.13	-0.04	-0.02	-4.78
2017	730.90	0.92	730.33	0.87	-0.57	-0.05	-0.08	-5.41
2018	709.80	0.89	709.11	0.84	-0.69	-0.05	-0.10	-5.92
2019	658.33	0.84	657.26	0.78	-1.07	-0.06	-0.16	-7.48
2020	647.47	0.76	647.72	0.71	0.25	-0.05	0.04	-6.36
2021	653.95	0.78	648.39	0.73	-5.56	-0.04	-0.85	-5.72

9.8 Source-specific planned improvements, including I 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.

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 2024

10.1.1.1 Recalculation in sector 1 Energy – Stationary combustion

10.1.1.1.1 Recalculations due to response to the last review process

No recalculation resulted from the last review process.

10.1.1.1.2 Recalculation due to improvement plan

The emission factor for abandoned underground mines were updated according to the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This update covered years from 2017 till 2021 in a subcategory 1B1a1iii.

The recalculation in activity data will be as follows.

Tab. 10-1 Updated activity data due to the improvement plan

Category	Fuels	Year
1.B.1.a.1.iii Abandoned underground mines	Solid fuel	2017-2021

10.1.1.1.3 Recalculation due updated activity data

Based on the update of activity data from CzSO some recalculations were necessary to be done.

The most of the recalculations are tiny and occur only in couple years as the correction of the previous values. Summarization of the recalculation released from the update of Activity data is listed in the table below.

1.A.1 – Energy industries

Due to the change of source data, recalculation had to be done in subsectors 1.A.1.a, 1.A.1.b and 1.A.1.c for gaseous fuel. In subsectors 1.A.1.a and 1.A.1.c for solid fuels. Activity data were also changed in the year 2018 for Gaseous fuel, therefore recalculation in the subsector 1.A.1.a, 1.A.1.b were done. Furthermore, activity data were also changed for Gaseous fuel in the year 2021 in subsector 1.A.1.c.

1.A.2 – Manufacturing industries and construction

Consumption of solid fuels had to be changed for the year 2021 due to the changed of Activity data from CzsO in all subcategories, see the table below.

The change of activity data of liquid fuels was updated for the year 2021 in these subcategories 1.A.2.e, 1.A.2.f and 1.A.2.g.

Based on update of activity data for Gaseous fuels in 2018 and 2021 recalculation had to be done in these subcategories 1.A.2.a, 1.A.2.b, 1.A.2.c, 1.A.2.d, 1.A.2.f, 1.A.2.g.

In the subcategory 1.A.2.f was found out wrong emission factor for CO2 in 2021. The emission factors were updated and recalculation of CO2 emissions was performed. See the table Tab. 10-3.

1.A.4 – Other sectors

Based on update of activity data from the CzSO amount of Gasoline in 2021 in subcategory 1.A.4.c.ii were changed. Due to the update of activity data in Gaseous fuels, recalculation had to be done in subcategories 1.A.4.a.i (2018 and 2021), 1.A.4.b.i and 1.A.4.c.i for the years 2018.

Activity data for solid fuels were changed in 2021, therefore recalculation in subcategories 1.A.4.a.i and 1.A.4.c.i were done.

1.A.5. – Non specified

Due to the change of activity data for the year 2021 liquid fuels (Mobile diesel) had to be recalculated.

Tab. 10-2

Sector	Type of fuels	Recalculation in years
1.A.1.a.i Electricity generation	Solid fuels	2021
1.A.1.c Manufacture of solid fuels and Other energy industries	Solid fuels	2002
1.A.1.c Manufacture of solid fuels and Other energy industries	Solid fuels	2021
1.A.2.a Iron and steel	Solid fuels	2021
1.A.2.b Non-Ferrous metals	Solid fuels	2021
1.A.2.c Chemicals	Solid fuels	2021
1.A.2.d Pulp, paper and print	Solid fuels	2021
1.A.2.e Food Processing, Beverages and Tobacco	Solid fuels	2021
1.A.2.f Non-Metalic Minerals	Solid fuels	2021

1.A.2.g Non-specified Industry	Solid fuels	2021
1.A.4.a Commercial/Institutional	Solid fuels	2021
1.A.4.c Agriculture/Forestry/Fishing/Fish Farms	Solid fuels	2021
1.A.2.e Food Processing, Beverages and Tobacco	Liquid fuels	2021
1.A.2.f Non-Metalic Minerals	Liquid fuels	2021
1.A.2.g Non-specified Industry	Liquid fuels	2021
1.A.4.c Agriculture/Forestry/Fishing/Fish Farms	Liquid fuels	2021
1.A.5.b – Mobile (non-specified)	Liquid fuels	2021
1.A.1.a.i Electricity generation	Gaseous fuels	2018
1.A.1.b Petroleum refining	Gaseous fuels	2018
1.A.1.c Manufacture of solid fuels and Other energy industries	Gaseous fuels	2021
1.A.2.a Iron and steel	Gaseous fuels	2018; 2021
1.A.2.b Non-Ferrous metals	Gaseous fuels	2018; 2021
1.A.2.c Chemicals	Gaseous fuels	2018; 2021
1.A.2.d Pulp, paper and print	Gaseous fuels	2018; 2021
1.A.2.e Food Processing, Beverages and Tobacco	Gaseous fuels	2018; 2021
1.A.2.f Non-Metalic Minerals	Gaseous fuels	2018; 2021
1.A.2.g Non-specified Industry	Gaseous fuels	2018; 2021
1.A.4.a Commercial/Institutional	Gaseous fuels	2018; 2021
1.A.4.b Residential	Gaseous fuels	2018
1.A.4.c Agriculture/Forestry/Fishing/Fish Farms	Gaseous fuels	2018

Tab. 10-3

Sector	Type of emissions	Recalculation in years
1.A.2.f Non-Metalic Minerals	CO_2	2021

10.1.1.2 Recalculation in sector 1 Energy – Mobile combustion

10.1.1.2.1 Recalculation due to response to the last review process

NA

10.1.1.2.2 Recalculation due to improvement plan

NA

10.1.1.2.3 Recalculation due to updated activity data

1.A.3.a – Domestic aviation, 1.D.1.a – International aviation

EUROCONTROL provided updated data for years 2015-2022. Time series 1990-2014 were updated based on the interpolation of these latest data. Emissions were recalculated with the updated IEFs in the entire time series 1990–2022.

Update of jet kerosene consumption for international aviation in year 2021 based on the latest IEA data.

1.A.3.b – Road transport

New version of COPERT programme (update from the version 5.5.1 to 5.7.2) was used to calculate emissions from road transport. Due to this update, entire time series 1990-2022 were recalculated. The following changes related to GHG emissions calculation were made in the new version:

- Updated emission factors of Euro 6 CNG passenger cars
- Updated emission factors of Euro VI diesel buses
- Updated emission factors of Euro VI diesel hybrid buses
- New vehicle category and emission factors added
    - Battery electric passenger cars
- Corrected hot emission factors of for LCVs N1-I
- Corrected N_2O emissions of petrol hybrid and petrol PHEV Euro 5 and 6 PCs
- Removal of CO_2 correction
- Trip length and duration per vehicle category

Activity data for the last four years were updated and years 2018-2021 were consequently recalculated which is given by the methodology of obtaining traffic performance data (for more details, please see chapter 3.2.16.3 in NIR). Due to this fact, the data 2019-2022 are preliminary.

Recalculation of emissions in time series 2016-2022 due to update of biodiesel consumption based on the latest IEA data.

Update of petrol net calorific value in 2021 based on the latest IEA data.

1.A.3.c – Railways

Recalculation of CO_2 emissions due to the methodology update – separation of non-bio and biodiesel consumption. Emissions were recalculated in time series 2016-2022.

Update of diesel net calorific values in years 2016-2022 based on the latest IEA data – separation of non-bio and biodiesel.

Update of specific consumption of traction diesel in years 2020 and 2021 for personal line-haul locomotives and rail cars based on the latest data from Czech railway operator České dráhy.

10.1.1.3 Recalculation in sector 2 Industrial Processes and Product Use

10.1.1.3.1 Recalculations due to response to the last review process

No recalculation was needed in response to the last review process.

10.1.1.3.2 Recalculation due to updated activity data

2.A Mineral Industry

2.A.4.a Other Process Uses of Carbonates - Ceramics - data of total production of tiles for the year 2021 were updated which resulted in minor change of emission factor.

2.B Chemical Industry

2.B.2 Nitric acid - recalculation due to the change of GWP values to AR5. Last year there were incorrectly used the AR4 GDW values. This year correct values were used. The change in emission is approximately 11 %. Only for the values since 2014-2020 as those values are taken from EU ETS forms as CO_2 eq. and recalculated to N_2O emission using GWP values. The values for years 1990-2013 are from CzSO in form of activity data (production of nitric acid/year) and from those the emission was calculated using CS emission factor.

2.B.8.g Styren - data for years 2019-2022 were observed straight from producer as those years activity data (amount of product per year) were missing in the EU ETS forms, thus activity data for those years in previous submission were calculated from production capacity of the plant and number of working days per each year.

2.C Metal Industry

2.C.1 Iron and Steel Production Data for Coal Tar were updated from the questionnaire for the year 2020 – 2021 which resulted in the slight correction of total emission of CO_2 in CRF data.

2. D Non-energy products from fuels and solvent use

2.D.3 Other urea catalyst - whole time series 2006-2022 were recalculated. Previously the Tier 1 approach was used to calculate emission from urea as a catalyst. The activity of urea (urea consumption factor) was 2 % for all vehicle categories. Activity data came from COPERT as amount of consumed fuel and emission was calculated using simple equation from IPCC methodology. Newly Tier 2 Approach is used. The emission of urea as a catalyst is newly calculated in COPERT version 5.7. The program takes into account country specific H:C and O:C ratio in the fuels and also different values of the urea consumption factor according to the vehicle categories. Except the new methodology for estimation of emission, there was also update in activity data (mainly for the bus transportation) and new version of Copert program. For detailed explanation of those two changes see chapter 1.A.3.b – Road transport.

2.F Product Uses as Substitutes for ODS

Whole timeline was changed for subcategory 2F1e HFC-134a because of change in activity data in model COPERT. Small change has been made in subcategory 2F1a for F-gas C_6F_{14} year 2021 where inserting error was observed during QA/QC process.

10.1.1.4 Recalculation in sector 3 Agriculture

The estimates of emissions from Agriculture were significantly affected by updated activity data (emission factors and volatilized and leaching nitrogen fractions), which enter the calculation of emissions from category 3D Emissions from Managed Soils. An overview of emissions from the sector in the last five submissions is evident from Fig. 10-1. The update of the calculation resulted in an average 4.2% increase in emissions from the sector. Changes are described in detail in paragraphs below.

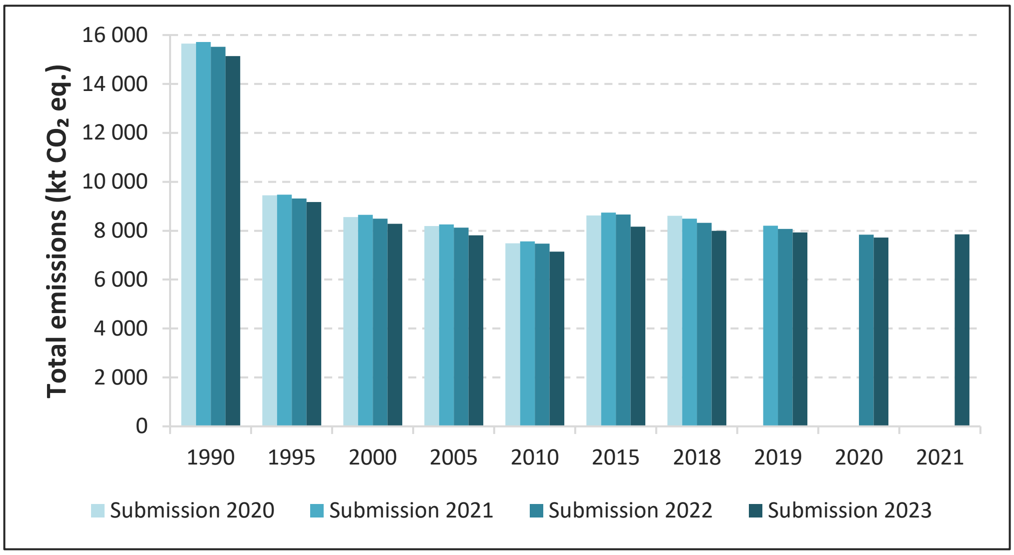

Fig. 10-1 Overview of total emissions from Agriculture sector in the last four submissions

10.1.1.4.1 3D Nitrous oxide Emissions from Managed Soils

In connection with the gradual transition of the methodology to a higher level of estimation (Tier 2), emission factors and volatilized and leaching nitrogen fractions included in the estimation of emissions were updated. Changes are presented in Tab. 10-4 and

Tab. **10-5**. Emission factors and fractions were updated according to IPCC 2019. These changes allow consideration of a wider range of manure storage technologies when relevant data is available. The methodology also allows considering the specific climatic characteristics of the regions in the Czech Republic in the estimates once the new activity data on regional nitrogen consumption become available.

Tab. 10-4 Changes in activity data used for estimation of direct N_2O emissions from managed soils.

Nitrogen sources	Emission factor (IPCC 2006) kg N_2O-N/ kg N input	Emission factor (IPCC 2019) kg N_2O-N/ kg N input	Relative effect to emission estimation	Share of total emission from 3D1 category (submission 2024)
Synthetic N fertilizers	0.01	0.016	Increase by 60 %	76 %
Organic N applied as fertilizer	0.01	0.006	Decrease by 67 %	7 %
Urine and dung N deposited on pasture (cattle, swine, poultry)	0.02	0.006	Decrease 70 %	2 %
Urine and dung N deposited on pasture (other animals)	0.01	0.003		
N in crop residues	0.01	0.006	Decrease 25-30 %	15 %
N mineralisation with loss of soil organic matter	0.01	0.006	-	-
Direct emission from managed soils			**Increase 11% in average**	**100 %**

Tab. 10-5 Changes in activity data used for estimation of indirect N_2O emissions from managed soils.

Nitrogen sources	Emission factor (IPCC 2006) kg N_2O-N/ kg N input	Emission factor (IPCC 2019) kg N_2O-N/ kg N input	Relative effect to emission estimation	Share of total emission from 3D2 category (submission 2024)
EF4 N volatilization and redeposition	0.01	0.014	Increase in average 34 %	41 %
Frac GASF (volatilisation from synthetic fertiliser)	0.1	0.11		
Frac GASM (volatilisation from organic fertilizers and PRP)	0.2	0.21		
EF5 leaching/runoff	0.0075	0.011	Decrease in average 18 %	59 %
Frac Leach (N loss by leaching)	0.3	0.24		
Indirect emission from managed soils			**Increase 4% in average**	**100 %**

The use of new activity data resulted in an increase in N_2O emissions from the sector of 4% on average and an increase in emissions from 3D category by 9%. The share of emissions from synthetic fertilizers in total emissions from managed soils has increased significantly.

10.1.1.4.2 Technical correction - TAM validation (poultry)

Estimation of Nex for poultry category was validated with the new TAM values for the period 2014-2022. The change does not have any impact on estimated data because Nex for poultry is derived from the actual version of Decree No.377/2013 Coll. (Chapter 3.2.2.3 in the NIR text).

10.1.1.4.3 Technical correction - Rape included in estimation of nitrogen from Crop residues.

Rape covers approx. 14 % of areas under crops in the Czech Republic. We consider its importance as a source of nitrogen from crop residues to be significant. Neither the IPCC 2006 nor IPCC 2009 methodology provides suitable parameters for estimating the amount of nitrogen in rapeseed biomass. We estimated the contribution of nitrogen from rape cultivation thanks to the data available from the GNOC model (Global Nitrous Oxide Calculator).

Emissions from crop residues originating from rape constitute 15 % of emissions from total crop residues (FCR). The increased emissions were partly compensated by applying a reduced emission factor 0.006 (as compared to the earlier 0.01) which decreased estimates of N_2O emissions from FCR by 30 % on average.

10.1.1.5 Recalculations in sector 4 LULUCF

10.1.1.5.1 Recalculation due to response to the last review process and recalculation due to use of country specific conditions

4.A Forest land

On the initiative of the inventory team, the emission estimates were recalculated for the entire category of 4.A Forest land and reporting period. This was required due to rectifications in the harvest input and proportions related to harvest residues, and secondarily due to the related revisions in disturbance matrices used for CBM-CFS3 model (Kurz et al. 2009, Kull et al. 2019). Finally, changes in activity data for prescribed burning affected non-CO_2 emissions (N_2O, CH_4). These improvements affected the estimates in all carbon pools and non-CO_2 emissions in category 4.A. The overall effect of the implemented revisions was 14 % for the reporting period, as the estimated emissions for 4.A Forest land decreased relative those in the previous NIR submission. Practically all that difference was attributed to 4.A.1 subcategory, while the quantitative impact on 4.A.2 was only about 1 % (decreased sink).

The detailed information on these recalculations is given in Chapter 6.4.5, including a graphical comparison of the current (NIR 2024) and the previous emission estimates for 4.A Forest land and the reporting period (Fig. 6-18).

4.B Cropland

Since the last submission, the emission estimates related to carbon stock changes were recalculated for both the categories 4.B.1 Cropland remaining Cropland and 4.B.2 Land converted to Cropland. This was due to the revised Tier 3 estimates aided by CBM for subcategory 4.B.2.1 involving conversion from Forest land (Tab. 6-8).

Overall, the estimated emissions decreased by 1.1% for the entire category 4.B. The detailed information on these recalculations is given in Chapter 6.5.5, including a graphical comparison of the current (NIR 2024) and the previous emission estimates for 4.B Cropland and the reporting period (Fig. 6-22).

4.C Grassland

Since the last submission, the emission estimates related to carbon stock changes were recalculated for both 4.C.1 and 4.C.2 subcategories of Grassland. This was due to the revised Tier 3 estimates aided by CBM for subcategory 4.C.2.1 involving conversion from Forest land (Tab. 6-8). Overall, the revised emission estimates in 4.C quantitatively differ by less than half a percent as compared to the previously reported estimates.

The detailed information on these recalculations is given in Chapter 6.6.5, including a graphical comparison of the current (NIR 2024) and the previous emission estimates for 4.C Grassland and the reporting period (Fig. 6-24).

4.D Wetlands

The emission estimates for the category 4.D Wetlands were recalculated in its subcategory 4.D.2. This was due to the changes implemented in 4.D.2.1 involving conversion from Forest land that rely on CBM-assisted Tier 3 estimates (Tab. 6-8). These changes decreased emissions for category 4.D (4.D.2) by 2 % relative to the previous NIR submission.

The information on these recalculations is given in Chapter 6.7.5, including a graphical comparison of the current (NIR 2024) and the previous emission estimates for 4.D Wetlands and the reporting period (Fig. 6-26).

4.E Settlements

The emission estimates for the category 4.E Settlements were recalculated in its subcategory 4.E.2. This was due to the changes implemented in 4.E.2.1 involving conversion from Forest land that rely on CBM-assisted Tier 3 estimates (Tab. 6-8). These changes increased emission estimates for category 4.E (4.E.2) by 1% relative to the previous NIR submission.

The information on these recalculations is given in Chapter 6.8.5, including a graphical comparison of the current (NIR 2024) and the previous emission estimates for 4.E Settlements and the reporting period (Fig. 6-28).

4.G HWP

No recalculation was made for the category 4.G HWP except the slightly changed activity data at FAO database on wood production and trade for the most recent years. These affected the earlier estimate of HWP contribution for 2021.

The information on these recalculations is given in Chapter 6.10.5, including a graphical comparison of the current (NIR 2024) and the previous emission estimates for 4.G HWP and the reporting period (Fig. 6-29).

10.1.1.6 Recalculation in sector 5 Waste

No recalculations were carried out in Waste sector in this submission.

10.1.1.7 Recalculations in indirect emissions

Recalculations were done for indirect CO_2 and N_2O for the whole time series 1990-2021. Reason for recalculations were changes in NFR activity data. Recalculation of NH_3 was the main reason for indirect N_2O emission changes and changes in CO and NMVOC gases for indirect CO_2 emissions

10.2 Implications for emission levels

Tab. 10-6 Implications of recalculations on CO_2 emission levels on example on 2021 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	105007.32	103217.44	-1789.89	-1.70	-1.51	-1.43
1. Energy	84322.22	84380.15	57.93	0.07	0.05	0.05
A. Fuel combustion activities	84267.39	84325.32	57.93	0.07	0.05	0.05
1. Energy industries	40829.05	40781.60	-47.45	-0.12	-0.04	-0.04
2. Manufacturing industries and construction	12770.41	12849.49	79.08	0.62	0.07	0.06
3. Transport	18733.60	18713.77	-19.84	-0.11	-0.02	-0.02
4. Other sectors	11618.74	11617.85	-0.89	-0.01	0.00	0.00
5. Other	315.58	362.61	47.03	14.90	0.04	0.04
B. Fugitive Emissions from Fuels	54.83	54.83	0.00	0.00	0.00	0.00
1. Solid fuels	51.25	51.25	0.00	0.00	0.00	0.00
2. Oil and natural gas	3.58	3.58	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	11924.38	11846.40	-77.98	-0.65	-0.07	-0.06
A. Mineral industry	3443.96	3443.96	0.00	0.00	0.00	0.00
B. Chemical industry	1908.84	1907.87	-0.97	-0.05	0.00	0.00
C. Metal industry	6431.51	6359.74	-71.77	-1.12	-0.06	-0.06
D. Non-energy products from fuels and solvent use	139.44	134.21	-5.24	-3.76	0.00	0.00
G. Other product manufacture and use	NO	NO	NA	NA	NA	NA
H. Other	0.63	0.63	0.00	0.00	0.00	0.00
3. Agriculture	321.91	321.91	0.00	0.00	0.00	0.00
A. Enteric fermentation	NA	NA	NA	NA	NA	NA
B. Manure management	NA	NA	NA	NA	NA	NA
C. Rice cultivation	NA	NA	NA	NA	NA	NA
D. Agricultural soils	NA	NA	NA	NA	NA	NA
E. Prescribed burning of savannahs	NA	NA	NA	NA	NA	NA
F. Field burning of agricultural residues	NA	NA	NA	NA	NA	NA
G. Liming	146.29	146.29	0.00	0.00	0.00	0.00
H. Urea application	175.61	175.61	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)	8342.10	6572.26	-1769.84	-21.22	NA	-1.41
A. Forestland	10984.04	9140.31	-1843.73	-16.79	NA	-1.47
B. Cropland	45.65	46.35	0.71	1.55	NA	0.00
C. Grassland	-496.87	-495.22	1.65	-0.33	NA	0.00
D. Wetlands	26.69	26.39	-0.31	-1.15	NA	0.00
E. Settlements	239.32	244.51	5.19	2.17	NA	0.00
F. Other land	NO,NA	NO,NA	NA	NA	NA	NA
G. Harvested wood products	-2456.74	-2390.08	66.65	-2.71	NA	0.05
H. Other	NO	NO	NA	NA	NA	NA
5. Waste	96.72	96.72	0.00	0.00	0.00	0.00
A. Solid waste disposal	NO,NE	NO,NE	NA	NA	NA	NA
B. Biological treatment of solid waste	NA	NA	NA	NA	NA	NA
C. Incineration and open burning of waste	96.72	96.72	0.00	0.00	0.00	0.00
D. Waste water treatment and discharge	NA	NA	NA	NA	NA	NA
E. Other	NO	NO	NA	NA	NA	NA
6. Other (As specified in summary 1.A)	NA	NO	NA	NA	NA	NA
Memo items:	NA	NA	NA	NA	NA	NA
International bunkers	374.85	466.20	91.35	24.37	0.08	0.07
Aviation	374.85	466.20	91.35	24.37	0.08	0.07
Navigation	NO	NO	NA	NA	NA	NA
Multilateral operations	NO	NO	NA	NA	NA	NA
CO_2 emissions from biomass	20685.64	20630.82	-54.82	-0.27	-0.05	-0.04
CO_2 captured	NO,NE	NO,NE	NA	NA	NA	NA
Long-term storage of C in waste disposal sites	48667.97	48667.97	0.00	0.00	0.00	0.00
Indirect N_2O	NA	NA	NA	NA	NA	NA
Indirect CO_2	653.95	641.72	-12.22	-1.87	-0.01	-0.01

Tab. 10-7 Implications of recalculations on CH_4 emission levels on example on 2021 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	13232.72	13213.83	-18.89	-0.14	-0.02	-0.02
1. Energy	3778.49	3761.09	-17.40	-0.46	-0.01	-0.01
A. Fuel combustion activities	1218.06	1215.77	-2.28	-0.19	0.00	0.00
1. Energy industries	40.61	40.60	-0.01	-0.04	0.00	0.00
2. Manufacturing industries and construction	53.54	53.67	0.13	0.25	0.00	0.00
3. Transport	28.05	25.90	-2.16	-7.68	0.00	0.00
4. Other sectors	1095.37	1095.10	-0.26	-0.02	0.00	0.00
5. Other	0.49	0.50	0.02	3.66	0.00	0.00
B. Fugitive Emissions from Fuels	2560.43	2545.31	-15.12	-0.59	-0.01	-0.01
1. Solid fuels	1881.91	1866.80	-15.12	-0.80	-0.01	-0.01
2. Oil and natural gas	678.52	678.52	0.00	0.00	0.00	0.00
C. CO_2 transport and storage	NA	NA	NA	NA	NA	NA
2. Industrial processes and product use	69.35	68.95	-0.40	-0.58	0.00	0.00
A. Mineral industry	NA	NA	NA	NA	NA	NA
B. Chemical industry	53.13	52.72	-0.40	-0.76	0.00	0.00
C. Metal industry	16.22	16.22	0.00	0.00	0.00	0.00
D. Non-energy products from fuels and solvent use	NO,NA	NO,NA	NA	NA	NA	NA
G. Other product manufacture and use	NO	NO	NA	NA	NA	NA
H. Other	NO	NO	NA	NA	NA	NA
3. Agriculture	4014.54	4013.60	-0.94	-0.02	0.00	0.00
A. Enteric fermentation	3628.43	3628.57	0.13	0.00	0.00	0.00
B. Manure management	386.10	385.03	-1.07	-0.28	0.00	0.00
C. Rice cultivation	NO	NO	NA	NA	NA	NA
D. Agricultural soils	NA,NE	NA,NE	NA	NA	NA	NA
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	NA	NA	NA	NA	NA	NA
H. Urea application	NA	NA	NA	NA	NA	NA
I. Other carbon-containing fertilizer	NA	NA	NA	NA	NA	NA
J. Other	NO	NO	NA	NA	NA	NA
4. Land use, land-use change and forestry (net)	8.73	8.58	-0.15	-1.69	NA	0.00
A. Forestland	8.73	8.58	-0.15	-1.69	NA	0.00
B. Cropland	NO	NO	NA	NA	NA	NA
C. Grassland	NO	NO	NA	NA	NA	NA
D. Wetlands	NO,NA	NO,NA	NA	NA	NA	NA
E. Settlements	NO,NA	NO,NA	NA	NA	NA	NA
F. Other land	NO,NA	NO,NA	NA	NA	NA	NA
G. Harvested wood products	NA	NA	NA	NA	NA	NA
H. Other	NO	NO	NA	NA	NA	NA
5. Waste	5361.62	5361.62	0.00	0.00	0.00	0.00
A. Solid waste disposal	3724.92	3724.92	0.00	0.00	0.00	0.00
B. Biological treatment of solid waste	737.62	737.62	0.00	0.00	0.00	0.00
C. Incineration and open burning of waste	5.30	5.30	0.00	0.00	0.00	0.00
D. Waste water treatment and discharge	893.78	893.78	0.00	0.00	0.00	0.00
E. Other	NO	NO	NA	NA	NA	NA
6. Other (As specified in summary 1.A)	NA	NO	NA	NA	NA	NA
Memo items:	NA	NA	NA	NA	NA	NA
International bunkers	0.07	0.09	0.02	24.37	0.00	0.00
Aviation	0.07	0.09	0.02	24.37	0.00	0.00
Navigation	NO	NO	NA	NA	NA	NA
Multilateral operations	NO	NO	NA	NA	NA	NA
CO_2 emissions from biomass	NA	NA	NA	NA	NA	NA
CO_2 captured	0.00	0.00	0.00	0.00	0.00	0.00
Long-term storage of C in waste disposal sites	NA	NA	NA	NA	NA	NA
Indirect N_2O	NA	NA	NA	NA	NA	NA
Indirect CO_2	NA	NA	NA	NA	NA	NA

Tab. 10-8 Implications of recalculations on N_2O emission levels on example on 2021 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	4691.18	5097.62	406.44	8.66	0.34	0.32
1. Energy	561.33	558.53	-2.79	-0.50	0.00	0.00
A. Fuel combustion activities	561.31	558.52	-2.79	-0.50	0.00	0.00
1. Energy industries	183.87	183.67	-0.20	-0.11	0.00	0.00
2. Manufacturing industries and construction	68.72	68.91	0.19	0.27	0.00	0.00
3. Transport	175.63	172.31	-3.32	-1.89	0.00	0.00
4. Other sectors	130.33	130.36	0.03	0.02	0.00	0.00
5. Other	2.76	3.28	0.52	18.76	0.00	0.00
B. Fugitive Emissions from Fuels	0.01	0.01	0.00	0.00	0.00	0.00
1. Solid fuels	NO,NA	NO,NA	NA	NA	NA	NA
2. Oil and natural gas	0.01	0.01	0.00	0.00	0.00	0.00
C. CO_2 transport and storage	NA	NA	NA	NA	NA	NA
2. Industrial processes and product use	370.79	384.20	13.41	3.62	0.01	0.01
A. Mineral industry	NA	NA	NA	NA	NA	NA
B. Chemical industry	172.04	185.45	13.41	7.80	0.01	0.01
C. Metal industry	NA	NA	NA	NA	NA	NA
D. Non-energy products from fuels and solvent use	NO,NA	NO,NA	NA	NA	NA	NA
G. Other product manufacture and use	198.75	198.75	0.00	0.00	0.00	0.00
H. Other	NO	NO	NA	NA	NA	NA
3. Agriculture	3508.10	3904.01	395.91	11.29	0.33	0.32
A. Enteric fermentation	NA	NA	NA	NA	NA	NA
B. Manure management	392.14	391.59	-0.55	-0.14	0.00	0.00
C. Rice cultivation	NA	NA	NA	NA	NA	NA
D. Agricultural soils	3115.96	3512.41	396.46	12.72	0.33	0.32
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	NA	NA	NA	NA	NA	NA
H. Urea application	NA	NA	NA	NA	NA	NA
I. Other carbon-containing fertilizer	NA	NA	NA	NA	NA	NA
J. Other	NO	NO	NA	NA	NA	NA
4. Land use, land-use change and forestry (net)	7.18	7.10	-0.08	-1.08	NA	0.00
A. Forestland	4.57	4.49	-0.08	-1.69	NA	0.00
B. Cropland	2.13	2.13	0.00	0.00	NA	0.00
C. Grassland	NO,NA	NO,NA	NA	NA	NA	NA
D. Wetlands	NO,NA	NO,NA	NA	NA	NA	NA
E. Settlements	NO,NA	NO,NA	NA	NA	NA	NA
F. Other land	NO,NA	NO,NA	NA	NA	NA	NA
G. Harvested wood products	NA	NA	NA	NA	NA	NA
H. Other	NO	NO	NA	NA	NA	NA
5. Waste	243.77	243.77	0.00	0.00	0.00	0.00
A. Solid waste disposal	NA	NA	NA	NA	NA	NA
B. Biological treatment of solid waste	66.18	66.18	0.00	0.00	0.00	0.00
C. Incineration and open burning of waste	4.63	4.63	0.00	0.00	0.00	0.00
D. Waste water treatment and discharge	172.96	172.96	0.00	0.00	0.00	0.00
E. Other	NO	NO	NA	NA	NA	NA
6. Other (As specified in summary 1.A)	NA	NO	NA	NA	NA	NA
Memo items:	NA	NA	NA	NA	NA	NA
International bunkers	2.70	3.36	0.66	24.37	0.00	0.00
Aviation	2.70	3.36	0.66	24.37	0.00	0.00
Navigation	NO	NO	NA	NA	NA	NA
Multilateral operations	NO	NO	NA	NA	NA	NA
CO_2 emissions from biomass	NA	NA	NA	NA	NA	NA
CO_2 captured	0.00	0.00	0.00	0.00	0.00	0.00
Long-term storage of C in waste disposal sites	NA	NA	NA	NA	NA	NA
Indirect N_2O	206.29	206.29	0.00	0.00	0.00	0.00
Indirect CO_2	NA	NA	NA	NA	NA	NA

Tab. 10-9 Implications of recalculations on F-gases emission levels on example on 2021 emission levels

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (PFC, HFC, NF_3, SF_6, HFC-PFC Mix)	Previous submission (CO_2-eq, kt)	Latest submission (CO_2-eq, kt)	Difference (CO_2-eq, kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %
F-gases: Total actual Emissions	**PFC, HFC, NF3, SF6**	3808.48	3835.91	27.43	0.72	0.02	0.02
2.B.9. Flurochemical production		NO	NO	NA	NA	NA	NA
2.B.10. Other		NO	NO	NA	NA	NA	NA
2.C.3. Aluminium production		NO	NO	NA	NA	NA	NA
2.C.4. Magnesium production		NO	NO	NA	NA	NA	NA
2.C.7. Other		NO	NO	NA	NA	NA	NA
2.E.1. Integrated circuit or semiconductor	PFC, NF3, SF6	35.08	35.08	NA	NA	NA	NA
2.E.2. TFT flat panel display		NO	NO	NA	NA	NA	NA
2.E.3. Photovoltaics		NO	NO	NA	NA	NA	NA
2.E.4. Heat transfer fluid		NO	NO	NA	NA	NA	NA
2.E.5. Other		NO	NO	NA	NA	NA	NA
2.F.1. Refrigeration and air conditioning	PFC, HFC	3676.73	3704.02	27.29	0.74	0.02	0.02
2.F.2. Foam blowing agents	HFC	1.03	1.03	NA	NA	NA	NA
2.F.3. Fire protection	PFC, HFC	30.00	30.00	NA	NA	NA	NA
2.F.4. Aerosols	HFC	2.37	2.37	NA	NA	NA	NA
2.F.5. Solvents		0.43	0.43	NA	NA	NA	NA
2.F.6. Other applications		NO	NO	NA	NA	NA	NA
2.G.1. Electrical equipment	SF6	58.43	58.43	NA	NA	NA	NA
2.G.2. SF6 and PFCs from other product use	SF6	4.40	4.40	NA	NA	NA	NA
2.G.4. Other		NO	NO	NA	NA	NA	NA
2.H. Other	HFC	0.02	0.15	0.14	835.98	0.00	0.00

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. 10-2. Both curves are following the same pattern. The CO_2 emission trend is lower in recent submission in average by 0.6%, through the whole time period.

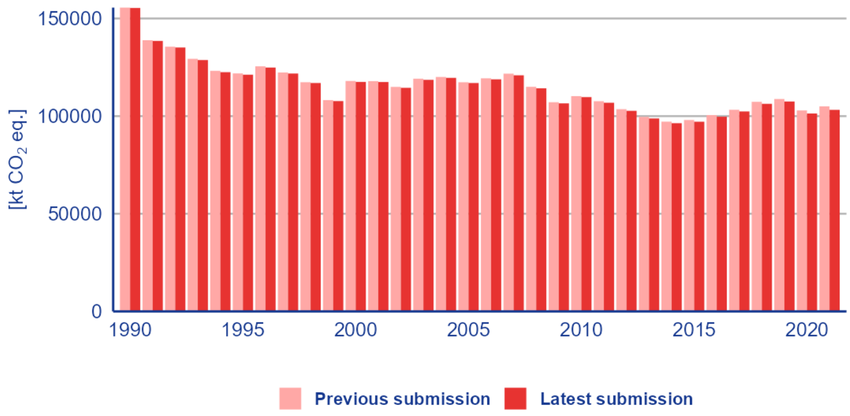

Fig. 10-2 Difference in trends of CO_2 emissions between the submissions 2023 and 2024, due to recalculations

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. 10-3. Both curves are following the same pattern, the CH_4 emission trend is lower in recent submission in average by 0.2%, through the whole time period.

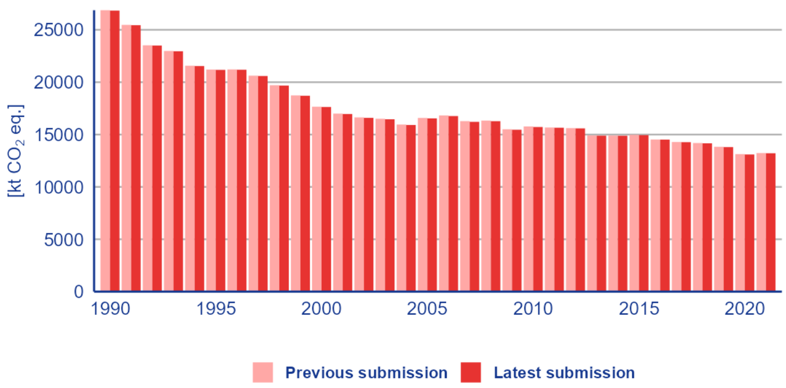

Fig. 10-3 Difference in trends of CH4 emissions in index form, between the submissions 2023 and 2024, due to recalculations

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. 10-4. Both curves are following the simmilar pattern, the N_2O emission trend is higher in recent submission in average by 6.4%, through the whole time period.

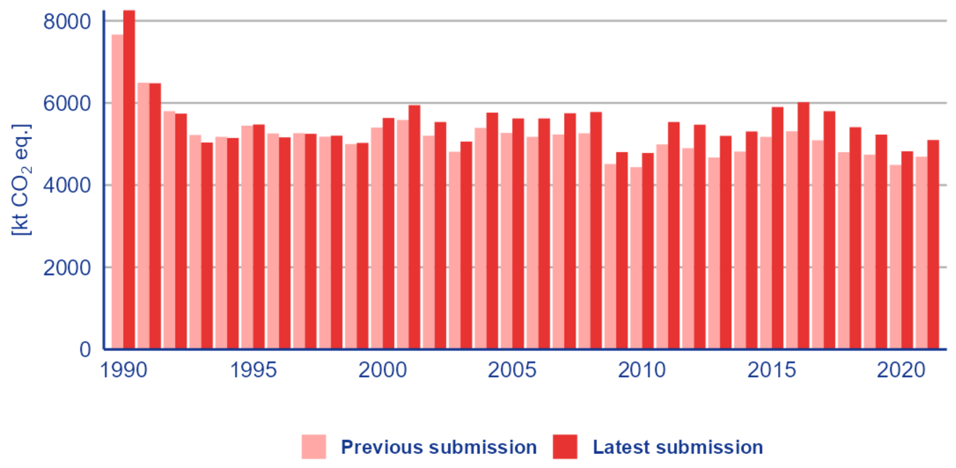

Fig. 10-4 Difference in trends of N_2O emissions, between the submissions 2023 and 2024, due to recalculations

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. 10-5. Both curves are following the same pattern.

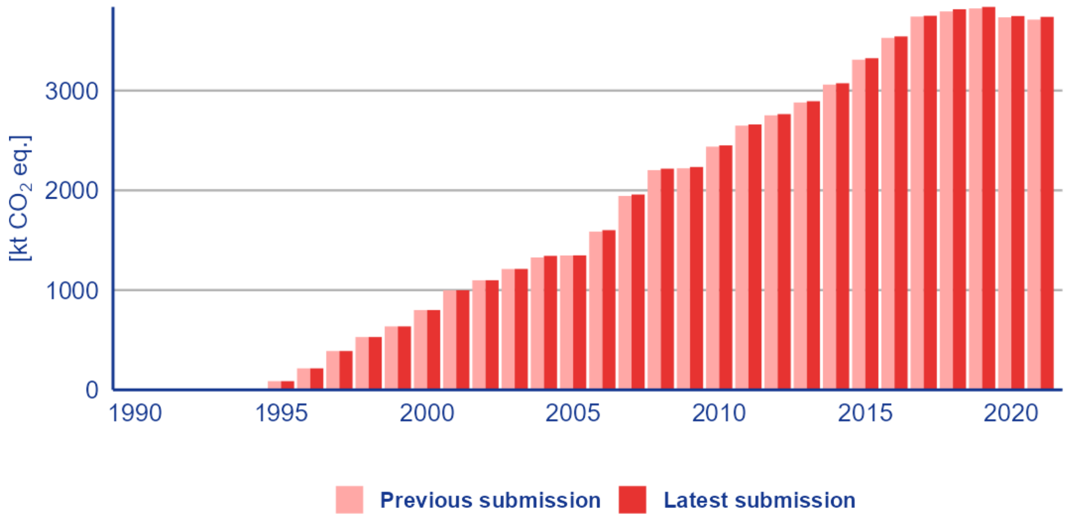

Fig. 10-5 Difference in trends of HFCs emissions in index form, between submission 2023 and 2024, due to recalculations

The influence of the recalculations for the emission trend of PFCs are illustrated on Fig. 10-6. Both curves are following the same pattern.

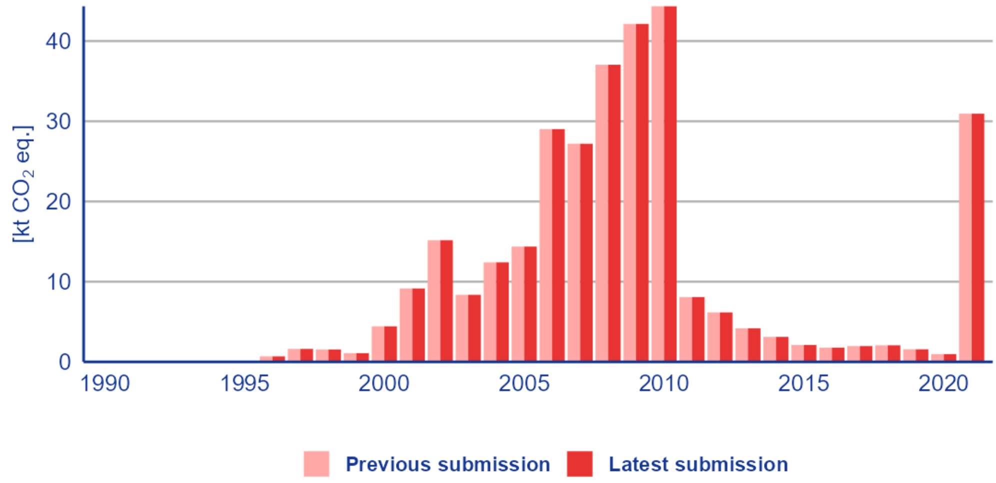

Fig. 10-6 Difference in trends of PFCs emissions, between submission 2023 and 2024, due to recalculations

The influence of the recalculations for the emission trend of SF_6 are illustrated on Fig. 10-7. Both curves are following the same pattern.

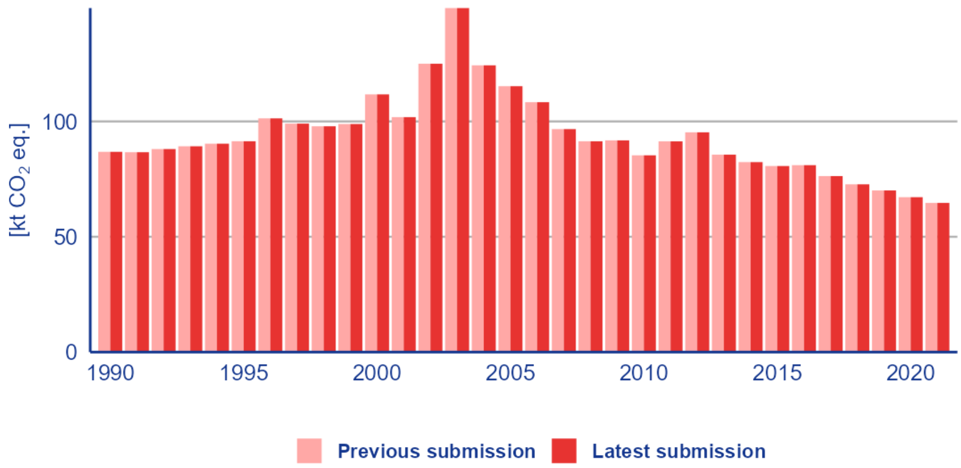

Fig. 10-7 Difference in trends of SF_6 emissions, between submission 2023 and 2024, due to recalculations

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. 10-8. Both curves are following the same pattern. The total emissions including LULUCF in trend is lower on average by 0.3% through the whole time period.

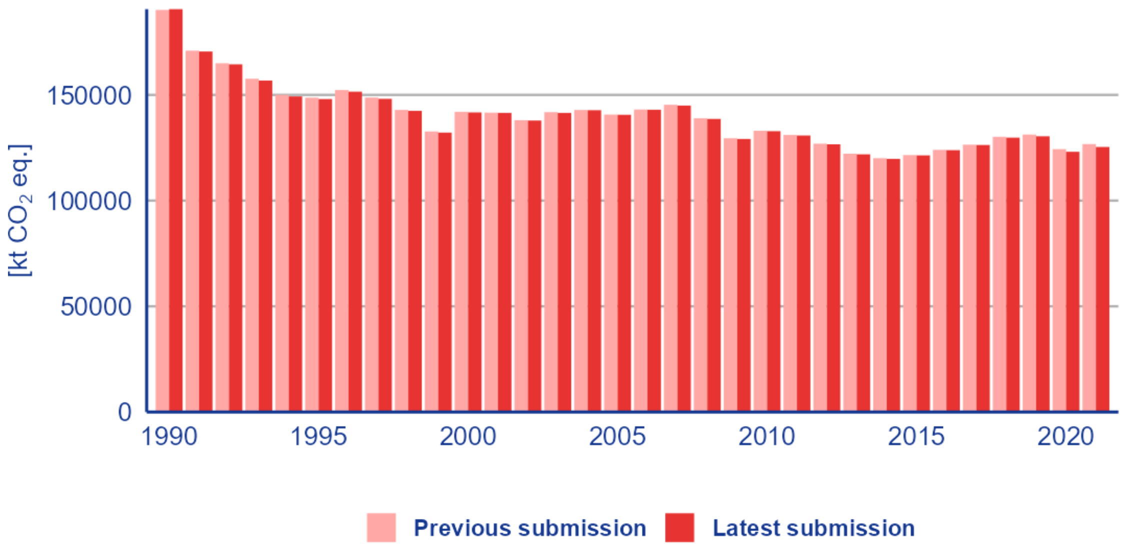

Fig. 10-8 Difference in trends of total emissions including LULUCF, between submission 2023 and 2024, due to recalculations

The influence of the recalculations for the emission trend of total emissions, excluding LULUCF are illustrated on Fig. 10-9. Both curves are following the same pattern. The total emissions excluding LULUCF in trend is higher on average by 0.3% through the whole time period.

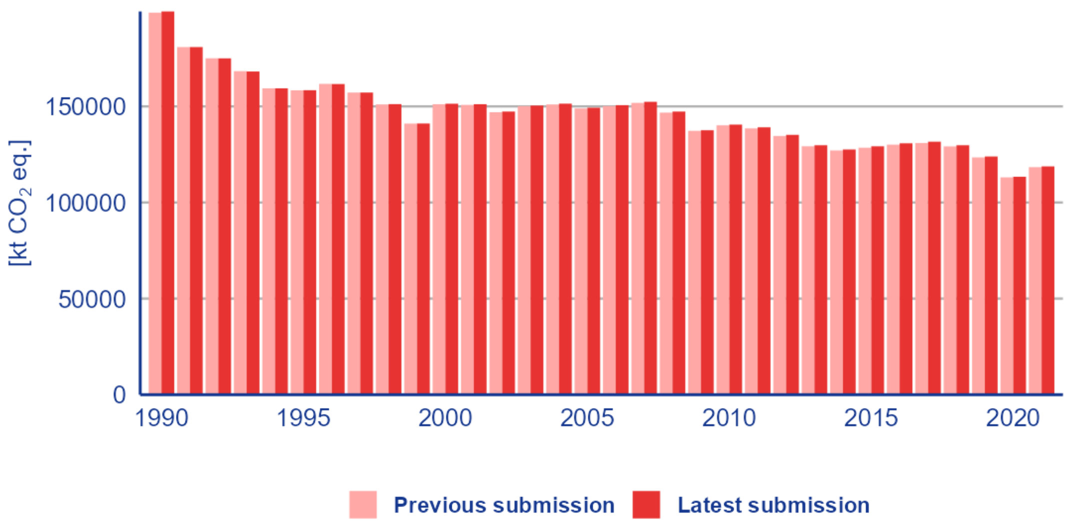

Fig. 10-9 Difference in trends of total emissions excluding LULUCF, between submission 2023 and 2024, due to recalculations

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. In this report, attention is focused on the two last reviews.

In September 2021, the Czech Republic was subject to the centralized review conducted remotely. No 'potential problems' were formulated, thus no resubmission after the review was carried out.

Further, the ARR was available at the final stage of preparation of this inventory, thus, only limited amount of recommendations could have been implemented.

10.4.1 Overview of implemented improvements in the 2024 submission

The following table summarises the main changes and that were performed in 2024 submission in comparison with previous submissions.

For changes in methodological descriptions please see

Tab. 10-11.

Tab. 10-10 Table of implemented improvements in the 2024 submission

Topic/Category, gas	Description of the change	Reason (motive) of the change	Reference to NIR or CRF Table
Sector: General issues			
Archiving	Partly resolved. Expert judgement forms have been archived from sectors Agriculture, Transportation and IPPU.	Improvement suggested by the UNFCCC recommendation G.2/ FCCC/ARR/2022/CZE	**NIR, chapter 1.3.3**
Key category analysis	Likely level of significance rough estimate to justify NE added to table 9	Improvement suggested by the UNFCCC recommendation G.1/ FCCC/ARR/2022/CZE	**CRF table 9**
Key category analysis	KCA calculationsheet updated correctly, which is reflected in NIR ch 1.5 KCA tables and text.	Improvement suggested by the UNFCCC recommendation G.5/ FCCC/ARR/2022/CZE	**NIR, chapter 1.5**
Sector: Energy – emissions from combustion			
1.A.2.c	Add explanation to CRF T9 (reference to NIR chapter) about NE in this subcategory	Improvement suggested by the UNFCCC recommendation E.12/ FCCC/ARR/2022/CZE	**CRF table 9, NIR 3.2.1.1**
General - energy	QC activities done to ensure data consistency between CRF, NIR and Annex 4	UNFCCC recommendation, E.1/ FCCC/ARR/2022/CZE	**Annex 4**
1.B.1.a	Added information about abondoned underground mines	UNFCCC recommendation, E.22/ FCCC/ARR/2022/CZE	**NIR, chapter 3.3.1**
1.B.2.b	Added explanation for the decrease of the IEF	Improvement suggested by UNFCCC recommendation, E.13/ FCCC/ARR/2022/CZE	**NIR 1.B.2.a.iii.3**
Sector: Industrial processes and Other Product Use			
	No change		
Sector: Agriculture			
3.D	First step to transition of the methodology to a higher level of estimation. Emission factors and fractions were updated according to IPCC 2019	Improvement suggested by the UNFCCC recommendation	**CRF 3.D**
Sector: LULUCF			
4.A.1	The NIR 2024 text will include more information on the issue of litter pool dynamics and the most recent adjustments implemented by the inventory team	UNFCCC recommendation, L.10/ FCCC/ARR/2022/CZE	**Nir text, Ch. 6.4, Annex 3.6**
4.A.2	The NIR 2024 text will include more information on the issue of litter pool dynamics, its effect in 4.A.2 category and the most recent adjustments implemented by the inventory team	UNFCCC recommendation, L.11/ FCCC/ARR/2022/CZE	**Nir text, Ch. 6.4, Annex 3.6**
Sector: Waste			
	No change		

Tab. 10-11 Methodological descriptions in submission 2024

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
Total (Net Emissions)			
1. Energy			
A. Fuel Combustion (Sectoral Approach)			
1. Energy Industries			
2. Manufacturing Industries and Construction			
3. Transport	√	√	NIR, Chapter 3.2.16.4 Railways (CRF 1.A.3.c)
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	√	√	4.5.3.2., 4.5.3.5
E. Electronics Industry			
F. Product Uses as Substitutes for ODS			
G. Other Product Manufacture and Use			
3. Agriculture			
A. Enteric Fermentation		√	5.2.1
B. Manure Management		√ √	5.2.2
C. Rice Cultivation			
D. Agricultural Soils		√	5.4.2
E. Prescribed Burning of Savannas			
F. Field Burning of Agricultural Residues			
G. Liming		v	5.7.2
H. Urea Application			
I. Other Carbon-containing Fertilizers			
J. Other			
4. Land Use, Land-Use Change and Forestry			
A. Forest Land	√	√	6.4.2.1, Annex 3.6
B. Cropland	√	√	6.4.2.1, Annex 3.6
C. Grassland	√	√	6.4.2.1, Annex 3.6
D. Wetlands	√	√	6.4.2.1, Annex 3.6
E. Settlements	√	√	6.4.2.1, Annex 3.6
F. Other Land			
G. Harvested Wood Products			
H. Other			
5. Waste			
A. Solid Waste Disposal			
B. Biological treatment of solid waste			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
C. Incineration and open burning of waste			
D. Wastewater treatment and discharge			
E. Other			
6. Other (as specified in Summary 1.A)			
Memo Items:			
International Bunkers			
Aviation			
Marine			
Multilateral Operations			
CO_2 Emissions from Biomass			
CO_2 Captured			
Long-term storage of C in waste disposal sites			
Indirect N_2O			
NIR Chapter	**DESCRIPTION**		**REFERENCE**
	Please tick where the latest NIR includes major changes		**If ticked please provide some more detailed information**
Chapter 1.2 Institutional arrangements			
Chapter 1.6 QA/QC plan			

10.4.2 Improvement plan

Provisional Improvement plan was included in the NIR already last year and in this submission was updated and supplemented. This plan is in accordance with the recommendation of the international Expert Review Team (ERT) and concentrates particularly on introduction the more sophisticated procedures of the higher Tiers. These procedures employ country-specific emission factors and other parameters required for determining greenhouse gas emissions. However, it is rather difficult to obtain the data required for these purposes, especially at the present time, when only limited funds are available for the national inventory. Thus, it is planned to introduce the procedures of the higher Tiers gradually, over a longer time interval. In accordance with the IPCC methodology, emphasis is simultaneously put on Key categories. The following table gives the anticipated timetable for introduction of these procedures. As announced in the last submission, the country-specific emission factor for estimating CO_2 emissions from combustion of Natural Gas has been determined (please see Annex 2). These factors were already employed in this submission (see Chapter 3).

In addition to the planned introduction of the procedures of the higher Tiers in the individual sectors, the Improvement plan also includes a more general aspect. For instance last year have been revised uncertainty estimates. A substantial improvement in this respect has already appeared in this submission (see Chapter 1).

Furthermore Improvement Plan also includes using of EU ETS data for the purposes of national inventory. Substantial effort is put into implementation of this issue. In this submission EU ETS data were used for emission estimates in some subcategories in 2.A Mineral Product (e.g. 2.A.1 Cement Production). EU ETS data would be useful tool for QA/QC procedures also in Energy sector.

With the implementation of this issue could help also MS assistance project (Assistance to MS with KP Reporting) which is now under operation. Issue of implementation of EU ETS data was raised by the Czech Republic. Another issues concerning Energy and IP sector were raised in this assistance project.

Tab. 10-12 Plan of improvements for key categories

Sector	Key Categories (KC)	GHG	% *) GHG	Type of KC	Present situation	Planned improvement	For submission
1	1.A.3.d Domestic Navigation	CO_2, CH_4, N_2O			Tier 1	Tier 2 or higher if possible. New sources of activity data	2024
1	1.A.4 Other sectors – Solid Fuels	CO_2	2.67	LA, TA	Activity data fluctuation in 1991 till 1995	Detailed research of data at the beginning of 90s is planned for the future submissions	2025
3	3.B Manure management	CH_4	0.29	TA	Tier 2	MCF calculation update according IPCCC 2019 Guidelines	2026
3	3.D. Agricultural soils	N_2O	2.28	LA,TA	Tier 2	Implementation of a regional approach to estimation	2026
4	4.A Forest land	CO_2	-	LA, TA	Tier 3	Tier 3 model-asssted estimates at NUTS3 geographical detail	2025
5	5.A Solid Waste Disposal	CH_4	2.92	LA, TA	Tier 1	Review of factor F	2025
5	5.B.1 Biological Treatment of Solid Waste - Composting	CH_4 N_2O	0.65 (5.B)	LA, TA	Tier 1	Methodology for emissions from household composts	2025
5	5.B.2 Biological Treatment of Solid Waste – Anaerobic digestion	CH_4	0.65 (5.B)	LA, TA	Tier 1	Methodology improvement	2025
5	5.D Wastewater Treatment and Discharge	CH_4 N_2O	0.88	LA, TA	Tier 1, CS, D	Review of biogas composition and used factors	2025

**) share in total GHG emissions excluding LULUCF*

11 Other Information

No other information submitted in 2024.

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Abbreviations

AACLC	Aggregate areas of cadastral land categories
A/C	Air-conditioning
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
CBM	Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)
CCA	Czech Cement Association
CCR	Czech Car Registry
CDV	Transport Research Centre (Centrum dopravního výzkumu)
CENIA	Czech Environmental Information Agency
CHMI	Czech Hydrometeorological Institute
CLA	Czech Lime Association
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CNG	Compressed Natural Gas
COD	Chemical Oxygen Demand
COP	Conference of Parties
COPERT	Computer Programme to calculate Emissions from Road Transport
COSMC	Czech Office for Surveying, Mapping and Cadastre
CRF	Common Reporting Format
CRI	Crop Research Institute
CS	Country specific
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)
ČD	Czech Railways
DOC	Degradable Organic Carbon
DOM	Dead Organic Matter
EEA	European Environmental Agency
EF	Emission Factor
EIG	Emission Inventory Guidebook
EMEP/EEA	European Monitoring and Evaluation Programme/Environmetal Protection Agency
ERT	Expert Review Team
ETS	Emission Trading Scheme
ETBE	Ethyl Tertiary Butyl Ether
FAO	Food and Agriculture Organization
FAME	Fatty Acid Methyl Esters
FMI	Forest Management Institute, Brandýs nad Labem
FMP	Forest Management Plans
FOD (model)	First Order Decay (model)
GCRI	Global Change Research Institute of the Czech Academy of Sciences
GDP	Gross Domectic Product
GHG	Greenhouse Gas
HDV	Heavy Duty Vehicle

HWP	Harwested Wood Products
CHMI	Czech Hydrometeorological institute
IAEI	Institute of Agriculture Economics and Information
IEA	International Energy Agency
IEF	Implied emission factor
IFER	Institute of Forest Ecosystem Research (Ústav pro výzkum lesních ekosystémů)
IFR	Instrument flight rules
IGU	International Gas Union
IIR	Czech Informative Inventory Report
IPCC	Intergovernmental Panel of Climate Change
IPR	Integrated Pollution Register
ISOH/VISOH	Information system of waste management/Public information system of waste management
ISPOP	Integrated system of mandatory reporting (Integrovaný systém plnění ohlašovacích povinností)
IW	Industrial Waste
IWW	Industrial Wastewater
KC	Key Category
KP LULUCF	LULUCF activities under Kyoto Protocol
LA	Level Assessment
LDV	Light Duty Vehicle
LFG	Landfill Gas
LKD	Lime Kiln Dust
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 Conversion Factor
MIT	Ministry of Industry and Trade
MoE	Ministry of Environment
MSW	Municipal Solid Waste
NACE	Nomenclature Classification of Economic Activities
NCV	Net Calorific Value
NEC	National Emission Ceilings
NFI	National Forest Inventory
NIR	National Inventory Report
NIS	National Inventory System (National system under Kyoto protocol, Art. 5)
NMVOC	Non-Methane Volatile Organic Compound
OECD	Organisation for Economic Co-operation and Development
OKD, a.s.	Ostrava – Karvina Mines (Ostravsko karvinské doly, a.s.)
OMD	Organic Matter Digestibility
OTE	Electricity Market Operator (Operátor trhu s elektřinou, a.s.)
PC	Passenger Car
QA/QC	Quality Assurance/Quality Control
R	Recovered methane
RA	Reference Approach
REZZO	Register of Emissions and Sources of Air Pollution (Registr emisí a zdrojů znečišťování ovzduší)
SA	Sectoral Approach
SCR	Selective catalytic reduction
SDA	Car Importers Association (Svaz dovozců automobilů)
STC	Technical control stations
SÚKL	State Institute for Drug Control (Státní ústav pro kontrolu léčiv)

SWDS	Solid Waste Disposal Sites
TA	Trend Assessment
TACR	Technological Agency of the Czech Republic
THC	Total Hydrocarbons
TOW	Total Organic Waste
TSC	Database of Technical Control Stations
ÚCL	Civil Aviation Authority
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)
VFR	Visual flight rules
VŠCHT	University of Chemistry and Technology Prague (Vysoká škola chemicko technologická)
WA	Weighted average
WWTP	Wastewater Treatment Plant

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Annexes to the National Inventory Report

Annex 1 Key Categories

Key Categories were estimated using IPCC 2006 Gl. approach 1 including and excluding LULUCF. Tab. A1 1 till Tab. A1 4 followed the approach in Tables 4.2 and 4.3 of the IPCC 2006 Gl.

Tab. A1 1 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2022 – Level Assessment including LULUCF

IPCC Source Categories	GHG	Latest Year Emission or Removal Estimate (kt CO2 eq.)	ABS Latest Year Emission or Removal Estimate (kt CO2 eq.)	LA, %	Cumulative Total (LA, %)
1.A.1 Energy industries - Solid Fuels	CO_2	38845.69	38845.69	30.72	30.72
1.A.3.b Road Transportation	CO_2	18916.69	18916.69	14.96	45.67
1.A.4 Other Sectors - Gaseous Fuels	CO_2	6154.93	6154.93	4.87	50.54
4.A.1 Forest Land remaining Forest Land	CO_2	6047.95	6047.95	4.78	55.32
2.C.1 Iron and Steel Production	CO_2	5634.33	5634.33	4.46	59.78
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5173.58	5173.58	4.09	63.87
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	4937.63	4937.63	3.90	67.77
5.A Solid Waste Disposal	CH_4	3724.92	3724.92	2.95	70.72
3.A Enteric Fermentation	CH_4	3680.70	3680.70	2.91	73.63
2.F.1 Refrigeration and Air conditioning	F-gases	3572.75	3572.75	2.83	76.45
1.A.4 Other Sectors - Solid Fuels	CO_2	3158.16	3158.16	2.50	78.95
1.A.1 Energy industries - Gaseous Fuels	CO_2	3001.65	3001.65	2.37	81.33
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	2839.60	2839.60	2.25	83.57
4.G Harvested wood products	CO_2	-1946.26	1946.26	1.54	85.11
2.A.1 Cement Production	CO_2	1846.97	1846.97	1.46	86.57
1.B.1.a Coal Mining and Handling	CH_4	1845.24	1845.24	1.46	88.03
1.A.4 Other Sectors - Liquid Fuels	CO_2	1223.42	1223.42	0.97	89.00
2.B.8 Petrochemical and Carbon Black Production	CO_2	1016.59	1016.59	0.80	89.80
5.D Wastewater treatment and discharge	CH_4	893.78	893.78	0.71	90.51
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	794.16	794.16	0.63	91.14
1.A.4 Other Sectors - Biomass	CH_4	767.46	767.46	0.61	91.74
2.A.4 Other Process Uses of Carbonates	CO_2	739.50	739.50	0.58	92.33
5.B Biological treatment of solid waste	CH_4	737.62	737.62	0.58	92.91
2.B.1 Ammonia Production	CO_2	682.45	682.45	0.54	93.45
2.A.2 Lime Production	CO_2	555.89	555.89	0.44	93.89
4.A.2 Land converted to Forest Land	CO_2	-551.17	551.17	0.44	94.33
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	545.40	545.40	0.43	94.76
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	543.22	543.22	0.43	95.19
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	485.49	485.49	0.38	95.57
1.A.1 Energy industries - Liquid Fuels	CO_2	428.22	428.22	0.34	95.91
3.B Manure Management	N_2O	386.96	386.96	0.31	96.21
3.B Manure Management	CH_4	375.14	375.14	0.30	96.51
4.C.1 Grassland remaining Grassland	CO_2	-310.86	310.86	0.25	96.76
1.A.4 Other Sectors - Solid Fuels	CH_4	271.04	271.04	0.21	96.97
1.A.5.b Other mobile - Liquid Fuels	CO_2	266.27	266.27	0.21	97.18
1.A.1 Energy industries - Other Fossil Fuels	CO_2	261.38	261.38	0.21	97.39
1.A.3.c Railways	CO_2	228.62	228.62	0.18	97.57
2.G Other Product Manufacture and Use	N_2O	198.75	198.75	0.16	97.73
4.E.2 Land converted to Settlements	CO_2	194.87	194.87	0.15	97.88

IPCC Source Categories	GHG	Latest Year Emission or Removal Estimate (kt CO2 eq.)	ABS Latest Year Emission or Removal Estimate (kt CO2 eq.)	LA, %	Cumulative Total (LA, %)
3.H Urea application	CO_2	191.94	191.94	0.15	98.03
4.C.2 Land converted to Grassland	CO_2	-190.01	190.01	0.15	98.18
1.A.3.b Road Transportation	N_2O	174.46	174.46	0.14	98.32
5.D Wastewater treatment and discharge	N_2O	172.96	172.96	0.14	98.46
1.A.1 Energy industries - Solid Fuels	N_2O	155.06	155.06	0.12	98.58
3.G Liming	CO_2	153.77	153.77	0.12	98.70
2.A.3 Glass Production	CO_2	145.87	145.87	0.12	98.82
2.B.10 Other	CO_2	139.01	139.01	0.11	98.93
2.B.2 Nitric Acid Production	N_2O	104.49	104.49	0.08	99.01
5.C Incineration and open burning of waste	CO_2	96.72	96.72	0.08	99.09
1.A.4 Other Sectors - Biomass	N_2O	96.67	96.67	0.08	99.16
2.D.1 Lubricant Use	CO_2	88.42	88.42	0.07	99.23
5.B Biological treatment of solid waste	N_2O	66.18	66.18	0.05	99.28
4.B.2 Land converted to Cropland	CO_2	64.27	64.27	0.05	99.34
2.G Other Product Manufacture and Use	F-gases	63.11	63.11	0.05	99.39
4.D.2. Land converted to Wetlands	CO_2	56.53	56.53	0.04	99.43
2.B.8 Petrochemical and Carbon Black Production	CH_4	55.59	55.59	0.04	99.47
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	55.40	55.40	0.04	99.52
2.E Electronics industry	F-gases	53.55	53.55	0.04	99.56
1.B.1.a Coal Mining and Handling	CO_2	48.65	48.65	0.04	99.60
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	36.74	36.74	0.03	99.63
1.A.1 Energy industries - Biomass	N_2O	32.22	32.22	0.03	99.65
2.F.3 Fire Protection	F-gases	31.41	31.41	0.02	99.68
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	29.23	29.23	0.02	99.70
1.A.1 Energy industries - Biomass	CH_4	25.54	25.54	0.02	99.72
1.A.3.b Road Transportation	CH_4	24.75	24.75	0.02	99.74
1.A.3.e Other Transportation	CO_2	22.32	22.32	0.02	99.76
2.D.3 Other non-energy products from fuels and solvent use	CO_2	22.11	22.11	0.02	99.78
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	21.34	21.34	0.02	99.79
4.B.1 Cropland remaining Cropland	CO_2	-21.26	21.26	0.02	99.81
4.A.1 Forest Land remaining Forest Land	CH_4	20.50	20.50	0.02	99.83
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	19.18	19.18	0.02	99.84
1.A.4 Other Sectors - Gaseous Fuels	CH_4	15.45	15.45	0.01	99.85
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	13.56	13.56	0.01	99.86
1.A.4 Other Sectors - Solid Fuels	N_2O	13.28	13.28	0.01	99.87
1.A.3.a Domestic Aviation	CO_2	12.40	12.40	0.01	99.88
1.A.4 Other Sectors - Liquid Fuels	N_2O	11.26	11.26	0.01	99.89
1.A.1 Energy industries - Solid Fuels	CH_4	11.23	11.23	0.01	99.90
4.A.1 Forest Land remaining Forest Land	N_2O	10.73	10.73	0.01	99.91
1.A.3.d Transport - Domestic navigation	CO_2	9.60	9.60	0.01	99.92
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	0.01	99.93
2.C.5 Lead Production	CO_2	9.37	9.37	0.01	99.93
2.C.1 Iron and Steel Production	CH_4	9.29	9.29	0.01	99.94
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	6.92	6.92	0.01	99.95
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	6.91	6.91	0.01	99.95
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	5.48	5.48	0.00	99.96
5.C Incineration and open burning of waste	CH_4	5.30	5.30	0.00	99.96
1.B.1.b Solid Fuel Transformation	CH_4	5.10	5.10	0.00	99.96

IPCC Source Categories	GHG	Latest Year Emission or Removal Estimate (kt CO2 eq.)	ABS Latest Year Emission or Removal Estimate (kt CO2 eq.)	LA, %	Cumulative Total (LA, %)
5.C Incineration and open burning of waste	N_2O	4.63	4.63	0.00	99.97
2.C.2 Ferroalloys Production	CH_4	3.89	3.89	0.00	99.97
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	3.13	3.13	0.00	99.97
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3.02	3.02	0.00	99.98
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2.92	2.92	0.00	99.98
2.F.4 Aerosols	F-gases	2.63	2.63	0.00	99.98
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	2.60	2.60	0.00	99.98
1.A.5.b Other mobile - Liquid Fuels	N_2O	2.55	2.55	0.00	99.98
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.46	2.46	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2.39	2.39	0.00	99.99
2.F.2 Foam Blowing Agents	F-gases	2.28	2.28	0.00	99.99
4.B.2. Land converted to Cropland	N_2O	2.27	2.27	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	CH_4	1.51	1.51	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	1.43	1.43	0.00	99.99
1.A.4 Other Sectors - Liquid Fuels	CH_4	1.17	1.17	0.00	99.99
1.A.3.c Railways	CH_4	1.14	1.14	0.00	100.00
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	1.03	1.03	0.00	100.00
2.C.6 Zinc Production	CO_2	0.92	0.92	0.00	100.00
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.56	0.56	0.00	100.00
2.H Other	CO_2	0.53	0.53	0.00	100.00
4(IV) Indirect N_2O Emissions from Managed Soils	N_2O	0.51	0.51	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.50	0.50	0.00	100.00
1.A.3.c Railways	N_2O	0.50	0.50	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0.33	0.33	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.32	0.32	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0.26	0.26	0.00	100.00
2.H Other	F-gases	0.18	0.18	0.00	100.00
1.A.3.a Domestic Aviation	N_2O	0.09	0.09	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.07	0.07	0.00	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.07	0.07	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.03	0.03	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.03	0.03	0.00	100.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	0.00	100.00
1.A.3.e Other Transportation	CH_4	0.01	0.01	0.00	100.00
1.A.3.e Other Transportation	N_2O	0.01	0.01	0.00	100.00
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	0.00	100.00
2.F.5 Solvents	F-gases	0.00	0.00	0.00	100.00

Tab. A1 2 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2022 – 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	4937.63	0.08	18.04	18.04
4.A.1 Forest Land remaining Forest Land	CO_2	-7266.06	6047.95	0.08	16.32	34.35
1.A.3.b Road Transportation	CO_2	10251.06	18916.69	0.06	12.68	47.03
1.A.4 Other Sectors - Solid Fuels	CO_2	24005.03	3158.16	0.06	12.32	59.36

IPCC Source Categories	GHG	Base Year Estimate	Current Year Estimate	Trend Assessment	% contribution to Trend	Cumulative total of contribution to trend
1.B.1.a Coal Mining and Handling	CH_4	11561.08	1845.24	0.03	5.60	64.96
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	38845.69	0.02	4.89	69.85
2.F.1 Refrigeration and Air conditioning	F-gases	0.00	3572.75	0.02	3.65	73.50
1.A.4 Other Sectors - Gaseous Fuels	CO_2	4173.90	6154.93	0.02	3.58	77.08
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	5502.33	545.40	0.01	3.01	80.09
5.A Solid Waste Disposal	CH_4	2007.82	3724.92	0.01	2.50	82.59
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	3001.65	0.01	2.20	84.79
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5685.63	5173.58	0.01	1.60	86.39
1.A.4 Other Sectors - Liquid Fuels	CO_2	3774.74	1223.42	0.01	1.20	87.59
5.B Biological treatment of solid waste	CH_4	0.00	737.62	0.00	0.75	88.34
1.A.4 Other Sectors - Solid Fuels	CH_4	1491.69	271.04	0.00	0.69	89.03
2.A.4 Other Process Uses of Carbonates	CO_2	113.86	739.50	0.00	0.68	89.71
3.G Liming	CO_2	1236.71	153.77	0.00	0.64	90.36
3.B Manure Management	CH_4	1574.96	375.14	0.00	0.64	90.99
2.C.1 Iron and Steel Production	CO_2	9782.03	5634.33	0.00	0.58	91.57
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.00	543.22	0.00	0.55	92.13
1.A.4 Other Sectors - Biomass	CH_4	363.17	767.46	0.00	0.55	92.68
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	428.22	0.00	0.54	93.22
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	1016.59	0.00	0.53	93.74
3.A Enteric Fermentation	CH_4	6611.86	3680.70	0.00	0.52	94.27
2.B.2 Nitric Acid Production	N_2O	932.80	104.49	0.00	0.50	94.76
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	3826.01	2839.60	0.00	0.42	95.19
4.G Harvested wood products	CO_2	-1680.47	-1946.26	0.00	0.36	95.54
4.C.1 Grassland remaining Grassland	CO_2	0.00	-310.86	0.00	0.32	95.86
2.A.2 Lime Production	CO_2	1336.65	555.89	0.00	0.30	96.16
2.A.1 Cement Production	CO_2	2489.18	1846.97	0.00	0.27	96.43
1.A.3.c Railways	CO_2	767.62	228.62	0.00	0.26	96.70
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	1170.32	485.49	0.00	0.26	96.96
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	261.38	0.00	0.25	97.21
3.B Manure Management	N_2O	996.40	386.96	0.00	0.25	97.46
1.B.1.a Coal Mining and Handling	CO_2	456.24	48.65	0.00	0.25	97.71
4.A.2 Land converted to Forest Land	CO_2	-234.97	-551.17	0.00	0.24	97.94
5.D Wastewater treatment and discharge	CH_4	1082.93	893.78	0.00	0.21	98.15
1.A.5.b Other mobile - Liquid Fuels	CO_2	192.04	266.27	0.00	0.15	98.30
2.B.10 Other	CO_2	0.00	139.01	0.00	0.14	98.44
3.H Urea application	CO_2	108.53	191.94	0.00	0.13	98.57
1.A.3.b Road Transportation	N_2O	82.69	174.46	0.00	0.12	98.69
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	1393.47	794.16	0.00	0.09	98.78
5.C Incineration and open burning of waste	CO_2	19.97	96.72	0.00	0.09	98.87
2.G Other Product Manufacture and Use	N_2O	183.38	198.75	0.00	0.08	98.96
1.A.4 Other Sectors - Biomass	N_2O	45.79	96.67	0.00	0.07	99.02
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	135.94	19.18	0.00	0.07	99.09
5.B Biological treatment of solid waste	N_2O	0.00	66.18	0.00	0.07	99.16
2.A.3 Glass Production	CO_2	142.75	145.87	0.00	0.06	99.22
2.B.1 Ammonia Production	CO_2	990.80	682.45	0.00	0.06	99.27
2.E Electronics industry	F-gases	0.00	53.55	0.00	0.05	99.33
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	96.04	13.56	0.00	0.05	99.38
1.A.4 Other Sectors - Solid Fuels	N_2O	91.86	13.28	0.00	0.05	99.42
4.D.2. Land converted to Wetlands	CO_2	24.10	56.53	0.00	0.04	99.46
5.D Wastewater treatment and discharge	N_2O	208.25	172.96	0.00	0.04	99.51

IPCC Source Categories	GHG	Base Year Estimate	Current Year Estimate	Trend Assessment	% contribution to Trend	Cumulative total of contribution to trend
1.A.1 Energy industries - Biomass	N_2O	0.43	32.22	0.00	0.03	99.54
2.F.3 Fire Protection	F-gases	0.00	31.41	0.00	0.03	99.57
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.51	55.59	0.00	0.03	99.60
1.A.3.b Road Transportation	CH_4	85.83	24.75	0.00	0.03	99.63
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	14.76	36.74	0.00	0.03	99.66
1.A.1 Energy industries - Biomass	CH_4	0.34	25.54	0.00	0.03	99.68
1.A.3.d Transport - Domestic navigation	CO_2	53.52	9.60	0.00	0.02	99.71
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	22.11	0.00	0.02	99.73
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	11.70	29.23	0.00	0.02	99.75
1.A.1 Energy industries - Solid Fuels	N_2O	213.31	155.06	0.00	0.02	99.77
1.A.3.e Other Transportation	CO_2	5.42	22.32	0.00	0.02	99.79
2.D.1 Lubricant Use	CO_2	116.13	88.42	0.00	0.02	99.81
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	13.76	21.34	0.00	0.01	99.82
1.A.3.a Domestic Aviation	CO_2	0.00	12.40	0.00	0.01	99.83
4.B.2 Land converted to Cropland	CO_2	120.78	64.27	0.00	0.01	99.85
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	68.82	55.40	0.00	0.01	99.86
1.A.4 Other Sectors - Gaseous Fuels	CH_4	10.72	15.45	0.00	0.01	99.87
4.A.1 Forest Land remaining Forest Land	CH_4	19.36	20.50	0.00	0.01	99.88
2.G Other Product Manufacture and Use	F-gases	86.83	63.11	0.00	0.01	99.88
4.E.2 Land converted to Settlements	CO_2	318.74	194.87	0.00	0.01	99.89
1.A.4 Other Sectors - Liquid Fuels	CH_4	13.05	1.17	0.00	0.01	99.90
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0.00	6.92	0.00	0.01	99.91
2.C.5 Lead Production	CO_2	4.04	9.37	0.00	0.01	99.91
4.C.2 Land converted to Grassland	CO_2	-143.86	-190.01	0.00	0.01	99.92
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	11.42	1.03	0.00	0.01	99.93
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0.00	5.48	0.00	0.01	99.93
5.C Incineration and open burning of waste	CH_4	0.00	5.30	0.00	0.01	99.94
2.C.6 Zinc Production	CO_2	8.70	0.92	0.00	0.00	99.94
1.B.1.b Solid Fuel Transformation	CH_4	0.84	5.10	0.00	0.00	99.95
5.C Incineration and open burning of waste	N_2O	0.46	4.63	0.00	0.00	99.95
4.A.1 Forest Land remaining Forest Land	N_2O	10.14	10.73	0.00	0.00	99.96
4.B.1 Cropland remaining Cropland	CO_2	-12.79	-21.26	0.00	0.00	99.96
2.C.2 Ferroalloys Production	CH_4	0.20	3.89	0.00	0.00	99.96
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	0.00	0.00	99.97
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	6.03	0.56	0.00	0.00	99.97
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.28	3.02	0.00	0.00	99.97
4.B.2. Land converted to Cropland	N_2O	7.92	2.27	0.00	0.00	99.98
2.F.4 Aerosols	F-gases	0.00	2.63	0.00	0.00	99.98
2.F.2 Foam Blowing Agents	F-gases	0.00	2.28	0.00	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.22	2.39	0.00	0.00	99.98
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	2.02	3.13	0.00	0.00	99.98
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2.03	2.92	0.00	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	2.94	0.33	0.00	0.00	99.99
1.A.5.b Other mobile - Liquid Fuels	N_2O	1.74	2.55	0.00	0.00	99.99
1.A.1 Energy industries - Solid Fuels	CH_4	15.72	11.23	0.00	0.00	99.99
2.C.1 Iron and Steel Production	CH_4	16.62	9.29	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.69	1.51	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.65	1.43	0.00	0.00	99.99

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 - Gaseous Fuels	CH_4	2.92	2.60	0.00	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	CH_4	1.59	0.26	0.00	0.00	100.00
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.76	2.46	0.00	0.00	100.00
4(IV) Indirect N_2O Emissions from Managed Soils	N_2O	1.78	0.51	0.00	0.00	100.00
2.H Other	CO_2	0.00	0.53	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.50	0.00	0.00	100.00
1.A.3.c Railways	N_2O	1.55	0.50	0.00	0.00	100.00
1.A.3.c Railways	CH_4	1.23	1.14	0.00	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	11.38	6.91	0.00	0.00	100.00
2.H Other	F-gases	0.00	0.18	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.38	0.07	0.00	0.00	100.00
1.A.3.a Domestic Aviation	N_2O	0.00	0.09	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.64	0.32	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.14	0.03	0.00	0.00	100.00
1.A.4 Other Sectors - Liquid Fuels	N_2O	17.85	11.26	0.00	0.00	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.17	0.07	0.00	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.02	0.03	0.00	0.00	100.00
1.A.3.e Other Transportation	CH_4	0.00	0.01	0.00	0.00	100.00
1.A.3.e Other Transportation	N_2O	0.00	0.01	0.00	0.00	100.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	0.00	0.00	100.00
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	0.00	0.00	100.00
2.F.5 Solvents	F-gases	0.00	0.00	0.00	0.00	100.00

Tab. A1 3 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2022 – Level Assessment excluding LULUCF

IPCC Source Categories	GHG	Latest Year Emission or Removal Estimate (Kt CO_2 eq.)	ABS Latest Year Emission or Removal Estimate (Kt CO_2 eq.)	LA, %	Cumulative Total (LA, %)
1.A.1 Energy industries - Solid Fuels	CO_2	38845.69	38845.69	33.19	33.19
1.A.3.b Road Transportation	CO_2	18916.69	18916.69	16.16	49.35
1.A.4 Other Sectors - Gaseous Fuels	CO_2	6154.93	6154.93	5.26	54.61
2.C.1 Iron and Steel Production	CO_2	5634.33	5634.33	4.81	59.42
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5173.58	5173.58	4.42	63.84
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	4937.63	4937.63	4.22	68.06
5.A Solid Waste Disposal	CH_4	3724.92	3724.92	3.18	71.24
3.A Enteric Fermentation	CH_4	3680.70	3680.70	3.14	74.39
2.F.1 Refrigeration and Air conditioning	F-gases	3572.75	3572.75	3.05	77.44
1.A.4 Other Sectors - Solid Fuels	CO_2	3158.16	3158.16	2.70	80.14
1.A.1 Energy industries - Gaseous Fuels	CO_2	3001.65	3001.65	2.56	82.70
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	2839.60	2839.60	2.43	85.13
2.A.1 Cement Production	CO_2	1846.97	1846.97	1.58	86.71
1.B.1.a Coal Mining and Handling	CH_4	1845.24	1845.24	1.58	88.28
1.A.4 Other Sectors - Liquid Fuels	CO_2	1223.42	1223.42	1.05	89.33
2.B.8 Petrochemical and Carbon Black Production	CO_2	1016.59	1016.59	0.87	90.20
5.D Wastewater treatment and discharge	CH_4	893.78	893.78	0.76	90.96
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	794.16	794.16	0.68	91.64
1.A.4 Other Sectors - Biomass	CH_4	767.46	767.46	0.66	92.29
2.A.4 Other Process Uses of Carbonates	CO_2	739.50	739.50	0.63	92.93
5.B Biological treatment of solid waste	CH_4	737.62	737.62	0.63	93.56
2.B.1 Ammonia Production	CO_2	682.45	682.45	0.58	94.14
2.A.2 Lime Production	CO_2	555.89	555.89	0.47	94.61

IPCC Source Categories	GHG	Latest Year Emission or Removal Estimate (Kt CO_2 eq.)	ABS Latest Year Emission or Removal Estimate (Kt CO_2 eq.)	LA, %	Cumulative Total (LA, %)
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	545.40	545.40	0.47	95.08
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	543.22	543.22	0.46	95.54
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	485.49	485.49	0.41	95.96
1.A.1 Energy industries - Liquid Fuels	CO_2	428.22	428.22	0.37	96.32
3.B Manure Management	N_2O	386.96	386.96	0.33	96.65
3.B Manure Management	CH_4	375.14	375.14	0.32	96.98
1.A.4 Other Sectors - Solid Fuels	CH_4	271.04	271.04	0.23	97.21
1.A.5.b Other mobile - Liquid Fuels	CO_2	266.27	266.27	0.23	97.43
1.A.1 Energy industries - Other Fossil Fuels	CO_2	261.38	261.38	0.22	97.66
1.A.3.c Railways	CO_2	228.62	228.62	0.20	97.85
2.G Other Product Manufacture and Use	N_2O	198.75	198.75	0.17	98.02
3.H Urea application	CO_2	191.94	191.94	0.16	98.19
1.A.3.b Road Transportation	N_2O	174.46	174.46	0.15	98.34
5.D Wastewater treatment and discharge	N_2O	172.96	172.96	0.15	98.48
1.A.1 Energy industries - Solid Fuels	N_2O	155.06	155.06	0.13	98.62
3.G Liming	CO_2	153.77	153.77	0.13	98.75
2.A.3 Glass Production	CO_2	145.87	145.87	0.12	98.87
2.B.10 Other	CO_2	139.01	139.01	0.12	98.99
2.B.2 Nitric Acid Production	N_2O	104.49	104.49	0.09	99.08
5.C Incineration and open burning of waste	CO_2	96.72	96.72	0.08	99.16
1.A.4 Other Sectors - Biomass	N_2O	96.67	96.67	0.08	99.25
2.D.1 Lubricant Use	CO_2	88.42	88.42	0.08	99.32
5.B Biological treatment of solid waste	N_2O	66.18	66.18	0.06	99.38
2.G Other Product Manufacture and Use	F-gases	63.11	63.11	0.05	99.43
2.B.8 Petrochemical and Carbon Black Production	CH_4	55.59	55.59	0.05	99.48
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	55.40	55.40	0.05	99.53
2.E Electronics industry	F-gases	53.55	53.55	0.05	99.57
1.B.1.a Coal Mining and Handling	CO_2	48.65	48.65	0.04	99.61
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	36.74	36.74	0.03	99.64
1.A.1 Energy industries - Biomass	N_2O	32.22	32.22	0.03	99.67
2.F.3 Fire Protection	F-gases	31.41	31.41	0.03	99.70
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	29.23	29.23	0.02	99.72
1.A.1 Energy industries - Biomass	CH_4	25.54	25.54	0.02	99.75
1.A.3.b Road Transportation	CH_4	24.75	24.75	0.02	99.77
1.A.3.e Other Transportation	CO_2	22.32	22.32	0.02	99.79
2.D.3 Other non-energy products from fuels and solvent use	CO_2	22.11	22.11	0.02	99.80
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	21.34	21.34	0.02	99.82
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	19.18	19.18	0.02	99.84
1.A.4 Other Sectors - Gaseous Fuels	CH_4	15.45	15.45	0.01	99.85
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	13.56	13.56	0.01	99.86
1.A.4 Other Sectors - Solid Fuels	N_2O	13.28	13.28	0.01	99.88
1.A.3.a Domestic Aviation	CO_2	12.40	12.40	0.01	99.89
1.A.4 Other Sectors - Liquid Fuels	N_2O	11.26	11.26	0.01	99.90
1.A.1 Energy industries - Solid Fuels	CH_4	11.23	11.23	0.01	99.91
1.A.3.d Transport - Domestic navigation	CO_2	9.60	9.60	0.01	99.91
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	0.01	99.92
2.C.5 Lead Production	CO_2	9.37	9.37	0.01	99.93
2.C.1 Iron and Steel Production	CH_4	9.29	9.29	0.01	99.94
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	6.92	6.92	0.01	99.94

IPCC Source Categories	GHG	Latest Year Emission or Removal Estimate (Kt CO_2 eq.)	ABS Latest Year Emission or Removal Estimate (Kt CO_2 eq.)	LA, %	Cumulative Total (LA, %)
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	6.91	6.91	0.01	99.95
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	5.48	5.48	0.00	99.95
5.C Incineration and open burning of waste	CH_4	5.30	5.30	0.00	99.96
1.B.1.b Solid Fuel Transformation	CH_4	5.10	5.10	0.00	99.96
5.C Incineration and open burning of waste	N_2O	4.63	4.63	0.00	99.97
2.C.2 Ferroalloys Production	CH_4	3.89	3.89	0.00	99.97
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	3.13	3.13	0.00	99.97
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3.02	3.02	0.00	99.98
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2.92	2.92	0.00	99.98
2.F.4 Aerosols	F-gases	2.63	2.63	0.00	99.98
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	2.60	2.60	0.00	99.98
1.A.5.b Other mobile - Liquid Fuels	N_2O	2.55	2.55	0.00	99.98
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.46	2.46	0.00	99.99
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2.39	2.39	0.00	99.99
2.F.2 Foam Blowing Agents	F-gases	2.28	2.28	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	CH_4	1.51	1.51	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	1.43	1.43	0.00	99.99
1.A.4 Other Sectors - Liquid Fuels	CH_4	1.17	1.17	0.00	99.99
1.A.3.c Railways	CH_4	1.14	1.14	0.00	100.00
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	1.03	1.03	0.00	100.00
2.C.6 Zinc Production	CO_2	0.92	0.92	0.00	100.00
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.56	0.56	0.00	100.00
2.H Other	CO_2	0.53	0.53	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.50	0.50	0.00	100.00
1.A.3.c Railways	N_2O	0.50	0.50	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	N_2O	0.33	0.33	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.32	0.32	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0.26	0.26	0.00	100.00
2.H Other	F-gases	0.18	0.18	0.00	100.00
1.A.3.a Domestic Aviation	N_2O	0.09	0.09	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.07	0.07	0.00	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.07	0.07	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.03	0.03	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.03	0.03	0.00	100.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	0.00	100.00
1.A.3.e Other Transportation	CH_4	0.01	0.01	0.00	100.00
1.A.3.e Other Transportation	N_2O	0.01	0.01	0.00	100.00
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	0.00	100.00
2.F.5 Solvents	F-gases	0.00	0.00	0.00	100.00

Tab. A1 4 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 2022 – 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	4937.63	0.08	20.07	20.07
1.A.3.b Road Transportation	CO_2	10251.06	18916.69	0.06	16.11	36.17
1.A.4 Other Sectors - Solid Fuels	CO_2	24005.03	3158.16	0.06	13.73	49.90

IPCC Source Categories	GHG	Base Year Estimate	Current Year Estimate	Trend Assessment	% contribution to Trend	Cumulative total of contribution to trend
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	38845.69	0.04	9.02	58.92
1.B.1.a Coal Mining and Handling	CH_4	11561.08	1845.24	0.02	6.21	65.13
1.A.4 Other Sectors - Gaseous Fuels	CO_2	4173.90	6154.93	0.02	4.62	69.75
2.F.1 Refrigeration and Air conditioning	F-gases	0.00	3572.75	0.02	4.47	74.22
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	5502.33	545.40	0.01	3.37	77.59
5.A Solid Waste Disposal	CH_4	2007.82	3724.92	0.01	3.18	80.77
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	3001.65	0.01	2.77	83.54
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5685.63	5173.58	0.01	2.28	85.82
1.A.4 Other Sectors - Liquid Fuels	CO_2	3774.74	1223.42	0.01	1.25	87.07
5.B Biological treatment of solid waste	CH_4	0.00	737.62	0.00	0.92	87.99
2.A.4 Other Process Uses of Carbonates	CO_2	113.86	739.50	0.00	0.84	88.83
1.A.4 Other Sectors - Solid Fuels	CH_4	1491.69	271.04	0.00	0.76	89.59
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	3826.01	2839.60	0.00	0.73	90.33
3.G Liming	CO_2	1236.71	153.77	0.00	0.72	91.05
1.A.4 Other Sectors - Biomass	CH_4	363.17	767.46	0.00	0.69	91.74
3.B Manure Management	CH_4	1574.96	375.14	0.00	0.69	92.43
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	1016.59	0.00	0.69	93.12
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.00	543.22	0.00	0.68	93.80
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	428.22	0.00	0.58	94.37
2.B.2 Nitric Acid Production	N_2O	932.80	104.49	0.00	0.56	94.93
2.A.1 Cement Production	CO_2	2489.18	1846.97	0.00	0.48	95.41
5.D Wastewater treatment and discharge	CH_4	1082.93	893.78	0.00	0.32	95.73
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	261.38	0.00	0.31	96.04
2.A.2 Lime Production	CO_2	1336.65	555.89	0.00	0.29	96.33
1.A.3.c Railways	CO_2	767.62	228.62	0.00	0.28	96.61
1.B.1.a Coal Mining and Handling	CO_2	456.24	48.65	0.00	0.28	96.88
3.A Enteric Fermentation	CH_4	6611.86	3680.70	0.00	0.27	97.15
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	1170.32	485.49	0.00	0.25	97.40
3.B Manure Management	N_2O	996.40	386.96	0.00	0.25	97.65
1.A.5.b Other mobile - Liquid Fuels	CO_2	192.04	266.27	0.00	0.19	97.84
2.B.10 Other	CO_2	0.00	139.01	0.00	0.17	98.02
3.H Urea application	CO_2	108.53	191.94	0.00	0.16	98.18
2.C.1 Iron and Steel Production	CO_2	9782.03	5634.33	0.00	0.16	98.33
1.A.3.b Road Transportation	N_2O	82.69	174.46	0.00	0.16	98.49
2.B.1 Ammonia Production	CO_2	990.80	682.45	0.00	0.12	98.62
2.G Other Product Manufacture and Use	N_2O	183.38	198.75	0.00	0.11	98.73
5.C Incineration and open burning of waste	CO_2	19.97	96.72	0.00	0.11	98.84
1.A.4 Other Sectors - Biomass	N_2O	45.79	96.67	0.00	0.09	98.92
5.B Biological treatment of solid waste	N_2O	0.00	66.18	0.00	0.08	99.01
2.A.3 Glass Production	CO_2	142.75	145.87	0.00	0.08	99.08
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	135.94	19.18	0.00	0.08	99.16
2.E Electronics industry	F-gases	0.00	53.55	0.00	0.07	99.23
5.D Wastewater treatment and discharge	N_2O	208.25	172.96	0.00	0.06	99.29
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	96.04	13.56	0.00	0.05	99.34
1.A.4 Other Sectors - Solid Fuels	N_2O	91.86	13.28	0.00	0.05	99.39
1.A.1 Energy industries - Biomass	N_2O	0.43	32.22	0.00	0.04	99.43
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.51	55.59	0.00	0.04	99.47
2.F.3 Fire Protection	F-gases	0.00	31.41	0.00	0.04	99.51
1.A.1 Energy industries - Solid Fuels	N_2O	213.31	155.06	0.00	0.04	99.55
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	14.76	36.74	0.00	0.04	99.58
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	1393.47	794.16	0.00	0.03	99.62

IPCC Source Categories	GHG	Base Year Estimate	Current Year Estimate	Trend Assessment	% contribution to Trend	Cumulative total of contribution to trend
1.A.3.b Road Transportation	CH_4	85.83	24.75	0.00	0.03	99.65
1.A.1 Energy industries - Biomass	CH_4	0.34	25.54	0.00	0.03	99.68
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	11.70	29.23	0.00	0.03	99.71
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	22.11	0.00	0.03	99.74
1.A.3.d Transport - Domestic navigation	CO_2	53.52	9.60	0.00	0.03	99.76
2.D.1 Lubricant Use	CO_2	116.13	88.42	0.00	0.03	99.79
1.A.3.e Other Transportation	CO_2	5.42	22.32	0.00	0.02	99.81
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	68.82	55.40	0.00	0.02	99.83
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	13.76	21.34	0.00	0.02	99.85
1.A.3.a Domestic Aviation	CO_2	0.00	12.40	0.00	0.02	99.86
2.G Other Product Manufacture and Use	F-gases	86.83	63.11	0.00	0.01	99.88
1.A.4 Other Sectors - Gaseous Fuels	CH_4	10.72	15.45	0.00	0.01	99.89
2.C.5 Lead Production	CO_2	4.04	9.37	0.00	0.01	99.90
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0.00	6.92	0.00	0.01	99.91
1.A.4 Other Sectors - Liquid Fuels	CH_4	13.05	1.17	0.00	0.01	99.92
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	11.42	1.03	0.00	0.01	99.92
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0.00	5.48	0.00	0.01	99.93
5.C Incineration and open burning of waste	CH_4	0.00	5.30	0.00	0.01	99.94
1.B.1.b Solid Fuel Transformation	CH_4	0.84	5.10	0.00	0.01	99.94
5.C Incineration and open burning of waste	N_2O	0.46	4.63	0.00	0.01	99.95
2.C.6 Zinc Production	CO_2	8.70	0.92	0.00	0.01	99.95
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	0.00	0.00	99.96
2.C.2 Ferroalloys Production	CH_4	0.20	3.89	0.00	0.00	99.96
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	6.03	0.56	0.00	0.00	99.97
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.28	3.02	0.00	0.00	99.97
2.F.4 Aerosols	F-gases	0.00	2.63	0.00	0.00	99.97
2.F.2 Foam Blowing Agents	F-gases	0.00	2.28	0.00	0.00	99.98
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.22	2.39	0.00	0.00	99.98
1.A.1 Energy industries - Solid Fuels	CH_4	15.72	11.23	0.00	0.00	99.98
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	2.02	3.13	0.00	0.00	99.98
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2.03	2.92	0.00	0.00	99.99
1.A.5.b Other mobile - Liquid Fuels	N_2O	1.74	2.55	0.00	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	2.94	0.33	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.69	1.51	0.00	0.00	99.99
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.65	1.43	0.00	0.00	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	2.92	2.60	0.00	0.00	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.76	2.46	0.00	0.00	99.99
1.A.4 Other Sectors - Liquid Fuels	N_2O	17.85	11.26	0.00	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.59	0.26	0.00	0.00	100.00
2.H Other	CO_2	0.00	0.53	0.00	0.00	100.00
2.C.1 Iron and Steel Production	CH_4	16.62	9.29	0.00	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.50	0.00	0.00	100.00
1.A.3.c Railways	N_2O	1.55	0.50	0.00	0.00	100.00
1.A.3.c Railways	CH_4	1.23	1.14	0.00	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	11.38	6.91	0.00	0.00	100.00
2.H Other	F-gases	0.00	0.18	0.00	0.00	100.00

IPCC Source Categories	GHG	Base Year Estimate	Current Year Estimate	Trend Assessment	% contribution to Trend	Cumulative total of contribution to trend
1.A.3.d Transport - Domestic navigation	N_2O	0.38	0.07	0.00	0.00	100.00
1.A.3.a Domestic Aviation	N_2O	0.00	0.09	0.00	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.14	0.03	0.00	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.64	0.32	0.00	0.00	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.17	0.07	0.00	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.02	0.03	0.00	0.00	100.00
1.A.3.e Other Transportation	CH_4	0.00	0.01	0.00	0.00	100.00
1.A.3.e Other Transportation	N_2O	0.00	0.01	0.00	0.00	100.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	0.00	0.00	100.00
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	0.00	0.00	100.00
2.F.5 Solvents	F-gases	0.00	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	25.75	25.75
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	35635.57	35635.57	17.08	42.83
1.A.4 Other Sectors - Solid Fuels	CO_2	24005.03	24005.03	11.51	54.34
1.B.1.a Coal Mining and Handling	CH_4	11561.08	11561.08	5.54	59.88
1.A.3.b Road Transportation	CO_2	10251.06	10251.06	4.91	64.80
2.C.1 Iron and Steel Production	CO_2	9782.03	9782.03	4.69	69.49
4.A.1 Forest Land remaining Forest Land	CO_2	-7266.06	7266.06	3.48	72.97
3.A Enteric Fermentation	CH_4	6611.86	6611.86	3.17	76.14
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5685.63	5685.63	2.73	78.86
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	5502.33	5502.33	2.64	81.50
1.A.4 Other Sectors - Gaseous Fuels	CO_2	4173.90	4173.90	2.00	83.50
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	3826.01	3826.01	1.83	85.34
1.A.4 Other Sectors - Liquid Fuels	CO_2	3774.74	3774.74	1.81	87.15
2.A.1 Cement Production	CO_2	2489.18	2489.18	1.19	88.34
5.A Solid Waste Disposal	CH_4	2007.82	2007.82	0.96	89.30
4.G Harvested wood products	CO_2	-1680.47	1680.47	0.81	90.11
3.B Manure Management	CH_4	1574.96	1574.96	0.75	90.86
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	1514.04	0.73	91.59
1.A.4 Other Sectors - Solid Fuels	CH_4	1491.69	1491.69	0.72	92.30
3.D.2 Indirect N2O Emissions From Managed Soils	N_2O	1393.47	1393.47	0.67	92.97
2.A.2 Lime Production	CO_2	1336.65	1336.65	0.64	93.61
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	1336.03	0.64	94.25
3.G Liming	CO_2	1236.71	1236.71	0.59	94.85
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	1170.32	1170.32	0.56	95.41
5.D Wastewater treatment and discharge	CH_4	1082.93	1082.93	0.52	95.93
3.B Manure Management	N_2O	996.40	996.40	0.48	96.40
2.B.1 Ammonia Production	CO_2	990.80	990.80	0.47	96.88
2.B.2 Nitric Acid Production	N_2O	932.80	932.80	0.45	97.33
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	792.47	0.38	97.71
1.A.3.c Railways	CO_2	767.62	767.62	0.37	98.07
1.B.1.a Coal Mining and Handling	CO_2	456.24	456.24	0.22	98.29
1.A.4 Other Sectors - Biomass	CH_4	363.17	363.17	0.17	98.47
4.E.2 Land converted to Settlements	CO_2	318.74	318.74	0.15	98.62
4.A.2 Land converted to Forest Land	CO_2	-234.97	234.97	0.11	98.73
1.A.1 Energy industries - Solid Fuels	N_2O	213.31	213.31	0.10	98.83
5.D Wastewater treatment and discharge	N_2O	208.25	208.25	0.10	98.93
1.A.5.b Other mobile - Liquid Fuels	CO_2	192.04	192.04	0.09	99.03

IPCC Source Categories	GHG	Base Year Estimate	Base Year Estimate (Abs)	Level Assessment	Cumulative Total (LA)
2.G Other Product Manufacture and Use	N_2O	183.38	183.38	0.09	99.11
4.C.2 Land converted to Grassland	CO_2	-143.86	143.86	0.07	99.18
2.A.3 Glass Production	CO_2	142.75	142.75	0.07	99.25
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	135.94	135.94	0.07	99.32
4.B.2 Land converted to Cropland	CO_2	120.78	120.78	0.06	99.37
2.D.1 Lubricant Use	CO_2	116.13	116.13	0.06	99.43
2.A.4 Other Process Uses of Carbonates	CO_2	113.86	113.86	0.05	99.48
3.H Urea application	CO_2	108.53	108.53	0.05	99.54
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	96.04	96.04	0.05	99.58
1.A.4 Other Sectors - Solid Fuels	N_2O	91.86	91.86	0.04	99.63
2.G Other Product Manufacture and Use	F-gases	86.83	86.83	0.04	99.67
1.A.3.b Road Transportation	CH_4	85.83	85.83	0.04	99.71
1.A.3.b Road Transportation	N_2O	82.69	82.69	0.04	99.75
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	68.82	68.82	0.03	99.78
1.A.3.d Transport - Domestic navigation	CO_2	53.52	53.52	0.03	99.81
1.A.4 Other Sectors - Biomass	N_2O	45.79	45.79	0.02	99.83
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.51	40.51	0.02	99.85
4.D.2. Land converted to Wetlands	CO_2	24.10	24.10	0.01	99.86
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	24.04	0.01	99.87
5.C Incineration and open burning of waste	CO_2	19.97	19.97	0.01	99.88
4.A.1 Forest Land remaining Forest Land	CH_4	19.36	19.36	0.01	99.89
1.A.4 Other Sectors - Liquid Fuels	N_2O	17.85	17.85	0.01	99.90
2.C.1 Iron and Steel Production	CH_4	16.62	16.62	0.01	99.91
1.A.1 Energy industries - Solid Fuels	CH_4	15.72	15.72	0.01	99.92
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	14.76	14.76	0.01	99.92
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	13.76	13.76	0.01	99.93
1.A.4 Other Sectors - Liquid Fuels	CH_4	13.05	13.05	0.01	99.93
4.B.1 Cropland remaining Cropland	CO_2	-12.79	12.79	0.01	99.94
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	11.70	11.70	0.01	99.95
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	11.42	11.42	0.01	99.95
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	11.38	11.38	0.01	99.96
1.A.4 Other Sectors - Gaseous Fuels	CH_4	10.72	10.72	0.01	99.96
4.A.1 Forest Land remaining Forest Land	N_2O	10.14	10.14	0.00	99.97
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	0.00	99.97
2.C.6 Zinc Production	CO_2	8.70	8.70	0.00	99.98
4.B.2. Land converted to Cropland	N_2O	7.92	7.92	0.00	99.98
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	6.03	6.03	0.00	99.98
1.A.3.e Other Transportation	CO_2	5.42	5.42	0.00	99.99
2.C.5 Lead Production	CO_2	4.04	4.04	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	2.94	2.94	0.00	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	2.92	2.92	0.00	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.76	2.76	0.00	99.99
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2.03	2.03	0.00	99.99
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	2.02	2.02	0.00	99.99
4(IV) Indirect N_2O Emissions from Managed Soils	N_2O	1.78	1.78	0.00	99.99
1.A.5.b Other mobile - Liquid Fuels	N_2O	1.74	1.74	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.59	1.59	0.00	100.00
1.A.3.c Railways	N_2O	1.55	1.55	0.00	100.00
1.A.3.c Railways	CH_4	1.23	1.23	0.00	100.00
1.B.1.b Solid Fuel Transformation	CH_4	0.84	0.84	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.69	0.69	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.65	0.65	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.64	0.64	0.00	100.00
5.C Incineration and open burning of waste	N_2O	0.46	0.46	0.00	100.00
1.A.1 Energy industries - Biomass	N_2O	0.43	0.43	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.38	0.38	0.00	100.00
1.A.1 Energy industries - Biomass	CH_4	0.34	0.34	0.00	100.00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.28	0.28	0.00	100.00
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.22	0.22	0.00	100.00

IPCC Source Categories	GHG	Base Year Estimate	Base Year Estimate (Abs)	Level Assessment	Cumulative Total (LA)
2.C.2 Ferroalloys Production	CH_4	0.20	0.20	0.00	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.17	0.17	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.14	0.14	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.03	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.02	0.02	0.00	100.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	0.00	100.00
1.A.3.e Other Transportation	CH_4	0.00	0.00	0.00	100.00
1.A.3.e Other Transportation	N_2O	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.3.a Domestic Aviation	CO_2	0.00	0.00	0.00	100.00
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	0.00	100.00
1.A.3.a Domestic Aviation	N_2O	0.00	0.00	0.00	100.00
2.B.10 Other	CO_2	0.00	0.00	0.00	100.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	0.00	0.00	100.00
2.E Electronics industry	F-gases	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air conditioning	F-gases	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing Agents	F-gases	0.00	0.00	0.00	100.00
2.F.3 Fire Protection	F-gases	0.00	0.00	0.00	100.00
2.F.4 Aerosols	F-gases	0.00	0.00	0.00	100.00
2.F.5 Solvents	F-gases	0.00	0.00	0.00	100.00
2.H Other	CO_2	0.00	0.00	0.00	100.00
2.H Other	F-gases	0.00	0.00	0.00	100.00
4.C.1 Grassland remaining Grassland	CO_2	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	CH_4	0.00	0.00	0.00	100.00
5.B Biological treatment of solid waste	N_2O	0.00	0.00	0.00	100.00

Tab. A1 6 Spreadsheet for Approach 1 KC IPCC 2006 Gl., 1990 – Level Assessment excluding LULUCF

IPCC Source Categories	GHG	Base Year Estimate	Base Year Estimate (Abs)	Level Assessment	Cumulative Total (LA)
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	53719.76	26.33	26.33
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	35635.57	35635.57	17.46	43.79
1.A.4 Other Sectors - Solid Fuels	CO_2	24005.03	24005.03	11.76	55.56
1.B.1.a Coal Mining and Handling	CH_4	11561.08	11561.08	5.67	61.22
1.A.3.b Road Transportation	CO_2	10251.06	10251.06	5.02	66.25
2.C.1 Iron and Steel Production	CO_2	9782.03	9782.03	4.79	71.04
4.A.1 Forest Land remaining Forest Land	CO_2	-7266.06	7266.06	3.56	74.60
3.A Enteric Fermentation	CH_4	6611.86	6611.86	3.24	77.84
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5685.63	5685.63	2.79	80.63
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	5502.33	5502.33	2.70	83.33
1.A.4 Other Sectors - Gaseous Fuels	CO_2	4173.90	4173.90	2.05	85.37
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	3826.01	3826.01	1.88	87.25
1.A.4 Other Sectors - Liquid Fuels	CO_2	3774.74	3774.74	1.85	89.10
2.A.1 Cement Production	CO_2	2489.18	2489.18	1.22	90.32
3.B Manure Management	CH_4	1574.96	1574.96	0.77	91.09
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	1514.04	0.74	91.83
1.A.4 Other Sectors - Solid Fuels	CH_4	1491.69	1491.69	0.73	92.56
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	1393.47	1393.47	0.68	93.24
2.A.2 Lime Production	CO_2	1336.65	1336.65	0.66	93.90
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	1336.03	0.65	94.55
3.G Liming	CO_2	1236.71	1236.71	0.61	95.16
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	1170.32	1170.32	0.57	95.73
5.D Wastewater treatment and discharge	CH_4	1082.93	1082.93	0.53	96.26
3.B Manure Management	N_2O	996.40	996.40	0.49	96.75

IPCC Source Categories	GHG	Base Year Estimate	Base Year Estimate (Abs)	Level Assessment	Cumulative Total (LA)
2.B.1 Ammonia Production	CO_2	990.80	990.80	0.49	97.24
2.B.2 Nitric Acid Production	N_2O	932.80	932.80	0.46	97.69
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	792.47	0.39	98.08
1.A.3.c Railways	CO_2	767.62	767.62	0.38	98.46
1.B.1.a Coal Mining and Handling	CO_2	456.24	456.24	0.22	98.68
1.A.4 Other Sectors - Biomass	CH_4	363.17	363.17	0.18	98.86
1.A.1 Energy industries - Solid Fuels	N_2O	213.31	213.31	0.10	98.97
5.D Wastewater treatment and discharge	N_2O	208.25	208.25	0.10	99.07
1.A.5.b Other mobile - Liquid Fuels	CO_2	192.04	192.04	0.09	99.16
2.G Other Product Manufacture and Use	N_2O	183.38	183.38	0.09	99.25
2.A.3 Glass Production	CO_2	142.75	142.75	0.07	99.32
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	135.94	135.94	0.07	99.39
2.D.1 Lubricant Use	CO_2	116.13	116.13	0.06	99.45
2.A.4 Other Process Uses of Carbonates	CO_2	113.86	113.86	0.06	99.50
3.H Urea application	CO_2	108.53	108.53	0.05	99.55
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	96.04	96.04	0.05	99.60
1.A.4 Other Sectors - Solid Fuels	N_2O	91.86	91.86	0.05	99.65
2.G Other Product Manufacture and Use	F-gases	86.83	86.83	0.04	99.69
1.A.3.b Road Transportation	CH_4	85.83	85.83	0.04	99.73
1.A.3.b Road Transportation	N_2O	82.69	82.69	0.04	99.77
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	68.82	68.82	0.03	99.80
1.A.3.d Transport - Domestic navigation	CO_2	53.52	53.52	0.03	99.83
1.A.4 Other Sectors - Biomass	N_2O	45.79	45.79	0.02	99.85
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.51	40.51	0.02	99.87
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	24.04	0.01	99.89
5.C Incineration and open burning of waste	CO_2	19.97	19.97	0.01	99.90
4.A.1 Forest Land remaining Forest Land	CH_4	19.36	19.36	0.01	99.90
1.A.4 Other Sectors - Liquid Fuels	N_2O	17.85	17.85	0.01	99.91
2.C.1 Iron and Steel Production	CH_4	16.62	16.62	0.01	99.92
1.A.1 Energy industries - Solid Fuels	CH_4	15.72	15.72	0.01	99.93
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	14.76	14.76	0.01	99.94
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	13.76	13.76	0.01	99.94
1.A.4 Other Sectors - Liquid Fuels	CH_4	13.05	13.05	0.01	99.95
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	11.70	11.70	0.01	99.96
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	11.42	11.42	0.01	99.96
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	11.38	11.38	0.01	99.97
1.A.4 Other Sectors - Gaseous Fuels	CH_4	10.72	10.72	0.01	99.97
4.A.1 Forest Land remaining Forest Land	N_2O	10.14	10.14	0.00	99.98
2.C.6 Zinc Production	CO_2	8.70	8.70	0.00	99.98
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	6.03	6.03	0.00	99.98
1.A.3.e Other Transportation	CO_2	5.42	5.42	0.00	99.99
2.C.5 Lead Production	CO_2	4.04	4.04	0.00	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	2.94	2.94	0.00	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	2.92	2.92	0.00	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.76	2.76	0.00	99.99
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2.03	2.03	0.00	99.99
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	2.02	2.02	0.00	99.99
1.A.5.b Other mobile - Liquid Fuels	N_2O	1.74	1.74	0.00	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	1.59	1.59	0.00	100.00
1.A.3.c Railways	N_2O	1.55	1.55	0.00	100.00
1.A.3.c Railways	CH_4	1.23	1.23	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.69	0.69	0.00	100.00
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.65	0.65	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.64	0.64	0.00	100.00
5.C Incineration and open burning of waste	N_2O	0.46	0.46	0.00	100.00
1.A.1 Energy industries - Biomass	N_2O	0.43	0.43	0.00	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.38	0.38	0.00	100.00
1.A.1 Energy industries - Biomass	CH_4	0.34	0.34	0.00	100.00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.28	0.28	0.00	100.00

IPCC Source Categories	GHG	Base Year Estimate	Base Year Estimate (Abs)	Level Assessment	Cumulative Total (LA)
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.22	0.22	0.00	100.00
2.C.2 Ferroalloys Production	CH_4	0.20	0.20	0.00	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.17	0.17	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.14	0.14	0.00	100.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.03	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.02	0.02	0.00	100.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	0.00	100.00
1.A.3.e Other Transportation	CH_4	0.00	0.00	0.00	100.00
1.A.3.e Other Transportation	N_2O	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.3.a Domestic Aviation	CO_2	0.00	0.00	0.00	100.00
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	0.00	100.00
1.A.3.a Domestic Aviation	N_2O	0.00	0.00	0.00	100.00
2.B.10 Other	CO_2	0.00	0.00	0.00	100.00
2.E Electronics industry	F-gases	0.00	0.00	0.00	100.00
2.F.1 Refrigeration and Air conditioning	F-gases	0.00	0.00	0.00	100.00
2.F.2 Foam Blowing Agents	F-gases	0.00	0.00	0.00	100.00
2.F.3 Fire Protection	F-gases	0.00	0.00	0.00	100.00
2.F.4 Aerosols	F-gases	0.00	0.00	0.00	100.00
2.F.5 Solvents	F-gases	0.00	0.00	0.00	100.00
2.H Other	CO_2	0.00	0.00	0.00	100.00
2.H Other	F-gases	0.00	0.00	0.00	100.00

Tab. A1 7 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2022 – 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)
5.A Solid Waste Disposal	CH_4	3724.92	3724.92	63.70	2.95	187.62	12.96	2.95	1.02	12.96
4.A.1 Forest Land remaining Forest Land	CO_2	6047.95	6047.95	38.05	4.78	181.94	12.57	4.78	0.61	25.53
2.F.1 Refrigeration and Air conditioning	F-gases	3572.75	3572.75	43.57	2.83	123.08	8.50	2.83	0.70	34.03
1.A.1 Energy industries - Solid Fuels	CO_2	38845.69	38845.69	3.29	30.72	100.92	6.97	30.72	0.05	41.01
4.G Harvested wood products	CO_2	-1946.26	1946.26	62.00	1.54	95.42	6.59	1.54	0.99	47.60
1.B.1.a Coal Mining and Handling	CH_4	1845.24	1845.24	38.20	1.46	55.73	3.85	1.46	0.61	51.45
1.A.3.b Road Transportation	CO_2	18916.69	18916.69	3.68	14.96	55.01	3.80	14.96	0.06	55.25
2.C.1 Iron and Steel Production	CO_2	5634.33	5634.33	12.21	4.46	54.38	3.76	4.46	0.20	59.01
5.B Biological treatment of solid waste	CH_4	737.62	737.62	91.29	0.58	53.24	3.68	0.58	1.46	62.69
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	2839.60	2839.60	20.62	2.25	46.29	3.20	2.25	0.33	65.88
3.A Enteric Fermentation	CH_4	3680.70	3680.70	15.81	2.91	46.02	3.18	2.91	0.25	69.06
5.D Wastewater treatment and discharge	CH_4	893.78	893.78	58.38	0.71	41.26	2.85	0.71	0.93	71.91
2.B.8 Petrochemical and Carbon Black Production	CO_2	1016.59	1016.59	40.31	0.80	32.40	2.24	0.80	0.65	74.15

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.4 Other Sectors - Biomass	CH_4	767.46	767.46	52.08	0.61	31.61	2.18	0.61	0.83	76.34
1.A.3.b Road Transportation	N_2O	174.46	174.46	189.30	0.14	26.11	1.80	0.14	3.03	78.14
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	543.22	543.22	60.70	0.43	26.07	1.80	0.43	0.97	79.94
1.A.4 Other Sectors - Solid Fuels	CO_2	3158.16	3158.16	9.93	2.50	24.80	1.71	2.50	0.16	81.65
1.A.4 Other Sectors - Gaseous Fuels	CO_2	6154.93	6154.93	4.74	4.87	23.08	1.59	4.87	0.08	83.25
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	794.16	794.16	30.41	0.63	19.10	1.32	0.63	0.49	84.57
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	485.49	485.49	49.72	0.38	19.09	1.32	0.38	0.80	85.89
3.B Manure Management	N_2O	386.96	386.96	40.31	0.31	12.33	0.85	0.31	0.65	86.74
1.A.4 Other Sectors - Solid Fuels	CH_4	271.04	271.04	55.86	0.21	11.97	0.83	0.21	0.89	87.57
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	4937.63	4937.63	2.79	3.90	10.91	0.75	3.90	0.04	88.32
4.A.2 Land converted to Forest Land	CO_2	-551.17	551.17	24.02	0.44	10.47	0.72	0.44	0.38	89.04
4.C.1 Grassland remaining Grassland	CO_2	-310.86	310.86	40.69	0.25	10.00	0.69	0.25	0.65	89.73
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5173.58	5173.58	2.24	4.09	9.17	0.63	4.09	0.04	90.37
1.A.1 Energy industries - Solid Fuels	N_2O	155.06	155.06	70.05	0.12	8.59	0.59	0.12	1.12	90.96
4.C.2 Land converted to Grassland	CO_2	-190.01	190.01	54.54	0.15	8.19	0.57	0.15	0.87	91.53
3.H Urea application	CO_2	191.94	191.94	52.20	0.15	7.92	0.55	0.15	0.84	92.08
5.D Wastewater treatment and discharge	N_2O	172.96	172.96	56.36	0.14	7.71	0.53	0.14	0.90	92.61
2.G Other Product Manufacture and Use	N_2O	198.75	198.75	43.57	0.16	6.85	0.47	0.16	0.70	93.08
3.B Manure Management	CH_4	375.14	375.14	22.36	0.30	6.63	0.46	0.30	0.36	93.54
2.A.4 Other Process Uses of Carbonates	CO_2	739.50	739.50	11.18	0.58	6.54	0.45	0.58	0.18	93.99
4.E.2 Land converted to Settlements	CO_2	194.87	194.87	42.04	0.15	6.48	0.45	0.15	0.67	94.44
1.A.4 Other Sectors - Liquid Fuels	CO_2	1223.42	1223.42	6.23	0.97	6.03	0.42	0.97	0.10	94.85
1.A.4 Other Sectors - Biomass	N_2O	96.67	96.67	71.50	0.08	5.47	0.38	0.08	1.14	95.23
1.A.3.b Road Transportation	CH_4	24.75	24.75	239.40	0.02	4.68	0.32	0.02	3.83	95.56
2.B.1 Ammonia Production	CO_2	682.45	682.45	8.60	0.54	4.64	0.32	0.54	0.14	95.88
1.A.1 Energy industries - Gaseous Fuels	CO_2	3001.65	3001.65	1.90	2.37	4.51	0.31	2.37	0.03	96.19

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)
2.A.1 Cement Production	CO_2	1846.97	1846.97	2.83	1.46	4.13	0.29	1.46	0.05	96.47
1.A.1 Energy industries - Other Fossil Fuels	CO_2	261.38	261.38	19.12	0.21	3.95	0.27	0.21	0.31	96.75
3.G Liming	CO_2	153.77	153.77	30.41	0.12	3.70	0.26	0.12	0.49	97.00
2.D.1 Lubricant Use	CO_2	88.42	88.42	50.25	0.07	3.51	0.24	0.07	0.80	97.24
2.G Other Product Manufacture and Use	F-gases	63.11	63.11	43.57	0.05	2.17	0.15	0.05	0.70	97.39
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	36.74	36.74	70.36	0.03	2.04	0.14	0.03	1.13	97.54
1.A.1 Energy industries - Biomass	N_2O	32.22	32.22	70.29	0.03	1.79	0.12	0.03	1.13	97.66
2.B.8 Petrochemical and Carbon Black Production	CH_4	55.59	55.59	40.31	0.04	1.77	0.12	0.04	0.65	97.78
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	55.40	55.40	40.31	0.04	1.77	0.12	0.04	0.65	97.90
4.D.2. Land converted to Wetlands	CO_2	56.53	56.53	39.47	0.04	1.76	0.12	0.04	0.63	98.03
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	545.40	545.40	3.89	0.43	1.68	0.12	0.43	0.06	98.14
4.B.2 Land converted to Cropland	CO_2	64.27	64.27	25.79	0.05	1.31	0.09	0.05	0.41	98.23
2.B.2 Nitric Acid Production	N_2O	104.49	104.49	15.52	0.08	1.28	0.09	0.08	0.25	98.32
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	21.34	21.34	74.33	0.02	1.25	0.09	0.02	1.19	98.41
2.A.2 Lime Production	CO_2	555.89	555.89	2.83	0.44	1.24	0.09	0.44	0.05	98.49
5.C Incineration and open burning of waste	CO_2	96.72	96.72	15.81	0.08	1.21	0.08	0.08	0.25	98.58
1.A.1 Energy industries - Liquid Fuels	CO_2	428.22	428.22	3.54	0.34	1.20	0.08	0.34	0.06	98.66
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	29.23	29.23	50.51	0.02	1.17	0.08	0.02	0.81	98.74
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	19.18	19.18	70.03	0.02	1.06	0.07	0.02	1.12	98.81
2.F.3 Fire Protection	F-gases	31.41	31.41	41.88	0.02	1.04	0.07	0.02	0.67	98.89
1.A.1 Energy industries - Biomass	CH_4	25.54	25.54	50.40	0.02	1.02	0.07	0.02	0.81	98.96
1.A.5.b Other mobile - Liquid Fuels	CO_2	266.27	266.27	4.80	0.21	1.01	0.07	0.21	0.08	99.03
1.B.1.a Coal Mining and Handling	CO_2	48.65	48.65	26.04	0.04	1.00	0.07	0.04	0.42	99.10
1.A.3.c Railways	CO_2	228.62	228.62	5.24	0.18	0.95	0.07	0.18	0.08	99.16
1.A.4 Other Sectors - Solid Fuels	N_2O	13.28	13.28	70.68	0.01	0.74	0.05	0.01	1.13	99.21
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	13.56	13.56	65.04	0.01	0.70	0.05	0.01	1.04	99.26
4.A.1 Forest Land remaining Forest Land	CH_4	20.50	20.50	41.91	0.02	0.68	0.05	0.02	0.67	99.31

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)
2.E Electronics industry	F-gases	53.55	53.55	15.30	0.04	0.65	0.04	0.04	0.24	99.35
1.A.4 Other Sectors - Liquid Fuels	N_2O	11.26	11.26	70.21	0.01	0.63	0.04	0.01	1.12	99.40
2.A.3 Glass Production	CO_2	145.87	145.87	5.39	0.12	0.62	0.04	0.12	0.09	99.44
1.A.1 Energy industries - Solid Fuels	CH_4	11.23	11.23	65.06	0.01	0.58	0.04	0.01	1.04	99.48
1.A.4 Other Sectors - Gaseous Fuels	CH_4	15.45	15.45	41.93	0.01	0.51	0.04	0.01	0.67	99.51
4.B.2. Land converted to Cropland	N_2O	2.27	2.27	285.24	0.00	0.51	0.04	0.00	4.57	99.55
4.B.1 Cropland remaining Cropland	CO_2	-21.26	21.26	30.06	0.02	0.51	0.03	0.02	0.48	99.58
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	6.92	6.92	80.52	0.01	0.44	0.03	0.01	1.29	99.61
2.B.10 Other	CO_2	139.01	139.01	3.91	0.11	0.43	0.03	0.11	0.06	99.64
2.C.5 Lead Production	CO_2	9.37	9.37	50.99	0.01	0.38	0.03	0.01	0.82	99.67
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	50.25	0.01	0.37	0.03	0.01	0.80	99.70
4.A.1 Forest Land remaining Forest Land	N_2O	10.73	10.73	41.91	0.01	0.36	0.02	0.01	0.67	99.72
5.C Incineration and open burning of waste	CH_4	5.30	5.30	82.46	0.00	0.35	0.02	0.00	1.32	99.74
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	6.91	6.91	63.11	0.01	0.34	0.02	0.01	1.01	99.77
5.C Incineration and open burning of waste	N_2O	4.63	4.63	72.80	0.00	0.27	0.02	0.00	1.17	99.79
5.B Biological treatment of solid waste	N_2O	66.18	66.18	5.04	0.05	0.26	0.02	0.05	0.08	99.80
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	5.48	5.48	60.70	0.00	0.26	0.02	0.00	0.97	99.82
1.B.1.b Solid Fuel Transformation	CH_4	5.10	5.10	62.10	0.00	0.25	0.02	0.00	0.99	99.84
2.C.1 Iron and Steel Production	CH_4	9.29	9.29	30.81	0.01	0.23	0.02	0.01	0.49	99.86
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3.02	3.02	80.37	0.00	0.19	0.01	0.00	1.29	99.87
1.A.5.b Other mobile - Liquid Fuels	N_2O	2.55	2.55	70.10	0.00	0.14	0.01	0.00	1.12	99.88
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	3.13	3.13	57.03	0.00	0.14	0.01	0.00	0.91	99.89
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2.92	2.92	53.54	0.00	0.12	0.01	0.00	0.86	99.90
2.D.3 Other non-energy products from fuels and solvent use	CO_2	22.11	22.11	7.07	0.02	0.12	0.01	0.02	0.11	99.91
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2.39	2.39	60.49	0.00	0.11	0.01	0.00	0.97	99.91
4(IV) Indirect N2O Emissions from Managed Soils	N_2O	0.51	0.51	283.61	0.00	0.11	0.01	0.00	4.54	99.92

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.3.c Railways	CH_4	1.14	1.14	125.30	0.00	0.11	0.01	0.00	2.01	99.93
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.46	2.46	53.38	0.00	0.10	0.01	0.00	0.85	99.94
1.A.3.e Other Transportation	CO_2	22.32	22.32	5.00	0.02	0.09	0.01	0.02	0.08	99.94
2.F.4 Aerosols	F-gases	2.63	2.63	41.88	0.00	0.09	0.01	0.00	0.67	99.95
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	2.60	2.60	41.72	0.00	0.09	0.01	0.00	0.67	99.95
2.C.2 Ferroalloys Production	CH_4	3.89	3.89	25.50	0.00	0.08	0.01	0.00	0.41	99.96
2.F.2 Foam Blowing Agents	F-gases	2.28	2.28	41.88	0.00	0.08	0.01	0.00	0.67	99.97
1.A.1 Energy industries - Gaseous Fuels	N_2O	1.43	1.43	53.36	0.00	0.06	0.00	0.00	0.85	99.97
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	1.03	1.03	70.04	0.00	0.06	0.00	0.00	1.12	99.97
1.A.3.a Domestic Aviation	CO_2	12.40	12.40	5.36	0.01	0.05	0.00	0.01	0.09	99.98
1.A.4 Other Sectors - Liquid Fuels	CH_4	1.17	1.17	55.27	0.00	0.05	0.00	0.00	0.88	99.98
1.A.3.c Railways	N_2O	0.50	0.50	125.39	0.00	0.05	0.00	0.00	2.01	99.98
1.A.1 Energy industries - Gaseous Fuels	CH_4	1.51	1.51	41.71	0.00	0.05	0.00	0.00	0.67	99.99
1.A.3.d Transport - Domestic navigation	CO_2	9.60	9.60	5.22	0.01	0.04	0.00	0.01	0.08	99.99
2.C.6 Zinc Production	CO_2	0.92	0.92	50.99	0.00	0.04	0.00	0.00	0.82	99.99
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.56	0.56	55.05	0.00	0.02	0.00	0.00	0.88	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	0.33	0.33	70.02	0.00	0.02	0.00	0.00	1.12	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.32	0.32	55.13	0.00	0.01	0.00	0.00	0.88	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0.26	0.26	55.03	0.00	0.01	0.00	0.00	0.88	100.00
2.C.2 Ferroalloys Production	CO_2	0.50	0.50	25.50	0.00	0.01	0.00	0.00	0.41	100.00
1.A.3.a Domestic Aviation	N_2O	0.09	0.09	110.07	0.00	0.01	0.00	0.00	1.76	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.07	0.07	137.27	0.00	0.01	0.00	0.00	2.20	100.00
2.H Other	F-gases	0.18	0.18	43.57	0.00	0.01	0.00	0.00	0.70	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.07	0.07	50.27	0.00	0.00	0.00	0.00	0.80	100.00
2.H Other	CO_2	0.53	0.53	5.39	0.00	0.00	0.00	0.00	0.09	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.03	0.03	101.41	0.00	0.00	0.00	0.00	1.62	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.03	0.03	50.42	0.00	0.00	0.00	0.00	0.81	100.00

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.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	74.33	0.00	0.00	0.00	0.00	1.19	100.00
1.A.3.e Other Transportation	N_2O	0.01	0.01	60.13	0.00	0.00	0.00	0.00	0.96	100.00
1.A.3.e Other Transportation	CH_4	0.01	0.01	50.16	0.00	0.00	0.00	0.00	0.80	100.00
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	78.60	0.00	0.00	0.00	0.00	1.26	100.00
2.F.5 Solvents	F-gases	0.00	0.00	41.88	0.00	0.00	0.00	0.00	0.67	100.00

Tab. A1 8 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2022 – 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)
5.A Solid Waste Disposal	CH_4	3724.92	3724.92	63.70	3.18	202.71	16.61	3.18	1.02	16.61
2.F.1 Refrigeration and Air conditioning	F-gases	3572.75	3572.75	43.57	3.05	132.98	10.89	3.05	0.70	27.50
1.A.1 Energy industries - Solid Fuels	CO_2	38845.69	38845.69	3.29	33.19	109.04	8.93	33.19	0.05	36.44
1.B.1.a Coal Mining and Handling	CH_4	1845.24	1845.24	38.20	1.58	60.22	4.93	1.58	0.61	41.37
1.A.3.b Road Transportation	CO_2	18916.69	18916.69	3.68	16.16	59.44	4.87	16.16	0.06	46.24
2.C.1 Iron and Steel Production	CO_2	5634.33	5634.33	12.21	4.81	58.76	4.81	4.81	0.20	51.05
5.B Biological treatment of solid waste	CH_4	737.62	737.62	91.29	0.63	57.53	4.71	0.63	1.46	55.77
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	2839.60	2839.60	20.62	2.43	50.01	4.10	2.43	0.33	59.86
3.A Enteric Fermentation	CH_4	3680.70	3680.70	15.81	3.14	49.72	4.07	3.14	0.25	63.94
5.D Wastewater treatment and discharge	CH_4	893.78	893.78	58.38	0.76	44.58	3.65	0.76	0.93	67.59
2.B.8 Petrochemical and Carbon Black Production	CO_2	1016.59	1016.59	40.31	0.87	35.01	2.87	0.87	0.65	70.46
1.A.4 Other Sectors - Biomass	CH_4	767.46	767.46	52.08	0.66	34.15	2.80	0.66	0.83	73.26
1.A.3.b Road Transportation	N_2O	174.46	174.46	189.30	0.15	28.22	2.31	0.15	3.03	75.57
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	543.22	543.22	60.70	0.46	28.17	2.31	0.46	0.97	77.87
1.A.4 Other Sectors - Solid Fuels	CO_2	3158.16	3158.16	9.93	2.70	26.79	2.20	2.70	0.16	80.07
1.A.4 Other Sectors - Gaseous Fuels	CO_2	6154.93	6154.93	4.74	5.26	24.94	2.04	5.26	0.08	82.11
3.D.2 Indirect N2O Emissions From Managed Soils	N_2O	794.16	794.16	30.41	0.68	20.64	1.69	0.68	0.49	83.80
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	485.49	485.49	49.72	0.41	20.62	1.69	0.41	0.80	85.49
3.B Manure Management	N_2O	386.96	386.96	40.31	0.33	13.33	1.09	0.33	0.65	86.58

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.4 Other Sectors - Solid Fuels	CH_4	271.04	271.04	55.86	0.23	12.94	1.06	0.23	0.89	87.64
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	4937.63	4937.63	2.79	4.22	11.79	0.97	4.22	0.04	88.61
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5173.58	5173.58	2.24	4.42	9.91	0.81	4.42	0.04	89.42
1.A.1 Energy industries - Solid Fuels	N_2O	155.06	155.06	70.05	0.13	9.28	0.76	0.13	1.12	90.18
3.H Urea application	CO_2	191.94	191.94	52.20	0.16	8.56	0.70	0.16	0.84	90.88
5.D Wastewater treatment and discharge	N_2O	172.96	172.96	56.36	0.15	8.33	0.68	0.15	0.90	91.57
2.G Other Product Manufacture and Use	N_2O	198.75	198.75	43.57	0.17	7.40	0.61	0.17	0.70	92.17
3.B Manure Management	CH_4	375.14	375.14	22.36	0.32	7.17	0.59	0.32	0.36	92.76
2.A.4 Other Process Uses of Carbonates	CO_2	739.50	739.50	11.18	0.63	7.06	0.58	0.63	0.18	93.34
1.A.4 Other Sectors - Liquid Fuels	CO_2	1223.42	1223.42	6.23	1.05	6.51	0.53	1.05	0.10	93.87
1.A.4 Other Sectors - Biomass	N_2O	96.67	96.67	71.50	0.08	5.91	0.48	0.08	1.14	94.36
1.A.3.b Road Transportation	CH_4	24.75	24.75	239.40	0.02	5.06	0.41	0.02	3.83	94.77
2.B.1 Ammonia Production	CO_2	682.45	682.45	8.60	0.58	5.02	0.41	0.58	0.14	95.18
1.A.1 Energy industries - Gaseous Fuels	CO_2	3001.65	3001.65	1.90	2.56	4.87	0.40	2.56	0.03	95.58
2.A.1 Cement Production	CO_2	1846.97	1846.97	2.83	1.58	4.46	0.37	1.58	0.05	95.95
1.A.1 Energy industries - Other Fossil Fuels	CO_2	261.38	261.38	19.12	0.22	4.27	0.35	0.22	0.31	96.30
3.G Liming	CO_2	153.77	153.77	30.41	0.13	4.00	0.33	0.13	0.49	96.62
2.D.1 Lubricant Use	CO_2	88.42	88.42	50.25	0.08	3.80	0.31	0.08	0.80	96.93
2.G Other Product Manufacture and Use	F-gases	63.11	63.11	43.57	0.05	2.35	0.19	0.05	0.70	97.13
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	36.74	36.74	70.36	0.03	2.21	0.18	0.03	1.13	97.31
1.A.1 Energy industries - Biomass	N_2O	32.22	32.22	70.29	0.03	1.93	0.16	0.03	1.13	97.47
2.B.8 Petrochemical and Carbon Black Production	CH_4	55.59	55.59	40.31	0.05	1.91	0.16	0.05	0.65	97.62
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	55.40	55.40	40.31	0.05	1.91	0.16	0.05	0.65	97.78
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	545.40	545.40	3.89	0.47	1.81	0.15	0.47	0.06	97.93
2.B.2 Nitric Acid Production	N_2O	104.49	104.49	15.52	0.09	1.39	0.11	0.09	0.25	98.04
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	21.34	21.34	74.33	0.02	1.36	0.11	0.02	1.19	98.15
2.A.2 Lime Production	CO_2	555.89	555.89	2.83	0.47	1.34	0.11	0.47	0.05	98.26
5.C Incineration and open burning of waste	CO_2	96.72	96.72	15.81	0.08	1.31	0.11	0.08	0.25	98.37
1.A.1 Energy industries - Liquid Fuels	CO_2	428.22	428.22	3.54	0.37	1.29	0.11	0.37	0.06	98.48

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.2 Manufacturing Industries and Construction - Biomass	CH_4	29.23	29.23	50.51	0.02	1.26	0.10	0.02	0.81	98.58
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	19.18	19.18	70.03	0.02	1.15	0.09	0.02	1.12	98.67
2.F.3 Fire Protection	F-gases	31.41	31.41	41.88	0.03	1.12	0.09	0.03	0.67	98.76
1.A.1 Energy industries - Biomass	CH_4	25.54	25.54	50.40	0.02	1.10	0.09	0.02	0.81	98.85
1.A.5.b Other mobile - Liquid Fuels	CO_2	266.27	266.27	4.80	0.23	1.09	0.09	0.23	0.08	98.94
1.B.1.a Coal Mining and Handling	CO_2	48.65	48.65	26.04	0.04	1.08	0.09	0.04	0.42	99.03
1.A.3.c Railways	CO_2	228.62	228.62	5.24	0.20	1.02	0.08	0.20	0.08	99.12
1.A.4 Other Sectors - Solid Fuels	N_2O	13.28	13.28	70.68	0.01	0.80	0.07	0.01	1.13	99.18
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	13.56	13.56	65.04	0.01	0.75	0.06	0.01	1.04	99.24
2.E Electronics industry	F-gases	53.55	53.55	15.30	0.05	0.70	0.06	0.05	0.24	99.30
1.A.4 Other Sectors - Liquid Fuels	N_2O	11.26	11.26	70.21	0.01	0.68	0.06	0.01	1.12	99.36
2.A.3 Glass Production	CO_2	145.87	145.87	5.39	0.12	0.67	0.05	0.12	0.09	99.41
1.A.1 Energy industries - Solid Fuels	CH_4	11.23	11.23	65.06	0.01	0.62	0.05	0.01	1.04	99.46
1.A.4 Other Sectors - Gaseous Fuels	CH_4	15.45	15.45	41.93	0.01	0.55	0.05	0.01	0.67	99.51
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	6.92	6.92	80.52	0.01	0.48	0.04	0.01	1.29	99.55
2.B.10 Other	CO_2	139.01	139.01	3.91	0.12	0.46	0.04	0.12	0.06	99.59
2.C.5 Lead Production	CO_2	9.37	9.37	50.99	0.01	0.41	0.03	0.01	0.82	99.62
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	50.25	0.01	0.40	0.03	0.01	0.80	99.65
5.C Incineration and open burning of waste	CH_4	5.30	5.30	82.46	0.00	0.37	0.03	0.00	1.32	99.68
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	6.91	6.91	63.11	0.01	0.37	0.03	0.01	1.01	99.71
5.C Incineration and open burning of waste	N_2O	4.63	4.63	72.80	0.00	0.29	0.02	0.00	1.17	99.74
5.B Biological treatment of solid waste	N_2O	66.18	66.18	5.04	0.06	0.28	0.02	0.06	0.08	99.76
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	5.48	5.48	60.70	0.00	0.28	0.02	0.00	0.97	99.78
1.B.1.b Solid Fuel Transformation	CH_4	5.10	5.10	62.10	0.00	0.27	0.02	0.00	0.99	99.81
2.C.1 Iron and Steel Production	CH_4	9.29	9.29	30.81	0.01	0.24	0.02	0.01	0.49	99.83
1.A.1 Energy industries - Other Fossil Fuels	N_2O	3.02	3.02	80.37	0.00	0.21	0.02	0.00	1.29	99.84
1.A.5.b Other mobile - Liquid Fuels	N_2O	2.55	2.55	70.10	0.00	0.15	0.01	0.00	1.12	99.85
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	3.13	3.13	57.03	0.00	0.15	0.01	0.00	0.91	99.87

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.4 Other Sectors - Gaseous Fuels	N_2O	2.92	2.92	53.54	0.00	0.13	0.01	0.00	0.86	99.88
2.D.3 Other non-energy products from fuels and solvent use	CO_2	22.11	22.11	7.07	0.02	0.13	0.01	0.02	0.11	99.89
1.A.1 Energy industries - Other Fossil Fuels	CH_4	2.39	2.39	60.49	0.00	0.12	0.01	0.00	0.97	99.90
1.A.3.c Railways	CH_4	1.14	1.14	125.30	0.00	0.12	0.01	0.00	2.01	99.91
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.46	2.46	53.38	0.00	0.11	0.01	0.00	0.85	99.92
1.A.3.e Other Transportation	CO_2	22.32	22.32	5.00	0.02	0.10	0.01	0.02	0.08	99.93
2.F.4 Aerosols	F-gases	2.63	2.63	41.88	0.00	0.09	0.01	0.00	0.67	99.93
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	2.60	2.60	41.72	0.00	0.09	0.01	0.00	0.67	99.94
2.C.2 Ferroalloys Production	CH_4	3.89	3.89	25.50	0.00	0.08	0.01	0.00	0.41	99.95
2.F.2 Foam Blowing Agents	F-gases	2.28	2.28	41.88	0.00	0.08	0.01	0.00	0.67	99.96
1.A.1 Energy industries - Gaseous Fuels	N_2O	1.43	1.43	53.36	0.00	0.07	0.01	0.00	0.85	99.96
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	1.03	1.03	70.04	0.00	0.06	0.01	0.00	1.12	99.97
1.A.3.a Domestic Aviation	CO_2	12.40	12.40	5.36	0.01	0.06	0.00	0.01	0.09	99.97
1.A.4 Other Sectors - Liquid Fuels	CH_4	1.17	1.17	55.27	0.00	0.06	0.00	0.00	0.88	99.97
1.A.3.c Railways	N_2O	0.50	0.50	125.39	0.00	0.05	0.00	0.00	2.01	99.98
1.A.1 Energy industries - Gaseous Fuels	CH_4	1.51	1.51	41.71	0.00	0.05	0.00	0.00	0.67	99.98
1.A.3.d Transport - Domestic navigation	CO_2	9.60	9.60	5.22	0.01	0.04	0.00	0.01	0.08	99.99
2.C.6 Zinc Production	CO_2	0.92	0.92	50.99	0.00	0.04	0.00	0.00	0.82	99.99
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.56	0.56	55.05	0.00	0.03	0.00	0.00	0.88	99.99
1.A.1 Energy industries - Liquid Fuels	N_2O	0.33	0.33	70.02	0.00	0.02	0.00	0.00	1.12	99.99
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.32	0.32	55.13	0.00	0.02	0.00	0.00	0.88	100.00
1.A.1 Energy industries - Liquid Fuels	CH_4	0.26	0.26	55.03	0.00	0.01	0.00	0.00	0.88	100.00
2.C.2 Ferroalloys Production	CO_2	0.50	0.50	25.50	0.00	0.01	0.00	0.00	0.41	100.00
1.A.3.a Domestic Aviation	N_2O	0.09	0.09	110.07	0.00	0.01	0.00	0.00	1.76	100.00
1.A.3.d Transport - Domestic navigation	N_2O	0.07	0.07	137.27	0.00	0.01	0.00	0.00	2.20	100.00
2.H Other	F-gases	0.18	0.18	43.57	0.00	0.01	0.00	0.00	0.70	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.07	0.07	50.27	0.00	0.00	0.00	0.00	0.80	100.00
2.H Other	CO_2	0.53	0.53	5.39	0.00	0.00	0.00	0.00	0.09	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0.03	0.03	101.41	0.00	0.00	0.00	0.00	1.62	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.03	0.03	50.42	0.00	0.00	0.00	0.00	0.81	100.00

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.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	74.33	0.00	0.00	0.00	0.00	1.19	100.00
1.A.3.e Other Transportation	N_2O	0.01	0.01	60.13	0.00	0.00	0.00	0.00	0.96	100.00
1.A.3.e Other Transportation	CH_4	0.01	0.01	50.16	0.00	0.00	0.00	0.00	0.80	100.00
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	78.60	0.00	0.00	0.00	0.00	1.26	100.00
2.F.5 Solvents	F-gases	0.00	0.00	41.88	0.00	0.00	0.00	0.00	0.67	100.00

Tab. A1 9 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2022 – Trend Assessment including LULUCF

IPCC Source Categories	GHG	Base Year Estimate (Abs)	Current Year Estimate (Abs)	Combined Uncertainty	TA_A1	Uncertain ammount BY	Uncertain ammount CY	BY uncertain total	CY uncertain total	Level A 2 assessment	Trend A2 Assessment	% contribution to Trend	Cumulative fraction of uncertainty (BY)	Cumulative Total (TA)
4.A.1 Forest Land remaining Forest Land	CO_2	-7266	6048	38	16	-2764	2301	-10030	8349	6	621	33	15.18	33.03
1.B.1.a Coal Mining and Handling	CH_4	11561	1845	38	6	4416	705	15977	2550	2	214	11	4.65	44.41
5.A Solid Waste Disposal	CH_4	2008	3725	64	3	1279	2373	3287	6098	4	160	8	15.66	52.90
2.F.1 Refrigeration and Air conditioning	F-gases	0	3573	44	4	0	1557	0	5129	4	159	8	10.27	61.36
1.A.4 Other Sectors - Solid Fuels	CO_2	24005	3158	10	12	2384	314	26389	3472	3	122	7	2.07	67.87
5.B Biological treatment of solid waste	CH_4	0	738	91	1	0	673	0	1411	1	69	4	4.44	71.53
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	35636	4938	3	18	996	138	36631	5076	4	50	3	0.91	74.21
1.A.3.b Road Transportation	CO_2	10251	18917	4	13	377	696	10628	19612	14	47	2	4.59	76.69
1.A.4 Other Sectors - Solid Fuels	CH_4	1492	271	56	1	833	151	2325	422	0	39	2	1.00	78.74
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0	543	61	1	0	330	0	873	1	34	2	2.18	80.53
1.A.4 Other Sectors - Biomass	CH_4	363	767	52	1	189	400	552	1167	1	29	2	2.64	82.05
1.A.3.b Road Transportation	N_2O	83	174	189	0	157	330	239	505	0	24	1	2.18	83.31
4.G Harvested wood products	CO_2	-1680	-1946	62	0	-1042	-1207	-2722	-3153	-2	22	1	-7.96	84.48
2.B.8 Petrochemical and Carbon Black Production	CO_2	792	1017	40	1	319	410	1112	1426	1	21	1	2.70	85.61
3.G Liming	CO_2	1237	154	30	1	376	47	1613	201	0	20	1	0.31	86.65
1.A.4 Other Sectors - Gaseous Fuels	CO_2	4174	6155	5	4	198	292	4372	6447	5	17	1	1.93	87.56
1.A.1 Energy industries - Solid Fuels	CO_2	53720	38846	3	5	1765	1276	55485	40122	30	16	1	8.42	88.41

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)
3.B Manure Management	CH_4	1575	375	22	1	352	84	1927	459	0	14	1	0.55	89.17
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	1170	485	50	0	582	241	1752	727	1	13	1	1.59	89.86
4.C.1 Grassland remaining Grassland	CO_2	0	-311	41	0	0	-126	0	-437	0	13	1	-0.83	90.55
5.D Wastewater treatment and discharge	CH_4	1083	894	58	0	632	522	1715	1416	1	12	1	3.44	91.21
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	5502	545	4	3	214	21	5717	567	0	12	1	0.14	91.83
3.B Manure Management	N_2O	996	387	40	0	402	156	1398	543	0	10	1	1.03	92.37
3.D.1 Direct N2O Emissions From Managed Soils	N_2O	3826	2840	21	0	789	585	4615	3425	3	9	0	3.86	92.83
3.A Enteric Fermentation	CH_4	6612	3681	16	1	1045	582	7657	4263	3	8	0	3.84	93.27
2.B.2 Nitric Acid Production	N_2O	933	104	16	0	145	16	1078	121	0	8	0	0.11	93.68
2.A.4 Other Process Uses of Carbonates	CO_2	114	739	11	1	13	83	127	822	1	8	0	0.55	94.09
1.A.4 Other Sectors - Liquid Fuels	CO_2	3775	1223	6	1	235	76	4010	1300	1	7	0	0.50	94.48
1.A.3.b Road Transportation	CH_4	86	25	239	0	205	59	291	84	0	7	0	0.39	94.87
2.C.1 Iron and Steel Production	CO_2	9782	5634	12	1	1194	688	10976	6322	5	7	0	4.54	95.24
3.H Urea application	CO_2	109	192	52	0	57	100	165	292	0	7	0	0.66	95.59
1.B.1.a Coal Mining and Handling	CO_2	456	49	26	0	119	13	575	61	0	6	0	0.08	95.93
4.A.2 Land converted to Forest Land	CO_2	-235	-551	24	0	-56	-132	-291	-684	-1	6	0	-0.87	96.23
1.A.4 Other Sectors - Biomass	N_2O	46	97	72	0	33	69	79	166	0	5	0	0.46	96.50
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24	261	19	0	5	50	29	311	0	5	0	0.33	96.75
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	136	19	70	0	95	13	231	33	0	5	0	0.09	97.01
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336	3002	2	2	25	57	1361	3059	2	4	0	0.38	97.23
2.G Other Product Manufacture and Use	N_2O	183	199	44	0	80	87	263	285	0	4	0	0.57	97.43
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5686	5174	2	2	128	116	5813	5290	4	4	0	0.77	97.62
1.A.4 Other Sectors - Solid Fuels	N_2O	92	13	71	0	65	9	157	23	0	3	0	0.06	97.79
1.A.2 Manufacturing Industries and	CH_4	96	14	65	0	62	9	158	22	0	3	0	0.06	97.96

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)
Construction - Solid Fuels														
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	1393	794	30	0	424	242	1817	1036	1	3	0	1.59	98.10
5.D Wastewater treatment and discharge	N_2O	208	173	56	0	117	97	326	270	0	2	0	0.64	98.23
1.A.1 Energy industries - Biomass	N_2O	0	32	70	0	0	23	1	55	0	2	0	0.15	98.35
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	15	37	70	0	10	26	25	63	0	2	0	0.17	98.46
1.A.1 Energy industries - Liquid Fuels	CO_2	1514	428	4	1	54	15	1568	443	0	2	0	0.10	98.56
4.D.2. Land converted to Wetlands	CO_2	24	57	39	0	10	22	34	79	0	2	0	0.15	98.65
1.A.1 Energy industries - Solid Fuels	N_2O	213	155	70	0	149	109	363	264	0	1	0	0.72	98.72
1.A.3.c Railways	CO_2	768	229	5	0	40	12	808	241	0	1	0	0.08	98.80
5.C Incineration and open burning of waste	CO_2	20	97	16	0	3	15	23	112	0	1	0	0.10	98.87
2.F.3 Fire Protection	F-gases	0	31	42	0	0	13	0	45	0	1	0	0.09	98.94
1.A.1 Energy industries - Biomass	CH_4	0	26	50	0	0	13	1	38	0	1	0	0.08	99.01
2.B.8 Petrochemical and Carbon Black Production	CH_4	41	56	40	0	16	22	57	78	0	1	0	0.15	99.08
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	12	29	51	0	6	15	18	44	0	1	0	0.10	99.14
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	14	21	74	0	10	16	24	37	0	1	0	0.10	99.19
2.A.2 Lime Production	CO_2	1337	556	3	0	38	16	1374	572	0	1	0	0.10	99.23
2.E Electronics industry	F-gases	0	54	15	0	0	8	0	62	0	1	0	0.05	99.28
4.B.2. Land converted to Cropland	N_2O	8	2	285	0	23	6	31	9	0	1	0	0.04	99.32
2.A.1 Cement Production	CO_2	2489	1847	3	0	70	52	2560	1899	1	1	0	0.34	99.36
2.D.1 Lubricant Use	CO_2	116	88	50	0	58	44	174	133	0	1	0	0.29	99.40
1.A.5.b Other mobile - Liquid Fuels	CO_2	192	266	5	0	9	13	201	279	0	1	0	0.08	99.44
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0	7	81	0	0	6	0	12	0	1	0	0.04	99.47
2.B.10 Other	CO_2	0	139	4	0	0	5	0	144	0	1	0	0.04	99.50
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	69	55	40	0	28	22	97	78	0	0	0	0.15	99.52
2.B.1 Ammonia Production	CO_2	991	682	9	0	85	59	1076	741	1	0	0	0.39	99.55
5.C Incineration and open burning of waste	CH_4	0	5	82	0	0	4	0	10	0	0	0	0.03	99.57

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 - Liquid Fuels	N_2O	11	1	70	0	8	1	19	2	0	0	0	0.00	99.60
1.A.4 Other Sectors - Liquid Fuels	CH_4	13	1	55	0	7	1	20	2	0	0	0	0.00	99.62
1.A.4 Other Sectors - Gaseous Fuels	CH_4	11	15	42	0	4	6	15	22	0	0	0	0.04	99.64
4.C.2 Land converted to Grassland	CO_2	-144	-190	55	0	-78	-104	-222	-294	0	0	0	-0.68	99.66
2.G Other Product Manufacture and Use	F-gases	87	63	44	0	38	27	125	91	0	0	0	0.18	99.68
2.C.5 Lead Production	CO_2	4	9	51	0	2	5	6	14	0	0	0	0.03	99.69
4.A.1 Forest Land remaining Forest Land	CH_4	19	21	42	0	8	9	27	29	0	0	0	0.06	99.71
5.B Biological treatment of solid waste	N_2O	0	66	5	0	0	3	0	70	0	0	0	0.02	99.73
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0	5	61	0	0	3	0	9	0	0	0	0.02	99.75
4.B.2 Land converted to Cropland	CO_2	121	64	26	0	31	17	152	81	0	0	0	0.11	99.77
5.C Incineration and open burning of waste	N_2O	0	5	73	0	0	3	1	8	0	0	0	0.02	99.78
4.E.2 Land converted to Settlements	CO_2	319	195	42	0	134	82	453	277	0	0	0	0.54	99.80
2.A.3 Glass Production	CO_2	143	146	5	0	8	8	150	154	0	0	0	0.05	99.82
1.B.1.b Solid Fuel Transformation	CH_4	1	5	62	0	1	3	1	8	0	0	0	0.02	99.83
2.C.6 Zinc Production	CO_2	9	1	51	0	4	0	13	1	0	0	0	0.00	99.84
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0	3	80	0	0	2	1	5	0	0	0	0.02	99.86
4.A.1 Forest Land remaining Forest Land	N_2O	10	11	42	0	4	4	14	15	0	0	0	0.03	99.87
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	6	1	55	0	3	0	9	1	0	0	0	0.00	99.88
4(IV) Indirect N_2O Emissions from Managed Soils	N_2O	2	1	284	0	5	1	7	2	0	0	0	0.01	99.89
2.D.2 Paraffin Wax Use	CO_2	9	9	50	0	5	5	14	14	0	0	0	0.03	99.90
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0	22	7	0	0	2	0	24	0	0	0	0.01	99.90
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0	2	60	0	0	1	0	4	0	0	0	0.01	99.91
1.A.3.d Transport - Domestic navigation	CO_2	54	10	5	0	3	1	56	10	0	0	0	0.00	99.92
4.B.1 Cropland remaining Cropland	CO_2	-13	-21	30	0	-4	-6	-17	-28	0	0	0	-0.04	99.92
2.F.4 Aerosols	F-gases	0	3	42	0	0	1	0	4	0	0	0	0.01	99.93

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.1 Energy industries - Liquid Fuels	N_2O	3	0	70	0	2	0	5	1	0	0	0	0.00	99.94
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	2	3	57	0	1	2	3	5	0	0	0	0.01	99.94
1.A.5.b Other mobile - Liquid Fuels	N_2O	2	3	70	0	1	2	3	4	0	0	0	0.01	99.95
2.C.2 Ferroalloys Production	CH_4	0	4	25	0	0	1	0	5	0	0	0	0.01	99.95
2.F.2 Foam Blowing Agents	F-gases	0	2	42	0	0	1	0	3	0	0	0	0.01	99.96
1.A.3.e Other Transportation	CO_2	5	22	5	0	0	1	6	23	0	0	0	0.01	99.96
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2	3	54	0	1	2	3	4	0	0	0	0.01	99.97
1.A.1 Energy industries - Solid Fuels	CH_4	16	11	65	0	10	7	26	19	0	0	0	0.05	99.97
1.A.3.a Domestic Aviation	CO_2	0	12	5	0	0	1	0	13	0	0	0	0.00	99.98
1.A.3.c Railways	N_2O	2	1	125	0	2	1	3	1	0	0	0	0.00	99.98
1.A.1 Energy industries - Gaseous Fuels	N_2O	1	1	53	0	0	1	1	2	0	0	0	0.01	99.98
1.A.1 Energy industries - Gaseous Fuels	CH_4	1	2	42	0	0	1	1	2	0	0	0	0.00	99.98
1.A.3.c Railways	CH_4	1	1	125	0	2	1	3	3	0	0	0	0.01	99.99
1.A.1 Energy industries - Liquid Fuels	CH_4	2	0	55	0	1	0	2	0	0	0	0	0.00	99.99
2.C.1 Iron and Steel Production	CH_4	17	9	31	0	5	3	22	12	0	0	0	0.02	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	3	2	53	0	1	1	4	4	0	0	0	0.01	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	3	3	42	0	1	1	4	4	0	0	0	0.01	99.99
1.A.3.d Transport - Domestic navigation	N_2O	0	0	137	0	1	0	1	0	0	0	0	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	11	7	63	0	7	4	19	11	0	0	0	0.03	100.00
2.C.2 Ferroalloys Production	CO_2	0	1	25	0	0	0	0	1	0	0	0	0.00	100.00
1.A.3.a Domestic Aviation	N_2O	0	0	110	0	0	0	0	0	0	0	0	0.00	100.00
2.H Other	F-gases	0	0	44	0	0	0	0	0	0	0	0	0.00	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0	0	101	0	0	0	0	0	0	0	0	0.00	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	1	0	55	0	0	0	1	0	0	0	0	0.00	100.00
1.A.4 Other Sectors - Liquid Fuels	N_2O	18	11	70	0	13	8	30	19	0	0	0	0.05	100.00
2.H Other	CO_2	0	1	5	0	0	0	0	1	0	0	0	0.00	100.00

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.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0	0	50	0	0	0	0	0	0	0	0	0.00	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0	0	50	0	0	0	0	0	0	0	0	0.00	100.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0	0	74	0	0	0	0	0	0	0	0	0.00	100.00
1.A.3.e Other Transportation	N_2O	0	0	60	0	0	0	0	0	0	0	0	0.00	100.00
1.A.3.e Other Transportation	CH_4	0	0	50	0	0	0	0	0	0	0	0	0.00	100.00
1.A.3.a Domestic Aviation	CH_4	0	0	79	0	0	0	0	0	0	0	0	0.00	100.00
2.F.5 Solvents	F-gases	0	0	42	0	0	0	0	0	0	0	0	0.00	100.00

Tab. A1 10 Spreadsheet for Approach 2 KC IPCC 2006 Gl., 2022 – 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.B.1.a Coal Mining and Handling	CH_4	11561	1845	38	6	4416	705	15977	2550	2	237	16	4.93	16.43
5.A Solid Waste Disposal	CH_4	2008	3725	64	3	1279	2373	3287	6098	5	203	14	16.61	30.46
2.F.1 Refrigeration and Air conditioning	F-gases	0	3573	44	4	0	1557	0	5129	4	195	13	10.89	43.95
1.A.4 Other Sectors - Solid Fuels	CO_2	24005	3158	10	14	2384	314	26389	3472	3	136	9	2.20	53.40
5.B Biological treatment of solid waste	CH_4	0	738	91	1	0	673	0	1411	1	84	6	6.91	59.24
1.A.3.b Road Transportation	CO_2	10251	18917	4	16	377	696	10628	19612	15	59	4	11.78	63.34
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	35636	4938	3	20	996	138	36631	5076	4	56	4	0.97	67.23
1.A.4 Other Sectors - Solid Fuels	CH_4	1492	271	56	1	833	151	2325	422	0	42	3	2.03	70.17
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0	543	61	1	0	330	0	873	1	41	3	4.33	73.02
1.A.4 Other Sectors - Biomass	CH_4	363	767	52	1	189	400	552	1167	1	36	2	7.13	75.52
1.A.3.b Road Transportation	N_2O	83	174	189	0	157	330	239	505	0	30	2	9.44	77.59
1.A.1 Energy industries - Solid Fuels	CO_2	53720	38846	3	9	1765	1276	55485	40122	31	30	2	8.93	79.64
2.B.8 Petrochemical and Carbon Black Production	CO_2	792	1017	40	1	319	410	1112	1426	1	28	2	11.80	81.56

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.4 Other Sectors - Gaseous Fuels	CO_2	4174	6155	5	5	198	292	4372	6447	5	22	2	13.84	83.08
3.G Liming	CO_2	1237	154	30	1	376	47	1613	201	0	22	2	14.17	84.59
5.D Wastewater treatment and discharge	CH_4	1083	894	58	0	632	522	1715	1416	1	19	1	17.82	85.89
3.B Manure Management	CH_4	1575	375	22	1	352	84	1927	459	0	15	1	18.41	86.96
3.D.1 Direct N2O Emissions From Managed Soils	N_2O	3826	2840	21	1	789	585	4615	3425	3	15	1	22.51	88.01
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	5502	545	4	3	214	21	5717	567	0	13	1	22.66	88.92
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	1170	485	50	0	582	241	1752	727	1	13	1	24.35	89.80
3.B Manure Management	N_2O	996	387	40	0	402	156	1398	543	0	10	1	25.44	90.49
2.A.4 Other Process Uses of Carbonates	CO_2	114	739	11	1	13	83	127	822	1	9	1	26.02	91.14
2.B.2 Nitric Acid Production	N_2O	933	104	16	1	145	16	1078	121	0	9	1	26.13	91.74
3.H Urea application	CO_2	109	192	52	0	57	100	165	292	0	8	1	26.83	92.32
1.A.4 Other Sectors - Liquid Fuels	CO_2	3775	1223	6	1	235	76	4010	1300	1	8	1	27.37	92.86
1.A.3.b Road Transportation	CH_4	86	25	239	0	205	59	291	84	0	8	1	27.78	93.40
1.B.1.a Coal Mining and Handling	CO_2	456	49	26	0	119	13	575	61	0	7	0	0.09	93.89
1.A.4 Other Sectors - Biomass	N_2O	46	97	72	0	33	69	79	166	0	6	0	0.57	94.33
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24	261	19	0	5	50	29	311	0	6	0	0.35	94.74
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	136	19	70	0	95	13	231	33	0	5	0	0.44	95.10
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336	3002	2	3	25	57	1361	3059	2	5	0	0.40	95.47
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5686	5174	2	2	128	116	5813	5290	4	5	0	1.21	95.82
2.G Other Product Manufacture and Use	N_2O	183	199	44	0	80	87	263	285	0	5	0	1.82	96.17
3.A Enteric Fermentation	CH_4	6612	3681	16	0	1045	582	7657	4263	3	4	0	5.89	96.46
1.A.4 Other Sectors - Solid Fuels	N_2O	92	13	71	0	65	9	157	23	0	4	0	5.96	96.71
5.D Wastewater treatment and discharge	N_2O	208	173	56	0	117	97	326	270	0	4	0	6.64	96.95
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	96	14	65	0	62	9	158	22	0	3	0	6.70	97.20
1.A.1 Energy industries - Biomass	N_2O	0	32	70	0	0	23	1	55	0	3	0	0.16	97.39
1.A.1 Energy industries - Solid Fuels	N_2O	213	155	70	0	149	109	363	264	0	3	0	0.76	97.57
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	15	37	70	0	10	26	25	63	0	2	0	0.94	97.74

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.1 Energy industries - Liquid Fuels	CO_2	1514	428	4	1	54	15	1568	443	0	2	0	0.11	97.88
2.C.1 Iron and Steel Production	CO_2	9782	5634	12	0	1194	688	10976	6322	5	2	0	4.92	98.02
5.C Incineration and open burning of waste	CO_2	20	97	16	0	3	15	23	112	0	2	0	5.03	98.13
2.F.3 Fire Protection	F-gases	0	31	42	0	0	13	0	45	0	2	0	5.12	98.25
2.B.8 Petrochemical and Carbon Black Production	CH_4	41	56	40	0	16	22	57	78	0	2	0	5.28	98.36
1.A.1 Energy industries - Biomass	CH_4	0	26	50	0	0	13	1	38	0	2	0	0.09	98.47
1.A.3.c Railways	CO_2	768	229	5	0	40	12	808	241	0	1	0	0.17	98.57
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	12	29	51	0	6	15	18	44	0	1	0	0.28	98.67
2.A.1 Cement Production	CO_2	2489	1847	3	0	70	52	2560	1899	1	1	0	0.64	98.76
2.D.1 Lubricant Use	CO_2	116	88	50	0	58	44	174	133	0	1	0	0.95	98.85
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	14	21	74	0	10	16	24	37	0	1	0	1.06	98.93
2.B.1 Ammonia Production	CO_2	991	682	9	0	85	59	1076	741	1	1	0	1.48	99.01
2.E Electronics industry	F-gases	0	54	15	0	0	8	0	62	0	1	0	1.53	99.08
3.D.2 Indirect N2O Emissions From Managed Soils	N_2O	1393	794	30	0	424	242	1817	1036	1	1	0	3.22	99.15
1.A.5.b Other mobile - Liquid Fuels	CO_2	192	266	5	0	9	13	201	279	0	1	0	3.31	99.21
2.A.2 Lime Production	CO_2	1337	556	3	0	38	16	1374	572	0	1	0	3.42	99.27
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	69	55	40	0	28	22	97	78	0	1	0	3.58	99.32
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0	7	81	0	0	6	0	12	0	1	0	3.62	99.37
2.B.10 Other	CO_2	0	139	4	0	0	5	0	144	0	1	0	3.66	99.42
2.G Other Product Manufacture and Use	F-gases	87	63	44	0	38	27	125	91	0	1	0	3.85	99.46
5.C Incineration and open burning of waste	CH_4	0	5	82	0	0	4	0	10	0	1	0	3.88	99.50
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	11	1	70	0	8	1	19	2	0	0	0	3.88	99.53
1.A.4 Other Sectors - Gaseous Fuels	CH_4	11	15	42	0	4	6	15	22	0	0	0	3.93	99.57
1.A.4 Other Sectors - Liquid Fuels	CH_4	13	1	55	0	7	1	20	2	0	0	0	3.93	99.60
2.C.5 Lead Production	CO_2	4	9	51	0	2	5	6	14	0	0	0	3.97	99.63
5.B Biological treatment of solid waste	N_2O	0	66	5	0	0	3	0	70	0	0	0	3.99	99.66
2.A.3 Glass Production	CO_2	143	146	5	0	8	8	150	154	0	0	0	4.05	99.69
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0	5	61	0	0	3	0	9	0	0	0	4.07	99.72

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)
5.C Incineration and open burning of waste	N_2O	0	5	73	0	0	3	1	8	0	0	0	4.09	99.74
1.B.1.b Solid Fuel Transformation	CH_4	1	5	62	0	1	3	1	8	0	0	0	4.12	99.77
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0	3	80	0	0	2	1	5	0	0	0	0.02	99.79
2.C.6 Zinc Production	CO_2	9	1	51	0	4	0	13	1	0	0	0	0.02	99.81
2.D.2 Paraffin Wax Use	CO_2	9	9	50	0	5	5	14	14	0	0	0	0.05	99.82
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	6	1	55	0	3	0	9	1	0	0	0	0.06	99.84
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0	22	7	0	0	2	0	24	0	0	0	0.01	99.85
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0	2	60	0	0	1	0	4	0	0	0	0.01	99.86
1.A.1 Energy industries - Solid Fuels	CH_4	16	11	65	0	10	7	26	19	0	0	0	0.05	99.87
1.A.3.d Transport - Domestic navigation	CO_2	54	10	5	0	3	1	56	10	0	0	0	0.05	99.88
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	2	3	57	0	1	2	3	5	0	0	0	0.07	99.89
2.F.4 Aerosols	F-gases	0	3	42	0	0	1	0	4	0	0	0	0.07	99.90
1.A.5.b Other mobile - Liquid Fuels	N_2O	2	3	70	0	1	2	3	4	0	0	0	0.09	99.91
1.A.1 Energy industries - Liquid Fuels	N_2O	3	0	70	0	2	0	5	1	0	0	0	0.00	99.92
2.C.2 Ferroalloys Production	CH_4	0	4	25	0	0	1	0	5	0	0	0	0.01	99.93
1.A.3.e Other Transportation	CO_2	5	22	5	0	0	1	6	23	0	0	0	0.02	99.94
2.F.2 Foam Blowing Agents	F-gases	0	2	42	0	0	1	0	3	0	0	0	0.02	99.95
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2	3	54	0	1	2	3	4	0	0	0	0.03	99.95
1.A.3.a Domestic Aviation	CO_2	0	12	5	0	0	1	0	13	0	0	0	0.04	99.96
1.A.1 Energy industries - Gaseous Fuels	N_2O	1	1	53	0	0	1	1	2	0	0	0	0.01	99.96
1.A.4 Other Sectors - Liquid Fuels	N_2O	18	11	70	0	13	8	30	19	0	0	0	0.06	99.97
1.A.3.c Railways	N_2O	2	1	125	0	2	1	3	1	0	0	0	0.07	99.97
1.A.3.c Railways	CH_4	1	1	125	0	2	1	3	3	0	0	0	0.08	99.98
1.A.1 Energy industries - Gaseous Fuels	CH_4	1	2	42	0	0	1	1	2	0	0	0	0.00	99.98
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	3	2	53	0	1	1	4	4	0	0	0	0.01	99.99
1.A.1 Energy industries - Liquid Fuels	CH_4	2	0	55	0	1	0	2	0	0	0	0	0.00	99.99
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	3	3	42	0	1	1	4	4	0	0	0	0.01	99.99

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.3.d Transport - Domestic navigation	N_2O	0	0	137	0	1	0	1	0	0	0	0	0.01	99.99
2.C.1 Iron and Steel Production	CH_4	17	9	31	0	5	3	22	12	0	0	0	0.03	99.99
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	11	7	63	0	7	4	19	11	0	0	0	0.06	100.00
2.C.2 Ferroalloys Production	CO_2	0	1	25	0	0	0	0	1	0	0	0	0.06	100.00
1.A.3.a Domestic Aviation	N_2O	0	0	110	0	0	0	0	0	0	0	0	0.06	100.00
2.H Other	F-gases	0	0	44	0	0	0	0	0	0	0	0	0.06	100.00
1.A.3.d Transport - Domestic navigation	CH_4	0	0	101	0	0	0	0	0	0	0	0	0.06	100.00
1.A.5.b Other mobile - Liquid Fuels	CH_4	1	0	55	0	0	0	1	0	0	0	0	0.06	100.00
2.H Other	CO_2	0	1	5	0	0	0	0	1	0	0	0	0.06	100.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0	0	50	0	0	0	0	0	0	0	0	0.06	100.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0	0	50	0	0	0	0	0	0	0	0	0.06	100.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0	0	74	0	0	0	0	0	0	0	0	0.06	100.00
1.A.3.e Other Transportation	N_2O	0	0	60	0	0	0	0	0	0	0	0	0.06	100.00
1.A.3.e Other Transportation	CH_4	0	0	50	0	0	0	0	0	0	0	0	0.06	100.00
1.A.3.a Domestic Aviation	CH_4	0	0	79	0	0	0	0	0	0	0	0	0.06	100.00
2.F.5 Solvents	F-gases	0	0	42	0	0	0	0	0	0	0	0	0.06	100.00

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	Latest year (t) emissions abs	Activity data uncertainty	Emission factor uncertainty
1.A.1 Energy industries - Solid Fuels	CO_2	53719.76	38845.69	2.76	1.78
1.A.1 Energy industries - Solid Fuels	CH_4	15.72	11.23	2.76	65.00
1.A.1 Energy industries - Solid Fuels	N_2O	213.31	155.06	2.76	70.00
1.A.1 Energy industries - Liquid Fuels	CO_2	1514.04	428.22	1.82	3.03
1.A.1 Energy industries - Liquid Fuels	CH_4	1.59	0.26	1.82	55.00
1.A.1 Energy industries - Liquid Fuels	N_2O	2.94	0.33	1.82	70.00
1.A.1 Energy industries - Gaseous Fuels	CO_2	1336.03	3001.65	1.83	0.50
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.69	1.51	1.83	41.67
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.65	1.43	1.83	53.33
1.A.1 Energy industries - Biomass	CH_4	0.34	25.54	6.33	50.00
1.A.1 Energy industries - Biomass	N_2O	0.43	32.22	6.33	70.00
1.A.1 Energy industries - Other Fossil Fuels	CO_2	24.04	261.38	7.70	17.50
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.22	2.39	7.70	60.00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.28	3.02	7.70	80.00
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	35635.57	4937.63	2.16	1.78
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	96.04	13.56	2.16	65.00
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	135.94	19.18	2.16	70.00
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	5502.33	545.40	2.44	3.03
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	6.03	0.56	2.44	55.00
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	11.42	1.03	2.44	70.00
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5685.63	5173.58	2.19	0.50
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	2.92	2.60	2.19	41.67
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.76	2.46	2.19	53.33
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	11.70	29.23	7.13	50.00
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	14.76	36.74	7.13	70.00
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.00	543.22	9.17	60.00
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0.00	5.48	9.17	60.00
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0.00	6.92	9.17	80.00
1.A.3.a Domestic Aviation	CO_2	0.00	12.40	4.00	3.57
1.A.3.a Domestic Aviation	CH_4	0.00	0.00	4.00	78.50
1.A.3.a Domestic Aviation	N_2O	0.00	0.09	4.00	110.00
1.A.3.b Road Transportation	CO_2	10251.06	18916.69	3.00	2.13
1.A.3.b Road Transportation	CH_4	85.83	24.75	3.00	239.38
1.A.3.b Road Transportation	N_2O	82.69	174.46	3.00	189.28
1.A.3.c Railways	CO_2	767.62	228.62	5.00	1.56
1.A.3.c Railways	CH_4	1.23	1.14	5.00	125.20
1.A.3.c Railways	N_2O	1.55	0.50	5.00	125.29
1.A.3.d Transport - Domestic navigation	CO_2	53.52	9.60	5.00	1.48
1.A.3.d Transport - Domestic navigation	CH_4	0.14	0.03	5.00	101.28
1.A.3.d Transport - Domestic navigation	N_2O	0.38	0.07	5.00	137.18
1.A.3.e Other Transportation	CO_2	5.42	22.32	4.00	3.00

Input DATA						
IPCC Source Category	**Gas**	**Base year emissions (1990) abs**	**Latest year (t) emissions abs**	**Activity data uncertainty**	**Emission factor uncertainty**
1.A.3.e Other Transportation	CH_4	0.00	0.01	4.00	50.00
1.A.3.e Other Transportation	N_2O	0.00	0.01	4.00	60.00
1.A.4 Other Sectors - Solid Fuels	CO_2	24005.03	3158.16	9.77	1.78
1.A.4 Other Sectors - Solid Fuels	CH_4	1491.69	271.04	9.77	55.00
1.A.4 Other Sectors - Solid Fuels	N_2O	91.86	13.28	9.77	70.00
1.A.4 Other Sectors - Liquid Fuels	CO_2	3774.74	1223.42	5.44	3.03
1.A.4 Other Sectors - Liquid Fuels	CH_4	13.05	1.17	5.44	55.00
1.A.4 Other Sectors - Liquid Fuels	N_2O	17.85	11.26	5.44	70.00
1.A.4 Other Sectors - Gaseous Fuels	CO_2	4173.90	6154.93	4.72	0.50
1.A.4 Other Sectors - Gaseous Fuels	CH_4	10.72	15.45	4.72	41.67
1.A.4 Other Sectors - Gaseous Fuels	N_2O	2.03	2.92	4.72	53.33
1.A.4 Other Sectors - Biomass	CH_4	363.17	767.46	14.58	50.00
1.A.4 Other Sectors - Biomass	N_2O	45.79	96.67	14.58	70.00
1.A.5.b Other mobile - Liquid Fuels	CO_2	192.04	266.27	3.72	3.03
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.64	0.32	3.72	55.00
1.A.5.b Other mobile - Liquid Fuels	N_2O	1.74	2.55	3.72	70.00
1.B.1.a Coal Mining and Handling	CO_2	456.24	48.65	7.27	25.00
1.B.1.a Coal Mining and Handling	CH_4	11561.08	1845.24	7.27	37.50
1.B.1.b Solid Fuel Transformation	CH_4	0.84	5.10	40.00	47.50
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.02	0.03	6.49	50.00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	11.38	6.91	6.49	62.78
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.17	0.07	5.18	50.00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	1170.32	485.49	5.18	49.44
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	2.02	3.13	25.00	51.26
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	13.76	21.34	25.00	70.00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.01	0.01	25.00	70.00
2.A.1 Cement Production	CO_2	2489.18	1846.97	2.00	2.00
2.A.2 Lime Production	CO_2	1336.65	555.89	2.00	2.00
2.A.3 Glass Production	CO_2	142.75	145.87	5.00	2.00
2.A.4 Other Process Uses of Carbonates	CO_2	113.86	739.50	5.00	10.00
2.B.1 Ammonia Production	CO_2	990.80	682.45	5.00	7.00
2.B.2 Nitric Acid Production	N_2O	932.80	104.49	4.00	15.00
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	68.82	55.40	5.00	40.00
2.B.8 Petrochemical and Carbon Black Production	CO_2	792.47	1016.59	5.00	40.00
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.51	55.59	5.00	40.00
2.B.10 Other	CO_2	0.00	139.01	3.00	2.50
2.C.1 Iron and Steel Production	CO_2	9782.03	5634.33	7.00	10.00
2.C.1 Iron and Steel Production	CH_4	16.62	9.29	7.00	30.00
2.C.2 Ferroalloys Production	CO_2	0.03	0.50	5.00	25.00
2.C.2 Ferroalloys Production	CH_4	0.20	3.89	5.00	25.00
2.C.5 Lead Production	CO_2	4.04	9.37	10.00	50.00
2.C.6 Zinc Production	CO_2	8.70	0.92	10.00	50.00
2.D.1 Lubricant Use	CO_2	116.13	88.42	5.00	50.00
2.D.2 Paraffin Wax Use	CO_2	9.43	9.43	5.00	50.00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.00	22.11	5.00	5.00
2.E Electronics industry	F-gases	0.00	53.55	3.00	15.00
2.F.1 Refrigeration and Air conditioning	F-gases	0.00	3572.75	37.00	23.00
2.F.2 Foam Blowing Agents	F-gases	0.00	2.28	35.00	23.00
2.F.3 Fire Protection	F-gases	0.00	31.41	35.00	23.00
2.F.4 Aerosols	F-gases	0.00	2.63	35.00	23.00
2.F.5 Solvents	F-gases	0.00	0.00	35.00	23.00
2.G Other Product Manufacture and Use	F-gases	86.83	63.11	37.00	23.00
2.G Other Product Manufacture and Use	N_2O	183.38	198.75	37.00	23.00
2.H Other	CO_2	0.00	0.53	5.00	2.00

Input DATA						
IPCC Source Category	Gas	Base year emissions (1990) abs	Latest year (t) emissions abs	Activity data uncertainty	Emission factor uncertainty
2.H Other	F-gases	0.00	0.18	37.00	23.00
3.A Enteric Fermentation	CH_4	6611.86	3680.70	5.00	15.00
3.B Manure Management	CH_4	1574.96	375.14	10.00	20.00
3.B Manure Management	N_2O	996.40	386.96	5.00	40.00
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	3826.01	2839.60	5.00	20.00
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	1393.47	794.16	5.00	30.00
3.G Liming	CO_2	1236.71	153.77	5.00	30.00
3.H Urea application	CO_2	108.53	191.94	15.00	50.00
4.A.1 Forest Land remaining Forest Land	CO_2	7266.06	6047.95	20.00	32.36
4.A.1 Forest Land remaining Forest Land	CH_4	19.36	20.50	20.00	36.82
4.A.1 Forest Land remaining Forest Land	N_2O	10.14	10.73	20.00	36.82
4.A.2 Land converted to Forest Land	CO_2	234.97	551.17	0.00	24.02
4.B.1 Cropland remaining Cropland	CO_2	12.79	21.26	0.00	30.06
4.B.2 Land converted to Cropland	CO_2	120.78	64.27	0.00	25.79
4.B.2. Land converted to Cropland	N_2O	7.92	2.27	0.00	285.24
4.C.1 Grassland remaining Grassland	CO_2	0.00	310.86	0.00	40.69
4.C.2 Land converted to Grassland	CO_2	143.86	190.01	0.00	54.54
4.D.2. Land converted to Wetlands	CO_2	24.10	56.53	0.00	39.47
4.E.2 Land converted to Settlements	CO_2	318.74	194.87	0.00	42.04
4.G Harvested wood products	CO_2	1680.47	1946.26	0.00	62.00
4(IV) Indirect N2O Emissions from Managed Soils	N_2O	1.78	0.51	0.00	283.61
5.A Solid Waste Disposal	CH_4	2007.82	3724.92	0.00	63.70
5.B Biological treatment of solid waste	CH_4	0.00	737.62	5.00	91.15
5.B Biological treatment of solid waste	N_2O	0.00	66.18	5.00	0.60
5.C Incineration and open burning of waste	CO_2	19.97	96.72	15.00	5.00
5.C Incineration and open burning of waste	CH_4	0.00	5.30	20.00	80.00
5.C Incineration and open burning of waste	N_2O	0.46	4.63	20.00	70.00
5.D Wastewater treatment and discharge	CH_4	1082.93	893.78	30.14	50.00
5.D Wastewater treatment and discharge	N_2O	208.25	172.96	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 in year t	Combined uncertainty as % of total national emissions in year t	Uncertain ammount in BY	Combined uncertainty as % of total national emissions in BY
1.A.1 Energy industries - Solid Fuels	CO_2	3.29	1276.25	1.01	1764.93	0,85
1.A.1 Energy industries - Solid Fuels	CH_4	65.06	7.30	0.01	10.23	0,00
1.A.1 Energy industries - Solid Fuels	N_2O	70.05	108.63	0.09	149.43	0,07
1.A.1 Energy industries - Liquid Fuels	CO_2	3.54	15.16	0.01	53.59	0,03
1.A.1 Energy industries - Liquid Fuels	CH_4	55.03	0.14	0.00	0.87	0,00
1.A.1 Energy industries - Liquid Fuels	N_2O	70.02	0.23	0.00	2.06	0,00
1.A.1 Energy industries - Gaseous Fuels	CO_2	1.90	57.05	0.05	25.39	0,01
1.A.1 Energy industries - Gaseous Fuels	CH_4	41.71	0.63	0.00	0.29	0,00
1.A.1 Energy industries - Gaseous Fuels	N_2O	53.36	0.76	0.00	0.35	0,00
1.A.1 Energy industries - Biomass	CH_4	50.40	12.87	0.01	0.17	0,00
1.A.1 Energy industries - Biomass	N_2O	70.29	22.65	0.02	0.30	0,00
1.A.1 Energy industries - Other Fossil Fuels	CO_2	19.12	49.97	0.04	4.60	0,00
1.A.1 Energy industries - Other Fossil Fuels	CH_4	60.49	1.45	0.00	0.13	0,00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	80.37	2.43	0.00	0.22	0,00
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	2.79	137.98	0.11	995.79	0,48
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	65.04	8.82	0.01	62.46	0,03
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	70.03	13.43	0.01	95.20	0,05

		Uncertainty of Emissions				
IPCC Source Category	Gas	Combined uncertainty	Uncertain ammount in year t	Combined uncertainty as % of total national emissions in year t	Uncertain ammount in BY	Combined uncertainty as % of total national emissions in BY
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	3.89	21.24	0.02	214.29	0,10
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	55.05	0.31	0.00	3.32	0,00
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	70.04	0.72	0.00	8.00	0,00
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	2.24	116.02	0.09	127.50	0,06
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	41.72	1.08	0.00	1.22	0,00
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	53.38	1.31	0.00	1.48	0,00
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	50.51	14.76	0.01	5.91	0,00
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	70.36	25.85	0.02	10.39	0,00
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	60.70	329.71	0.26	0.00	0,00
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	60.70	3.33	0.00	0.00	0,00
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	80.52	5.57	0.00	0.00	0,00
1.A.3.a Domestic Aviation	CO_2	5.36	0.66	0.00	0.00	0,00
1.A.3.a Domestic Aviation	CH_4	78.60	0.00	0.00	0.00	0,00
1.A.3.a Domestic Aviation	N_2O	110.07	0.10	0.00	0.00	0,00
1.A.3.b Road Transportation	CO_2	3.68	695.74	0.55	377.02	0,18
1.A.3.b Road Transportation	CH_4	239.40	59.24	0.05	205.48	0,10
1.A.3.b Road Transportation	N_2O	189.30	330.25	0.26	156.54	0,08
1.A.3.c Railways	CO_2	5.24	11.97	0.01	40.20	0,02
1.A.3.c Railways	CH_4	125.30	1.42	0.00	1.54	0,00
1.A.3.c Railways	N_2O	125.39	0.63	0.00	1.95	0,00
1.A.3.d Transport - Domestic navigation	CO_2	5.22	0.50	0.00	2.79	0,00
1.A.3.d Transport - Domestic navigation	CH_4	101.41	0.03	0.00	0.14	0,00
1.A.3.d Transport - Domestic navigation	N_2O	137.27	0.09	0.00	0.53	0,00
1.A.3.e Other Transportation	CO_2	5.00	1.12	0.00	0.27	0,00
1.A.3.e Other Transportation	CH_4	50.16	0.01	0.00	0.00	0,00
1.A.3.e Other Transportation	N_2O	60.13	0.01	0.00	0.00	0,00
1.A.4 Other Sectors - Solid Fuels	CO_2	9.93	313.63	0.25	2383.86	1,14
1.A.4 Other Sectors - Solid Fuels	CH_4	55.86	151.41	0.12	833.27	0,40
1.A.4 Other Sectors - Solid Fuels	N_2O	70.68	9.38	0.01	64.93	0,03
1.A.4 Other Sectors - Liquid Fuels	CO_2	6.23	76.23	0.06	235.21	0,11
1.A.4 Other Sectors - Liquid Fuels	CH_4	55.27	0.65	0.00	7.21	0,00
1.A.4 Other Sectors - Liquid Fuels	N_2O	70.21	7.91	0.01	12.53	0,01
1.A.4 Other Sectors - Gaseous Fuels	CO_2	4.74	291.88	0.23	197.93	0,09
1.A.4 Other Sectors - Gaseous Fuels	CH_4	41.93	6.48	0.01	4.49	0,00
1.A.4 Other Sectors - Gaseous Fuels	N_2O	53.54	1.57	0.00	1.09	0,00
1.A.4 Other Sectors - Biomass	CH_4	52.08	399.71	0.32	189.14	0,09
1.A.4 Other Sectors - Biomass	N_2O	71.50	69.12	0.05	32.74	0,02
1.A.5.b Other mobile - Liquid Fuels	CO_2	4.80	12.77	0.01	9.21	0,00
1.A.5.b Other mobile - Liquid Fuels	CH_4	55.13	0.18	0.00	0.35	0,00
1.A.5.b Other mobile - Liquid Fuels	N_2O	70.10	1.79	0.00	1.22	0,00
1.B.1.a Coal Mining and Handling	CO_2	26.04	12.67	0.01	118.79	0,06
1.B.1.a Coal Mining and Handling	CH_4	38.20	704.85	0.56	4416.14	2,12
1.B.1.b Solid Fuel Transformation	CH_4	62.10	3.17	0.00	0.52	0,00

		Uncertainty of Emissions				
IPCC Source Category	Gas	Combined uncertainty	Uncertain ammount in year t	Combined uncertainty as % of total national emissions in year t	Uncertain ammount in BY	Combined uncertainty as % of total national emissions in BY
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	50.42	0.01	0.00	0.01	0,00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	63.11	4.36	0.00	7.18	0,00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	50.27	0.03	0.00	0.08	0,00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	49.72	241.36	0.19	581.83	0,28
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	57.03	1.78	0.00	1.15	0,00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	74.33	15.86	0.01	10.23	0,00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	74.33	0.01	0.00	0.01	0,00
2.A.1 Cement Production	CO_2	2.83	52.24	0.04	70.40	0,03
2.A.2 Lime Production	CO_2	2.83	15.72	0.01	37.81	0,02
2.A.3 Glass Production	CO_2	5.39	7.86	0.01	7.69	0,00
2.A.4 Other Process Uses of Carbonates	CO_2	11.18	82.68	0.07	12.73	0,01
2.B.1 Ammonia Production	CO_2	8.60	58.71	0.05	85.23	0,04
2.B.2 Nitric Acid Production	N_2O	15.52	16.22	0.01	144.81	0,07
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	40.31	22.33	0.02	27.74	0,01
2.B.8 Petrochemical and Carbon Black Production	CO_2	40.31	409.80	0.32	319.45	0,15
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.31	22.41	0.02	16.33	0,01
2.B.10 Other	CO_2	3.91	5.43	0.00	0.00	0,00
2.C.1 Iron and Steel Production	CO_2	12.21	687.76	0.54	1194.05	0,57
2.C.1 Iron and Steel Production	CH_4	30.81	2.86	0.00	5.12	0,00
2.C.2 Ferroalloys Production	CO_2	25.50	0.13	0.00	0.01	0,00
2.C.2 Ferroalloys Production	CH_4	25.50	0.99	0.00	0.05	0,00
2.C.5 Lead Production	CO_2	50.99	4.78	0.00	2.06	0,00
2.C.6 Zinc Production	CO_2	50.99	0.47	0.00	4.44	0,00
2.D.1 Lubricant Use	CO_2	50.25	44.43	0.04	58.36	0,03
2.D.2 Paraffin Wax Use	CO_2	50.25	4.74	0.00	4.74	0,00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	7.07	1.56	0.00	0.00	0,00
2.E Electronics industry	F-gases	15.30	8.19	0.01	0.00	0,00
2.F.1 Refrigeration and Air conditioning	F-gases	43.57	1556.50	1.23	0.00	0,00
2.F.2 Foam Blowing Agents	F-gases	41.88	0.95	0.00	0.00	0,00
2.F.3 Fire Protection	F-gases	41.88	13.15	0.01	0.00	0,00
2.F.4 Aerosols	F-gases	41.88	1.10	0.00	0.00	0,00
2.F.5 Solvents	F-gases	41.88	0.00	0.00	0.00	0,00
2.G Other Product Manufacture and Use	F-gases	43.57	27.50	0.02	37.83	0,02
2.G Other Product Manufacture and Use	N_2O	43.57	86.59	0.07	79.89	0,04
2.H Other	CO_2	5.39	0.03	0.00	0.00	0,00
2.H Other	F-gases	43.57	0.08	0.00	0.00	0,00
3.A Enteric Fermentation	CH_4	15.81	581.97	0.46	1045.43	0,50
3.B Manure Management	CH_4	22.36	83.88	0.07	352.17	0,17
3.B Manure Management	N_2O	40.31	155.99	0.12	401.66	0,19
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	20.62	585.40	0.46	788.75	0,38
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	30.41	241.53	0.19	423.81	0,20
3.G Liming	CO_2	30.41	46.77	0.04	376.13	0,18

		Uncertainty of Emissions					
IPCC Source Category	Gas	Combined uncertainty	Uncertain ammount in year t	Combined uncertainty as % of total national emissions in year t	Uncertain ammount in BY	Combined uncertainty as % of total national emissions in BY
3.H Urea application	CO_2	52.20	100.19	0.08	56.66	0,03
4.A.1 Forest Land remaining Forest Land	CO_2	38.05	2300.95	1.82	2764.38	1,33
4.A.1 Forest Land remaining Forest Land	CH_4	41.91	8.59	0.01	8.11	0,00
4.A.1 Forest Land remaining Forest Land	N_2O	41.91	4.50	0.00	4.25	0,00
4.A.2 Land converted to Forest Land	CO_2	24.02	132.41	0.10	56.45	0,03
4.B.1 Cropland remaining Cropland	CO_2	30.06	6.39	0.01	3.85	0,00
4.B.2 Land converted to Cropland	CO_2	25.79	16.57	0.01	31.14	0,01
4.B.2. Land converted to Cropland	N_2O	285.24	6.46	0.01	22.59	0,01
4.C.1 Grassland remaining Grassland	CO_2	40.69	126.49	0.10	0.00	0,00
4.C.2 Land converted to Grassland	CO_2	54.54	103.63	0.08	78.46	0,04
4.D.2. Land converted to Wetlands	CO_2	39.47	22.32	0.02	9.51	0,00
4.E.2 Land converted to Settlements	CO_2	42.04	81.92	0.06	133.99	0,06
4.G Harvested wood products	CO_2	62.00	1206.68	0.95	1041.89	0,50
4(IV) Indirect N2O Emissions from Managed Soils	N_2O	283.61	1.45	0.00	5.05	0,00
5.A Solid Waste Disposal	CH_4	63.70	2372.74	1.88	1278.96	0,61
5.B Biological treatment of solid waste	CH_4	91.29	673.36	0.53	0.00	0,00
5.B Biological treatment of solid waste	N_2O	5.04	3.33	0.00	0.00	0,00
5.C Incineration and open burning of waste	CO_2	15.81	15.29	0.01	3.16	0,00
5.C Incineration and open burning of waste	CH_4	82.46	4.37	0.00	0.00	0,00
5.C Incineration and open burning of waste	N_2O	72.80	3.37	0.00	0.33	0,00
5.D Wastewater treatment and discharge	CH_4	58.38	521.82	0.41	632.25	0,30
5.D Wastewater treatment and discharge	N_2O	56.36	97.47	0.08	117.36	0,06
	Level uncertainty =		18305.30	3.57	25178.77	3.23

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	0.0300	0.1862	0.0533	0.7277	0.5324
1.A.1 Energy industries - Solid Fuels	CH_4	0.0000	0.0001	0.0005	0.0002	0.0000
1.A.1 Energy industries - Solid Fuels	N_2O	0.0001	0.0007	0.0086	0.0029	0.0001
1.A.1 Energy industries - Liquid Fuels	CO_2	-0.0023	0.0021	-0.0071	0.0053	0.0001
1.A.1 Energy industries - Liquid Fuels	CH_4	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.1 Energy industries - Liquid Fuels	N_2O	0.0000	0.0000	-0.0005	0.0000	0.0000
1.A.1 Energy industries - Gaseous Fuels	CO_2	0.0105	0.0144	0.0053	0.0373	0.0014
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.0000	0.0000	0.0003	0.0000	0.0000
1.A.1 Energy industries - Biomass	CH_4	0.0001	0.0001	0.0061	0.0011	0.0000
1.A.1 Energy industries - Biomass	N_2O	0.0002	0.0002	0.0107	0.0014	0.0001

IPCC Source Category	Gas	Uncertainty of Trend				
		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 - Other Fossil Fuels	CO_2	0.0012	0.0013	0.0207	0.0136	0.0006
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.0000	0.0000	0.0007	0.0001	0.0000
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.0000	0.0000	0.0011	0.0002	0.0000
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	-0.0798	0.0237	-0.1417	0.0722	0.0253
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	-0.0002	0.0001	-0.0139	0.0002	0.0002
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	-0.0003	0.0001	-0.0212	0.0003	0.0005
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	-0.0134	0.0026	-0.0406	0.0090	0.0017
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.0000	0.0000	-0.0008	0.0000	0.0000
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	0.0000	0.0000	-0.0020	0.0000	0.0000
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	0.0083	0.0248	0.0041	0.0767	0.0059
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	0.0001	0.0001	0.0053	0.0014	0.0000
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	0.0001	0.0002	0.0093	0.0018	0.0001
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.0026	0.0026	0.1562	0.0338	0.0256
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0.0000	0.0000	0.0016	0.0003	0.0000
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0.0000	0.0000	0.0027	0.0004	0.0000
1.A.3.a Domestic Aviation	CO_2	0.0001	0.0001	0.0002	0.0003	0.0000
1.A.3.a Domestic Aviation	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Domestic Aviation	N_2O	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Road Transportation	CO_2	0.0609	0.0907	0.1295	0.3847	0.1648
1.A.3.b Road Transportation	CH_4	-0.0001	0.0001	-0.0313	0.0005	0.0010
1.A.3.b Road Transportation	N_2O	0.0006	0.0008	0.1128	0.0035	0.0127
1.A.3.c Railways	CO_2	-0.0011	0.0011	-0.0018	0.0077	0.0001
1.A.3.c Railways	CH_4	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.3.c Railways	N_2O	0.0000	0.0000	-0.0003	0.0000	0.0000
1.A.3.d Transport - Domestic navigation	CO_2	-0.0001	0.0000	-0.0002	0.0003	0.0000
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	0.0000
1.A.3.e Other Transportation	CO_2	0.0001	0.0001	0.0003	0.0006	0.0000
1.A.3.e Other Transportation	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Other Transportation	N_2O	0.0000	0.0000	0.0000	0.0000	0.0000

		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.4 Other Sectors - Solid Fuels	CO_2	-0.0546	0.0151	-0.0970	0.2092	0.0532
1.A.4 Other Sectors - Solid Fuels	CH_4	-0.0030	0.0013	-0.1670	0.0180	0.0282
1.A.4 Other Sectors - Solid Fuels	N_2O	-0.0002	0.0001	-0.0142	0.0009	0.0002
1.A.4 Other Sectors - Liquid Fuels	CO_2	-0.0051	0.0059	-0.0155	0.0451	0.0023
1.A.4 Other Sectors - Liquid Fuels	CH_4	0.0000	0.0000	-0.0018	0.0000	0.0000
1.A.4 Other Sectors - Liquid Fuels	N_2O	0.0000	0.0001	0.0001	0.0004	0.0000
1.A.4 Other Sectors - Gaseous Fuels	CO_2	0.0174	0.0295	0.0087	0.1968	0.0388
1.A.4 Other Sectors - Gaseous Fuels	CH_4	0.0000	0.0001	0.0018	0.0005	0.0000
1.A.4 Other Sectors - Gaseous Fuels	N_2O	0.0000	0.0000	0.0004	0.0001	0.0000
1.A.4 Other Sectors - Biomass	CH_4	0.0026	0.0037	0.1312	0.0758	0.0230
1.A.4 Other Sectors - Biomass	N_2O	0.0003	0.0005	0.0231	0.0096	0.0006
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.0007	0.0013	0.0022	0.0067	0.0000
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.0000	0.0000	0.0005	0.0001	0.0000
1.B.1.a Coal Mining and Handling	CO_2	-0.0011	0.0002	-0.0273	0.0024	0.0008
1.B.1.a Coal Mining and Handling	CH_4	-0.0247	0.0088	-0.9277	0.0909	0.8689
1.B.1.b Solid Fuel Transformation	CH_4	0.0000	0.0000	0.0010	0.0014	0.0000
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	0.0000	0.0000	0.0000	0.0003	0.0000
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	-0.0011	0.0023	-0.0531	0.0171	0.0031
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	0.0000	0.0000	0.0005	0.0005	0.0000
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	0.0001	0.0001	0.0044	0.0036	0.0000
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.1 Cement Production	CO_2	0.0016	0.0089	0.0032	0.0250	0.0006
2.A.2 Lime Production	CO_2	-0.0012	0.0027	-0.0024	0.0075	0.0001
2.A.3 Glass Production	CO_2	0.0003	0.0007	0.0006	0.0049	0.0000
2.A.4 Other Process Uses of Carbonates	CO_2	0.0032	0.0035	0.0321	0.0251	0.0017
2.B.1 Ammonia Production	CO_2	0.0004	0.0033	0.0027	0.0231	0.0005
2.B.2 Nitric Acid Production	N_2O	-0.0022	0.0005	-0.0331	0.0028	0.0011
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	0.0001	0.0003	0.0026	0.0019	0.0000
2.B.8 Petrochemical and Carbon Black Production	CO_2	0.0026	0.0049	0.1028	0.0345	0.0118
2.B.8 Petrochemical and Carbon Black Production	CH_4	0.0001	0.0003	0.0060	0.0019	0.0000
2.B.10 Other	CO_2	0.0007	0.0007	0.0017	0.0028	0.0000
2.C.1 Iron and Steel Production	CO_2	-0.0014	0.0270	-0.0142	0.2674	0.0717
2.C.1 Iron and Steel Production	CH_4	0.0000	0.0000	-0.0001	0.0004	0.0000

		Uncertainty of Trend				
IPCC Source Category	**Gas**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by EF uncertainty**	**Uncertainty in trend in national emissions introduced by AD uncertainty**	**Uncertainty introduced into the trend in total national emissions**
2.C.2 Ferroalloys Production	CO_2	0.0000	0.0000	0.0001	0.0000	0.0000
2.C.2 Ferroalloys Production	CH_4	0.0000	0.0000	0.0005	0.0001	0.0000
2.C.5 Lead Production	CO_2	0.0000	0.0000	0.0017	0.0006	0.0000
2.C.6 Zinc Production	CO_2	0.0000	0.0000	-0.0010	0.0001	0.0000
2.D.1 Lubricant Use	CO_2	0.0001	0.0004	0.0043	0.0030	0.0000
2.D.2 Paraffin Wax Use	CO_2	0.0000	0.0000	0.0009	0.0003	0.0000
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.0001	0.0001	0.0005	0.0007	0.0000
2.E Electronics industry	F-gases	0.0003	0.0003	0.0039	0.0011	0.0000
2.F.1 Refrigeration and Air conditioning	F-gases	0.0171	0.0171	0.3939	0.8962	0.9583
2.F.2 Foam Blowing Agents	F-gases	0.0000	0.0000	0.0003	0.0005	0.0000
2.F.3 Fire Protection	F-gases	0.0002	0.0002	0.0035	0.0075	0.0001
2.F.4 Aerosols	F-gases	0.0000	0.0000	0.0003	0.0006	0.0000
2.F.5 Solvents	F-gases	0.0000	0.0000	0.0000	0.0000	0.0000
2.G Other Product Manufacture and Use	F-gases	0.0001	0.0003	0.0012	0.0158	0.0003
2.G Other Product Manufacture and Use	N_2O	0.0004	0.0010	0.0097	0.0499	0.0026
2.H Other	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000
2.H Other	F-gases	0.0000	0.0000	0.0000	0.0000	0.0000
3.A Enteric Fermentation	CH_4	-0.0016	0.0176	-0.0236	0.1248	0.0161
3.B Manure Management	CH_4	-0.0028	0.0018	-0.0556	0.0254	0.0037
3.B Manure Management	N_2O	-0.0010	0.0019	-0.0416	0.0131	0.0019
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	0.0025	0.0136	0.0499	0.0963	0.0118
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	-0.0002	0.0038	-0.0073	0.0269	0.0008
3.G Liming	CO_2	-0.0029	0.0007	-0.0857	0.0052	0.0074
3.H Urea application	CO_2	0.0006	0.0009	0.0302	0.0195	0.0013
4.A.1 Forest Land remaining Forest Land	CO_2	0.0079	0.0290	0.2548	0.8200	0.7374
4.A.1 Forest Land remaining Forest Land	CH_4	0.0000	0.0001	0.0015	0.0028	0.0000
4.A.1 Forest Land remaining Forest Land	N_2O	0.0000	0.0001	0.0008	0.0015	0.0000
4.A.2 Land converted to Forest Land	CO_2	0.0020	0.0026	0.0471	0.0000	0.0022
4.B.1 Cropland remaining Cropland	CO_2	0.0001	0.0001	0.0019	0.0000	0.0000
4.B.2 Land converted to Cropland	CO_2	0.0000	0.0003	-0.0011	0.0000	0.0000
4.B.2. Land converted to Cropland	N_2O	0.0000	0.0000	-0.0035	0.0000	0.0000
4.C.1 Grassland remaining Grassland	CO_2	0.0015	0.0015	0.0606	0.0000	0.0037
4.C.2 Land converted to Grassland	CO_2	0.0005	0.0009	0.0269	0.0000	0.0007
4.D.2. Land converted to Wetlands	CO_2	0.0002	0.0003	0.0079	0.0000	0.0001
4.E.2 Land converted to Settlements	CO_2	0.0000	0.0009	0.0003	0.0000	0.0000

		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**
4.G Harvested wood products	CO_2	0.0044	0.0093	0.2756	0.0000	0.0760
4(IV) Indirect N_2O Emissions from Managed Soils	N_2O	0.0000	0.0000	-0.0008	0.0000	0.0000
5.A Solid Waste Disposal	CH_4	0.0120	0.0179	0.7657	0.0000	0.5862
5.B Biological treatment of solid waste	CH_4	0.0035	0.0035	0.3223	0.0250	0.1045
5.B Biological treatment of solid waste	N_2O	0.0003	0.0003	0.0002	0.0022	0.0000
5.C Incineration and open burning of waste	CO_2	0.0004	0.0005	0.0020	0.0098	0.0001
5.C Incineration and open burning of waste	CH_4	0.0000	0.0000	0.0020	0.0007	0.0000
5.C Incineration and open burning of waste	N_2O	0.0000	0.0000	0.0015	0.0006	0.0000
5.D Wastewater treatment and discharge	CH_4	0.0011	0.0043	0.0569	0.1826	0.0366
5.D Wastewater treatment and discharge	N_2O	0.0002	0.0008	0.0112	0.0305	0.0011
					Trend uncertainty =	1.70

Tab. A2 4 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**	**Uncertain ammount in BY**	**Combined uncertainty as % of total national emissions in BY**
1.A.1 Energy industries - Solid Fuels	CO_2	3.29	1276.25	1.09	1764.93	0,64
1.A.1 Energy industries - Solid Fuels	CH_4	65.06	7.30	0.01	10.23	0,00
1.A.1 Energy industries - Solid Fuels	N_2O	70.05	108.63	0.09	149.43	0,05
1.A.1 Energy industries - Liquid Fuels	CO_2	3.54	15.16	0.01	53.59	0,01
1.A.1 Energy industries - Liquid Fuels	CH_4	55.03	0.14	0.00	0.87	0,00
1.A.1 Energy industries - Liquid Fuels	N_2O	70.02	0.23	0.00	2.06	0,00
1.A.1 Energy industries - Gaseous Fuels	CO_2	1.90	57.05	0.05	25.39	0,03
1.A.1 Energy industries - Gaseous Fuels	CH_4	41.71	0.63	0.00	0.29	0,00
1.A.1 Energy industries - Gaseous Fuels	N_2O	53.36	0.76	0.00	0.35	0,00
1.A.1 Energy industries - Biomass	CH_4	50.40	12.87	0.01	0.17	0,01
1.A.1 Energy industries - Biomass	N_2O	70.29	22.65	0.02	0.30	0,01
1.A.1 Energy industries - Other Fossil Fuels	CO_2	19.12	49.97	0.04	4.60	0,03
1.A.1 Energy industries - Other Fossil Fuels	CH_4	60.49	1.45	0.00	0.13	0,00
1.A.1 Energy industries - Other Fossil Fuels	N_2O	80.37	2.43	0.00	0.22	0,00
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	2.79	137.98	0.12	995.79	0,07
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	65.04	8.82	0.01	62.46	0,00
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	70.03	13.43	0.01	95.20	0,01
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	3.89	21.24	0.02	214.29	0,01

IPCC Source Category	Gas	Uncertainty of Emissions				
		Combined uncertainty	Uncertain ammount	Combined uncertainty as % of total national emissions in year t	Uncertain ammount in BY	Combined uncertainty as % of total national emissions in BY
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	55.05	0.31	0.00	3.32	0,00
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	70.04	0.72	0.00	8.00	0,00
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	2.24	116.02	0.10	127.50	0,06
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	41.72	1.08	0.00	1.22	0,00
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	53.38	1.31	0.00	1.48	0,00
1.A.2 Manufacturing Industries and Construction - Biomass	CH_4	50.51	14.76	0.01	5.91	0,01
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	70.36	25.85	0.02	10.39	0,01
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	60.70	329.71	0.28	0.00	0,17
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	60.70	3.33	0.00	0.00	0,00
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	80.52	5.57	0.00	0.00	0,00
1.A.3.a Domestic Aviation	CO_2	5.36	0.66	0.00	0.00	0,00
1.A.3.a Domestic Aviation	CH_4	78.60	0.00	0.00	0.00	0,00
1.A.3.a Domestic Aviation	N_2O	110.07	0.10	0.00	0.00	0,00
1.A.3.b Road Transportation	CO_2	3.68	695.74	0.59	377.02	0,35
1.A.3.b Road Transportation	CH_4	239.40	59.24	0.05	205.48	0,03
1.A.3.b Road Transportation	N_2O	189.30	330.25	0.28	156.54	0,17
1.A.3.c Railways	CO_2	5.24	11.97	0.01	40.20	0,01
1.A.3.c Railways	CH_4	125.30	1.42	0.00	1.54	0,00
1.A.3.c Railways	N_2O	125.39	0.63	0.00	1.95	0,00
1.A.3.d Transport - Domestic navigation	CO_2	5.22	0.50	0.00	2.79	0,00
1.A.3.d Transport - Domestic navigation	CH_4	101.41	0.03	0.00	0.14	0,00
1.A.3.d Transport - Domestic navigation	N_2O	137.27	0.09	0.00	0.53	0,00
1.A.3.e Other Transportation	CO_2	5.00	1.12	0.00	0.27	0,00
1.A.3.e Other Transportation	CH_4	50.16	0.01	0.00	0.00	0,00
1.A.3.e Other Transportation	N_2O	60.13	0.01	0.00	0.00	0,00
1.A.4 Other Sectors - Solid Fuels	CO_2	9.93	313.63	0.27	2383.86	0,16
1.A.4 Other Sectors - Solid Fuels	CH_4	55.86	151.41	0.13	833.27	0,08
1.A.4 Other Sectors - Solid Fuels	N_2O	70.68	9.38	0.01	64.93	0,00
1.A.4 Other Sectors - Liquid Fuels	CO_2	6.23	76.23	0.07	235.21	0,04
1.A.4 Other Sectors - Liquid Fuels	CH_4	55.27	0.65	0.00	7.21	0,00
1.A.4 Other Sectors - Liquid Fuels	N_2O	70.21	7.91	0.01	12.53	0,00
1.A.4 Other Sectors - Gaseous Fuels	CO_2	4.74	291.88	0.25	197.93	0,15
1.A.4 Other Sectors - Gaseous Fuels	CH_4	41.93	6.48	0.01	4.49	0,00
1.A.4 Other Sectors - Gaseous Fuels	N_2O	53.54	1.57	0.00	1.09	0,00
1.A.4 Other Sectors - Biomass	CH_4	52.08	399.71	0.34	189.14	0,20
1.A.4 Other Sectors - Biomass	N_2O	71.50	69.12	0.06	32.74	0,03
1.A.5.b Other mobile - Liquid Fuels	CO_2	4.80	12.77	0.01	9.21	0,01
1.A.5.b Other mobile - Liquid Fuels	CH_4	55.13	0.18	0.00	0.35	0,00
1.A.5.b Other mobile - Liquid Fuels	N_2O	70.10	1.79	0.00	1.22	0,00
1.B.1.a Coal Mining and Handling	CO_2	26.04	12.67	0.01	118.79	0,01
1.B.1.a Coal Mining and Handling	CH_4	38.20	704.85	0.60	4416.14	0,35
1.B.1.b Solid Fuel Transformation	CH_4	62.10	3.17	0.00	0.52	0,00
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	50.42	0.01	0.00	0.01	0,00

		Uncertainty of Emissions				
IPCC Source Category	Gas	Combined uncertainty	Uncertain ammount	Combined uncertainty as % of total national emissions in year t	Uncertain ammount in BY	Combined uncertainty as % of total national emissions in BY
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	63.11	4.36	0.00	7.18	0,00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	50.27	0.03	0.00	0.08	0,00
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	49.72	241.36	0.21	581.83	0,12
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	57.03	1.78	0.00	1.15	0,00
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	74.33	15.86	0.01	10.23	0,01
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	74.33	0.01	0.00	0.01	0,00
2.A.1 Cement Production	CO_2	2.83	52.24	0.04	70.40	0,03
2.A.2 Lime Production	CO_2	2.83	15.72	0.01	37.81	0,01
2.A.3 Glass Production	CO_2	5.39	7.86	0.01	7.69	0,00
2.A.4 Other Process Uses of Carbonates	CO_2	11.18	82.68	0.07	12.73	0,04
2.B.1 Ammonia Production	CO_2	8.60	58.71	0.05	85.23	0,03
2.B.2 Nitric Acid Production	N_2O	15.52	16.22	0.01	144.81	0,01
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	40.31	22.33	0.02	27.74	0,01
2.B.8 Petrochemical and Carbon Black Production	CO_2	40.31	409.80	0.35	319.45	0,21
2.B.8 Petrochemical and Carbon Black Production	CH_4	40.31	22.41	0.02	16.33	0,01
2.B.10 Other	CO_2	3.91	5.43	0.00	0.00	0,00
2.C.1 Iron and Steel Production	CO_2	12.21	687.76	0.59	1194.05	0,35
2.C.1 Iron and Steel Production	CH_4	30.81	2.86	0.00	5.12	0,00
2.C.2 Ferroalloys Production	CO_2	25.50	0.13	0.00	0.01	0,00
2.C.2 Ferroalloys Production	CH_4	25.50	0.99	0.00	0.05	0,00
2.C.5 Lead Production	CO_2	50.99	4.78	0.00	2.06	0,00
2.C.6 Zinc Production	CO_2	50.99	0.47	0.00	4.44	0,00
2.D.1 Lubricant Use	CO_2	50.25	44.43	0.04	58.36	0,02
2.D.2 Paraffin Wax Use	CO_2	50.25	4.74	0.00	4.74	0,00
2.D.3 Other non-energy products from fuels and solvent use	CO_2	7.07	1.56	0.00	0.00	0,00
2.E Electronics industry	F-gases	15.30	8.19	0.01	0.00	0,00
2.F.1 Refrigeration and Air conditioning	F-gases	43.57	1556.50	1.33	0.00	0,78
2.F.2 Foam Blowing Agents	F-gases	41.88	0.95	0.00	0.00	0,00
2.F.3 Fire Protection	F-gases	41.88	13.15	0.01	0.00	0,01
2.F.4 Aerosols	F-gases	41.88	1.10	0.00	0.00	0,00
2.F.5 Solvents	F-gases	41.88	0.00	0.00	0.00	0,00
2.G Other Product Manufacture and Use	F-gases	43.57	27.50	0.02	37.83	0,01
2.G Other Product Manufacture and Use	N_2O	43.57	86.59	0.07	79.89	0,04
2.H Other	CO_2	5.39	0.03	0.00	0.00	0,00
2.H Other	F-gases	43.57	0.08	0.00	0.00	0,00
3.A Enteric Fermentation	CH_4	15.81	581.97	0.50	1045.43	0,29
3.B Manure Management	CH_4	22.36	83.88	0.07	352.17	0,04
3.B Manure Management	N_2O	40.31	155.99	0.13	401.66	0,08
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	20.62	585.40	0.50	788.75	0,29
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	30.41	241.53	0.21	423.81	0,12
3.G Liming	CO_2	30.41	46.77	0.04	376.13	0,02
3.H Urea application	CO_2	52.20	100.19	0.09	56.66	0,05
5.A Solid Waste Disposal	CH_4	63.70	2372.74	2.03	1278.96	1,19
5.B Biological treatment of solid waste	CH_4	91.29	673.36	0.58	0.00	0,34
5.B Biological treatment of solid waste	N_2O	5.04	3.33	0.00	0.00	0,00
5.C Incineration and open burning of waste	CO_2	15.81	15.29	0.01	3.16	0,01

		Uncertainty of Emissions				
IPCC Source Category	Gas	Combined uncertainty	Uncertain ammount	Combined uncertainty as % of total national emissions in year t	Uncertain ammount in BY	Combined uncertainty as % of total national emissions in BY
5.C Incineration and open burning of waste	CH_4	82.46	4.37	0.00	0.00	0,00
5.C Incineration and open burning of waste	N_2O	72.80	3.37	0.00	0.33	0,00
5.D Wastewater treatment and discharge	CH_4	58.38	521.82	0.45	632.25	0,26
5.D Wastewater treatment and discharge	N_2O	56.36	97.47	0.08	117.36	0,05
	Level uncertainty =		14286.94	3.15	21019.08	1.85

Tab. A2 5 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	0.0362	0.1954	0.0643	0.7638	0.5875
1.A.1 Energy industries - Solid Fuels	CH_4	0.0000	0.0001	0.0006	0.0002	0.0000
1.A.1 Energy industries - Solid Fuels	N_2O	0.0001	0.0008	0.0104	0.0030	0.0001
1.A.1 Energy industries - Liquid Fuels	CO_2	-0.0023	0.0022	-0.0071	0.0056	0.0001
1.A.1 Energy industries - Liquid Fuels	CH_4	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.1 Energy industries - Liquid Fuels	N_2O	0.0000	0.0000	-0.0005	0.0000	0.0000
1.A.1 Energy industries - Gaseous Fuels	CO_2	0.0111	0.0151	0.0056	0.0392	0.0016
1.A.1 Energy industries - Gaseous Fuels	CH_4	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.1 Energy industries - Gaseous Fuels	N_2O	0.0000	0.0000	0.0003	0.0000	0.0000
1.A.1 Energy industries - Biomass	CH_4	0.0001	0.0001	0.0064	0.0012	0.0000
1.A.1 Energy industries - Biomass	N_2O	0.0002	0.0002	0.0113	0.0015	0.0001
1.A.1 Energy industries - Other Fossil Fuels	CO_2	0.0012	0.0013	0.0218	0.0143	0.0007
1.A.1 Energy industries - Other Fossil Fuels	CH_4	0.0000	0.0000	0.0007	0.0001	0.0000
1.A.1 Energy industries - Other Fossil Fuels	N_2O	0.0000	0.0000	0.0012	0.0002	0.0000
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	-0.0806	0.0248	-0.1432	0.0758	0.0262
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CH_4	-0.0002	0.0001	-0.0141	0.0002	0.0002
1.A.2 Manufacturing Industries and Construction - Solid Fuels	N_2O	-0.0003	0.0001	-0.0214	0.0003	0.0005
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	-0.0136	0.0027	-0.0411	0.0095	0.0018
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.0000	0.0000	-0.0008	0.0000	0.0000
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	N_2O	0.0000	0.0000	-0.0020	0.0000	0.0000
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	0.0092	0.0260	0.0046	0.0805	0.0065
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CH_4	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	N_2O	0.0000	0.0000	0.0002	0.0000	0.0000

		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.2 Manufacturing Industries and Construction - Biomass	CH_4	0.0001	0.0001	0.0056	0.0015	0.0000
1.A.2 Manufacturing Industries and Construction - Biomass	N_2O	0.0001	0.0002	0.0099	0.0019	0.0001
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.0027	0.0027	0.1640	0.0354	0.0281
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0.0000	0.0000	0.0017	0.0004	0.0000
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0.0000	0.0000	0.0028	0.0005	0.0000
1.A.3.a Domestic Aviation	CO_2	0.0001	0.0001	0.0002	0.0004	0.0000
1.A.3.a Domestic Aviation	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Domestic Aviation	N_2O	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Road Transportation	CO_2	0.0648	0.0952	0.1378	0.4038	0.1820
1.A.3.b Road Transportation	CH_4	-0.0001	0.0001	-0.0311	0.0005	0.0010
1.A.3.b Road Transportation	N_2O	0.0006	0.0009	0.1198	0.0037	0.0144
1.A.3.c Railways	CO_2	-0.0011	0.0012	-0.0017	0.0081	0.0001
1.A.3.c Railways	CH_4	0.0000	0.0000	0.0003	0.0000	0.0000
1.A.3.c Railways	N_2O	0.0000	0.0000	-0.0003	0.0000	0.0000
1.A.3.d Transport - Domestic navigation	CO_2	-0.0001	0.0000	-0.0002	0.0003	0.0000
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	0.0000
1.A.3.e Other Transportation	CO_2	0.0001	0.0001	0.0003	0.0006	0.0000
1.A.3.e Other Transportation	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Other Transportation	N_2O	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.4 Other Sectors - Solid Fuels	CO_2	-0.0552	0.0159	-0.0980	0.2195	0.0578
1.A.4 Other Sectors - Solid Fuels	CH_4	-0.0031	0.0014	-0.1681	0.0188	0.0286
1.A.4 Other Sectors - Solid Fuels	N_2O	-0.0002	0.0001	-0.0144	0.0009	0.0002
1.A.4 Other Sectors - Liquid Fuels	CO_2	-0.0050	0.0062	-0.0152	0.0474	0.0025
1.A.4 Other Sectors - Liquid Fuels	CH_4	0.0000	0.0000	-0.0018	0.0000	0.0000
1.A.4 Other Sectors - Liquid Fuels	N_2O	0.0000	0.0001	0.0003	0.0004	0.0000
1.A.4 Other Sectors - Gaseous Fuels	CO_2	0.0186	0.0310	0.0093	0.2065	0.0427
1.A.4 Other Sectors - Gaseous Fuels	CH_4	0.0000	0.0001	0.0019	0.0005	0.0000
1.A.4 Other Sectors - Gaseous Fuels	N_2O	0.0000	0.0000	0.0005	0.0001	0.0000
1.A.4 Other Sectors - Biomass	CH_4	0.0028	0.0039	0.1393	0.0796	0.0257
1.A.4 Other Sectors - Biomass	N_2O	0.0004	0.0005	0.0245	0.0100	0.0007
1.A.5.b Other mobile - Liquid Fuels	CO_2	0.0008	0.0013	0.0023	0.0070	0.0001
1.A.5.b Other mobile - Liquid Fuels	CH_4	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Other mobile - Liquid Fuels	N_2O	0.0000	0.0000	0.0005	0.0001	0.0000
1.B.1.a Coal Mining and Handling	CO_2	-0.0011	0.0002	-0.0277	0.0025	0.0008
1.B.1.a Coal Mining and Handling	CH_4	-0.0250	0.0093	-0.9357	0.0955	0.8847
1.B.1.b Solid Fuel Transformation	CH_4	0.0000	0.0000	0.0011	0.0015	0.0000
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	0.0000	0.0000	0.0001	0.0003	0.0000
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	-0.0010	0.0024	-0.0507	0.0179	0.0029
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CO_2	0.0000	0.0000	0.0005	0.0006	0.0000
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	0.0001	0.0001	0.0047	0.0038	0.0000

		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.B.2.c Fugitive Emissions from Fuels - Venting and flaring	N_2O	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.1 Cement Production	CO_2	0.0019	0.0093	0.0038	0.0263	0.0007
2.A.2 Lime Production	CO_2	-0.0012	0.0028	-0.0023	0.0079	0.0001
2.A.3 Glass Production	CO_2	0.0003	0.0007	0.0006	0.0052	0.0000
2.A.4 Other Process Uses of Carbonates	CO_2	0.0034	0.0037	0.0338	0.0263	0.0018
2.B.1 Ammonia Production	CO_2	0.0005	0.0034	0.0035	0.0243	0.0006
2.B.2 Nitric Acid Production	N_2O	-0.0022	0.0005	-0.0336	0.0030	0.0011
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	N_2O	0.0001	0.0003	0.0030	0.0020	0.0000
2.B.8 Petrochemical and Carbon Black Production	CO_2	0.0028	0.0051	0.1107	0.0362	0.0136
2.B.8 Petrochemical and Carbon Black Production	CH_4	0.0002	0.0003	0.0064	0.0020	0.0000
2.B.10 Other	CO_2	0.0007	0.0007	0.0017	0.0030	0.0000
2.C.1 Iron and Steel Production	CO_2	-0.0006	0.0283	-0.0063	0.2806	0.0788
2.C.1 Iron and Steel Production	CH_4	0.0000	0.0000	-0.0001	0.0005	0.0000
2.C.2 Ferroalloys Production	CO_2	0.0000	0.0000	0.0001	0.0000	0.0000
2.C.2 Ferroalloys Production	CH_4	0.0000	0.0000	0.0005	0.0001	0.0000
2.C.5 Lead Production	CO_2	0.0000	0.0000	0.0018	0.0007	0.0000
2.C.6 Zinc Production	CO_2	0.0000	0.0000	-0.0011	0.0001	0.0000
2.D.1 Lubricant Use	CO_2	0.0001	0.0004	0.0050	0.0031	0.0000
2.D.2 Paraffin Wax Use	CO_2	0.0000	0.0000	0.0010	0.0003	0.0000
2.D.3 Other non-energy products from fuels and solvent use	CO_2	0.0001	0.0001	0.0006	0.0008	0.0000
2.E Electronics industry	F-gases	0.0003	0.0003	0.0040	0.0011	0.0000
2.F.1 Refrigeration and Air conditioning	F-gases	0.0180	0.0180	0.4134	0.9405	1.0555
2.F.2 Foam Blowing Agents	F-gases	0.0000	0.0000	0.0003	0.0006	0.0000
2.F.3 Fire Protection	F-gases	0.0002	0.0002	0.0036	0.0078	0.0001
2.F.4 Aerosols	F-gases	0.0000	0.0000	0.0003	0.0007	0.0000
2.F.5 Solvents	F-gases	0.0000	0.0000	0.0000	0.0000	0.0000
2.G Other Product Manufacture and Use	F-gases	0.0001	0.0003	0.0014	0.0166	0.0003
2.G Other Product Manufacture and Use	N_2O	0.0005	0.0010	0.0105	0.0523	0.0028
2.H Other	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000
2.H Other	F-gases	0.0000	0.0000	0.0000	0.0000	0.0000
3.A Enteric Fermentation	CH_4	-0.0011	0.0185	-0.0161	0.1309	0.0174
3.B Manure Management	CH_4	-0.0028	0.0019	-0.0556	0.0267	0.0038
3.B Manure Management	N_2O	-0.0010	0.0019	-0.0402	0.0138	0.0018
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	0.0030	0.0143	0.0590	0.1010	0.0137
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	-0.0001	0.0040	-0.0040	0.0283	0.0008
3.G Liming	CO_2	-0.0029	0.0008	-0.0867	0.0055	0.0075
3.H Urea application	CO_2	0.0006	0.0010	0.0322	0.0205	0.0015
5.A Solid Waste Disposal	CH_4	0.0128	0.0187	0.8147	0.0000	0.6638
5.B Biological treatment of solid waste	CH_4	0.0037	0.0037	0.3383	0.0262	0.1151
5.B Biological treatment of solid waste	N_2O	0.0003	0.0003	0.0002	0.0024	0.0000
5.C Incineration and open burning of waste	CO_2	0.0004	0.0005	0.0021	0.0103	0.0001
5.C Incineration and open burning of waste	CH_4	0.0000	0.0000	0.0021	0.0008	0.0000
5.C Incineration and open burning of waste	N_2O	0.0000	0.0000	0.0015	0.0007	0.0000
5.D Wastewater treatment and discharge	CH_4	0.0013	0.0045	0.0644	0.1917	0.0409

		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**
5.D Wastewater treatment and discharge	N_2O	0.0003	0.0009	0.0127	0.0320	0.0012
					Trend uncertainty =	1.66

Annex 3 Detailed methodological descriptions for individual sources or sink categories

A 3.1 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

A 3.1.1 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 methodology for GHG inventory, IPCC provides default emission factors for CO_2, for the individual types of fuels (IPCC,1997 and 2006).

The default emission factors, tabulated in IPCC methodology were determined as middle values on the basis of many calorimetric and analytical tests of individual types of fuels. It is necessary to remember that the used data for determination of this emission factors has predominantly American origin and further comes from the 80s. For the needs of current national inventory, where the nature of the various types of fuels may be different, the default emission factors are not necessary sufficiently satisfactory.

Hence, the new versions of the IPCC methodology (IPCC, 2000 and 2006) recommends to all countries, where emissions of CO_2 from combustion of solid fuels is a so called key category, to check and update the emission factors of CO_2 for calculation of emissions of CO_2 on the basis of national data. In the Czech Republic, where the main part of the CO_2 emissions from solid fuels comes from the combustion of lignite (brown coal) and bituminous coal, it is significant to determine country specific emission factors for these two types of fuels.

The default emission factors for lignite (brown coal) and bituminous coal, provided in the older and newer version of the IPCC methodology, practically do not differ. In the recommended values for oxidation factor, however a substantial change appeared: while the older version (IPCC, 1997) reported default value of oxidation factor 0.98, new version (IPCC, 2006) provides default value of 1, which is the maximum possible and considering the solid fuels, in practice unreachable. In the IPCC methodology this change was introduced, because the authors of the new version were aware that these values are for solid fuels so geographically and technologically specific, that it could be difficult to generalize them. Default value of 1 was chosen as a conservative estimate, preventing possible underestimation of emission determination. Therefore a country, which wants to prevent possible overestimation of the emissions of CO_2 from combustion of solid fuels, has to determine representative country specific values of oxidation factor for individual types of solid fuels, on the basis of local data.

For determination of the country specific emission factors it is necessary to obtain data about the carbon content in given type of fuel and its net calorific value.

The factor for the carbon content (CC) is for the individual types of solid fuels defined as the ratio of weight of the carbon and the amount of energy in this fuel of the mass m

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

where wc is the fraction of mass of carbon in the fuel and Q_i is its net calorific value. It is important to notice, that all variables in the equation (A3-1) are related to the fuel (carbon) with its current water content in the supplied fuel, i.e. in the state, when it is determined the quantity (i.e. mass): raw - index ^{r} .

As the calorific value is expressed in MJ/kg (=TJ/kt), carbon content in% mass (C^r = 100*w_C) and CC in t C/TJ, it is possible to rewrite the previous equation to:

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

The emission factor for CO_2 (t CO_2/TJ) is obtained by multiplying by the ratio of the molar weight of carbon dioxide and carbon

$$EF(CO_2) = CC \cdot 3.664 \qquad \text{(A3-3)}$$

IPCC methodology provides the following default factors for carbon content CC:

Lignite (brown coal): 27.6 (t C/TJ)

Bituminous coal: 25.8 (t C/TJ)

In the Czech national inventory these emission factors were used until 2006. On the basis of the recommendation of international expert review team (ERT) of UNFCCC, during the review conducted in February 2007, it was decided to use for lignite (brown coal) and bituminous coal factors for CC values 25.43 and 27.27 (t C/TJ), which can be found in the national study from 1999 (Fott, 1999) and are pertaining to the state of the coal in the Czech Republic in the 90s. For determination of the oxidation factor the necessary data was not available, therefore for all solid fuels was used the default value of 0.98 from 1996 Guidelines, for the whole time series from 1990 to 2012 (2006 Guidelines come into force from the current year 2013).

In the last years related to the implementation of the emission trading within EU ETS, the operators of the bigger plants combusting coal began to systematically address the laboratory determined emission factors for different types of coal, combusted in these plants according to the prescribed requirements of the European Directive 82/2003 EC including the relevant guidelines, regarding the methodology of monitoring. Some operators gradually extended this assessment also by the determination of oxidation factors, whose values depend not only on the type of coal, but also on the nature of the combustion source.

Data from the coal analysis from 1999 naturally was not so extensive. Further the coal base in the beginning of the 90s in the Czech Republic largely changed - production in less efficient mines have been gradually phased out and the in the existing mines now often is extracted on different places for example, in deeper coal layers. For these reasons, the research team of the Czech national inventory decided in the frame of its improvement plan to revise the emission factors, used until now and to determine new oxidation factors. Detailed description of the used approach, input data and discussion of the reached results, can be found in the study of authors E. Krtková, P. Fott and V. Neužil, prepared for publication in scientific journal. In the further text of this Annex clarification of the principle of the used method is reported and the reached results from the above mentioned paper are presented.

1. 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 neighbouring 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 analyses, 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 analyses 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 analysed 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.

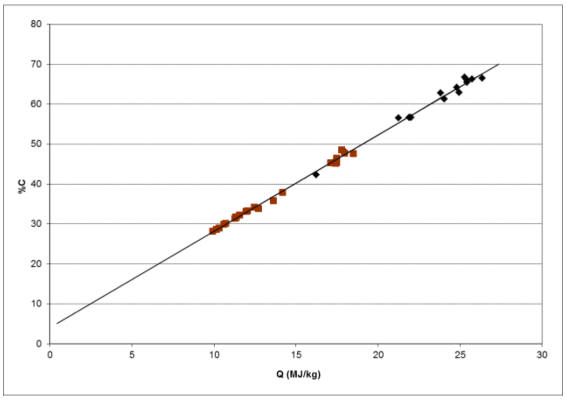

Fig. A3 1 Combined set of aggregated data “Comb”. Correlation between carbon content (%C) and net calorific value for lignite (brown coal) (indicated with brown squares) and bituminous coal (indicated with black squares)

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.

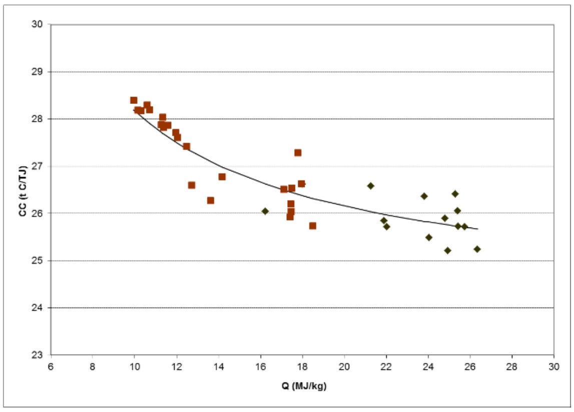

Fig. A3 2 Combined set of aggregated data "Comb". Correlation between the factor of carbon content CC and net calorific value for brown coal (indicated as brown squares) and black coal (indicated as black squares), found through the eq. A3-5.

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.

2. 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”:

$$OF = \frac{0.9696 + 0.9719 + 0.9708}{3} = 0.9707$$

3. 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

$$94.317 \cdot 0.9707 = 91.554 \frac{t\,CO_2}{TJ}$$

A 3.2 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 in 2014. 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 was 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 percent)

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 A3-6

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

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).

A 3.3 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.

A 3.4 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

$$EF (CO_2) = 0.269 \bullet (Qv/3.6)^2 – 2.988 \bullet (Qv/3.6) + 59.212 \qquad (A3\text{-}12)$$

which was tightly fit to all 10 points (correlation coefficient R^2 = 0.999). In this correlation expression Q_v represents the net calorific value related to the volume under "trade conditions" (101.3 kPa, 15° C).

The calculations of the regression curve for the samples 5 – 10 indicated in particularly close range of Qv: 34.11 – 34.27 MJ/m^3. The lowest net calorific value (31.31 MJ/m^3) was determined for sample number 3 (Dutch field) and the highest (38.28 MJ/m^3) for Norwegian gas type. The low net calorific value of Dutch Natural Gas is caused by relatively high content of nitrogen; the high net calorific value of the Norwegian Natural Gas is a result of the higher content of C2, C3 and C4 hydrocarbons (especially ethane).

The above-described methodology was tested on a relatively small dataset. To obtain sufficiently reliable correlation, this methodology had to be tested on a dataset which would provide composition of Natural Gas in sufficient time series. In cooperation with CzSO a dataset comprising analyses of Natural Gas composition was obtained. These analyses are continuously evaluated in the laboratory of NET4GAS, Ltd. Daily average values on the Natural Gas composition from the first day in the month were available for evaluation of the CO_2 emission factor. The dataset of these analyses began on 1st January 2007 and the last data are from 1st September 2011. Furthermore data for 1st February 2012 were also available. The report on each analysis contains data on the molar composition of the Natural Gas, physical characteristics and conditions during which the analysis was performed. Overall, 58 analyses were available. Fig. A3 3 depicts the trend of net calorific values in time.

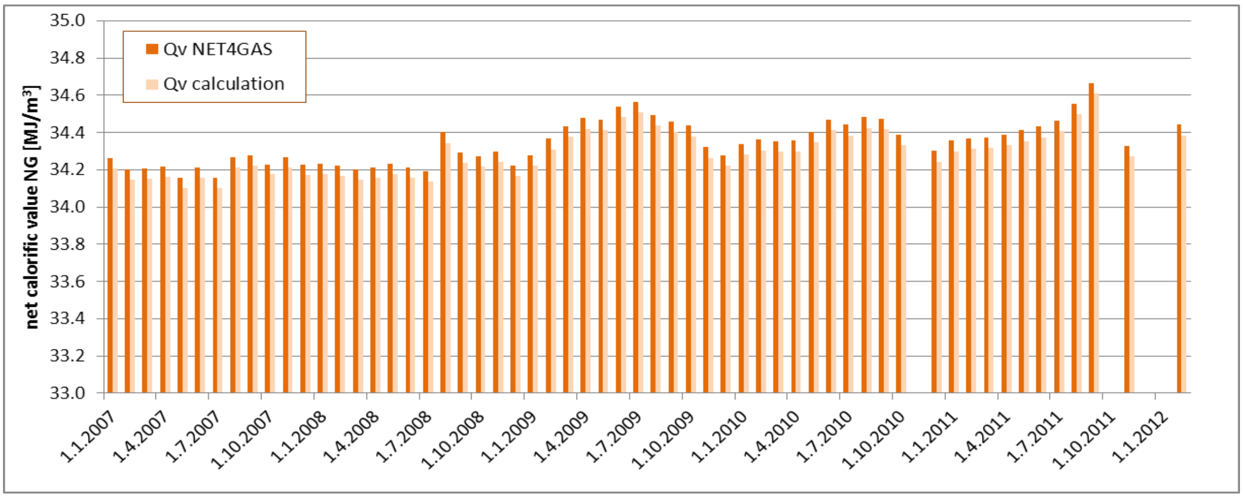

Fig. A3 3 Net calorific values given in NET4GAS Ltd. reports and net calorific values calculated on the basis of composition of Natural Gas in 1.1.2007 – 1.2.2012 (both values are given at 15°C)

The figure indicates a good match between the two depicted values; the deviation is almost constant and reaches an average value of 0.16%. The deviation is probably caused by the fact that the measured values correspond to the non-state gas behaviour; however the calculation is based on the assumption of ideal gas behaviour. For this reason, the net calorific values from the NET4GAS Ltd. reports were used for calculation of the emission factor. The reports contain data related to the reference temperature 20° C; thus, it was necessary to recalculate net calorific values and densities for 15° C.

The results of the calculations are depicted in Fig. A3 4. 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).

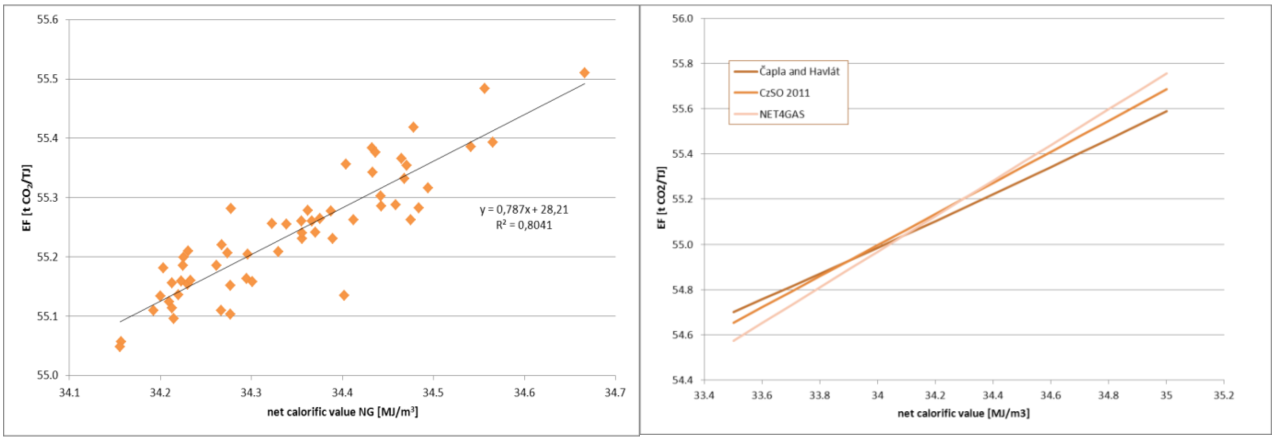

Fig. A3 4 Correlation of EF [t CO_2/TJ] and net calorific value of Natural Gas and Comparison of three approaches used for calculation

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. A3 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.

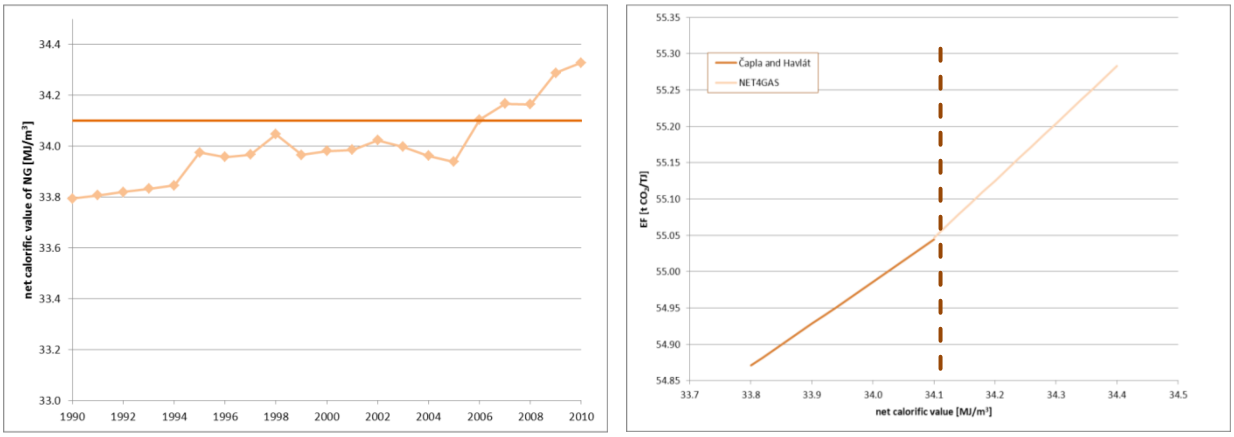

Fig. A3 5 Trend in Natural Gas NCV 1990 – 2010 and Correlation between NCV and EF combined from two approaches – Čapla and Havlát (NCV lower than 34.1 MJ/m³) and computed correlation on the basis of NET4GAS dataset (NCV higher than 34.1 MJ/m³)

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. A3 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/m³]	[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. A3-15):

$$EF\ (CO_2) = 0.787 \bullet Qv + 28.21 \qquad \text{(A3-15)}$$

The availability of analyses of the Natural Gas composition should be ensured in the coming years. The validity of equation (A3-15) 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.

A 3.5 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.

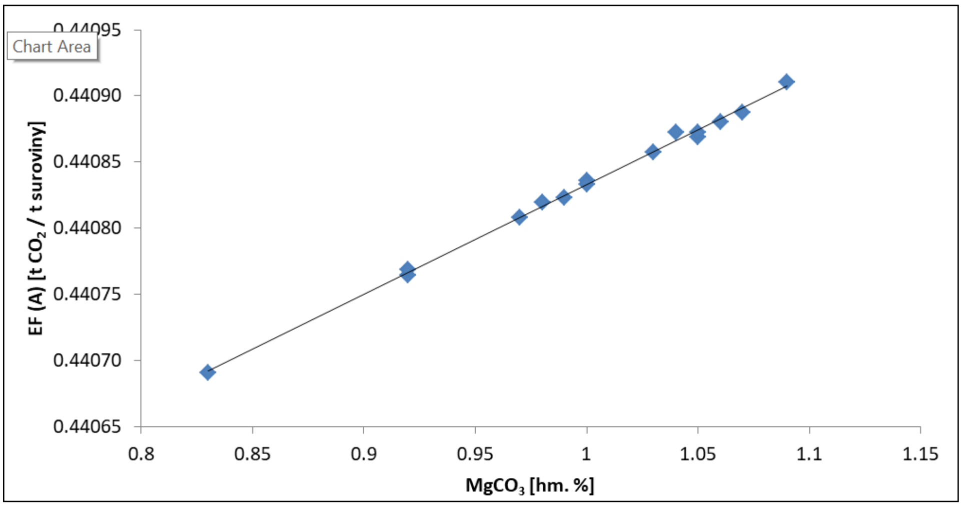

Fig. A3 6 Correlation between emission factor and mass representation of $MgCO_3$ in input material

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

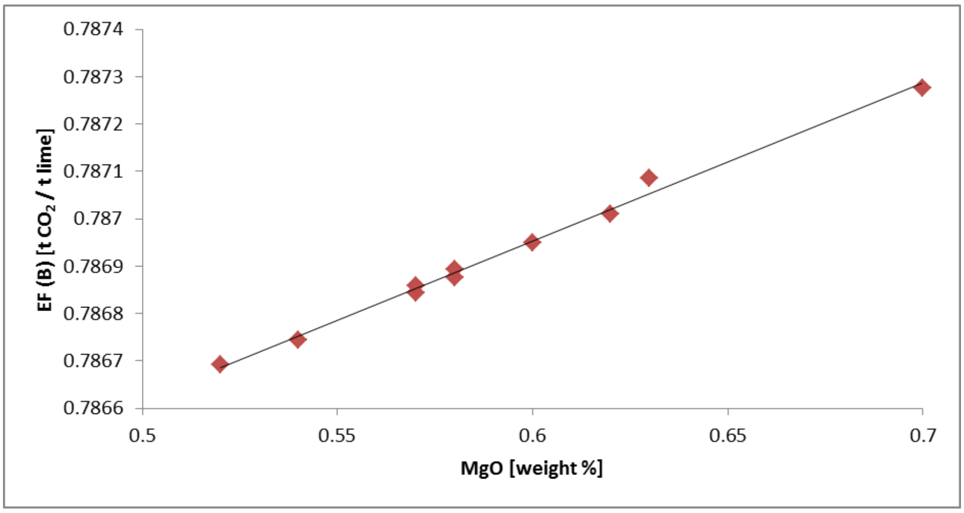

Fig. A3 7 Correlation of emission factor in mass representation of MgO in output material

As Fig. A3 6 and Fig. A3 7 show, 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 shows oscillating weighted total emission factor derived from the ETS which fluctuates near the country specific emission factor values.

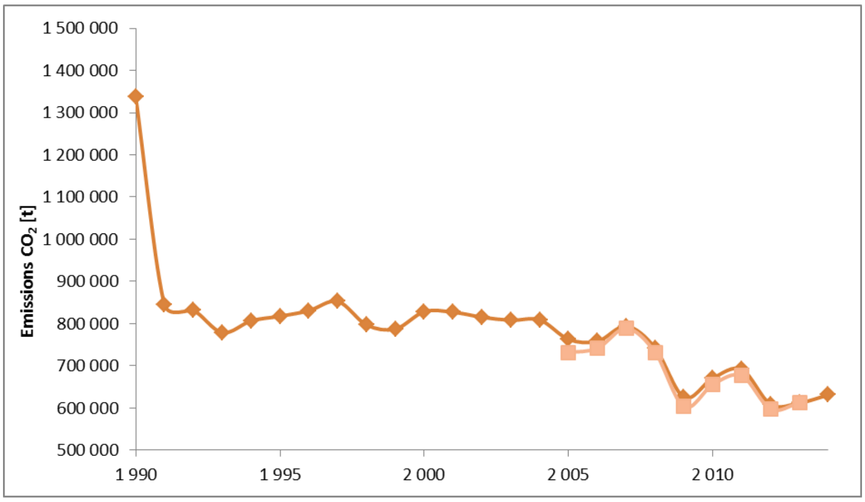

Fig. A3 8 Development of emissions of CO_2 from production of lime in CR for period 1990 – 2014

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.

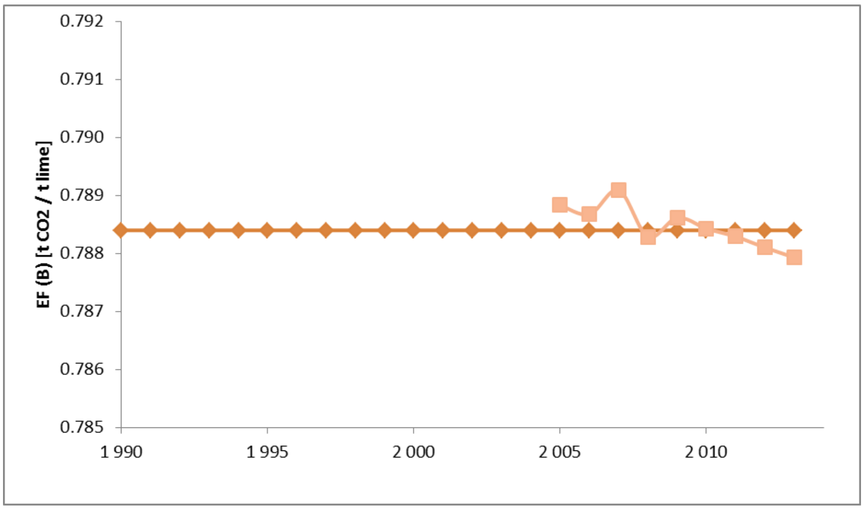

Fig. A3 9 Development of EF for production of lime in CR for period 1990 - 2014 (method B)

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.

A 3.6 CBM-CFS3 model – calibration, use and verification

A 3.6.1 Introduction

The earlier (NIR 2022) inventory submission introduced a Tier 3 model carbon stock change estimation in emission categories associated with forestry using a specifically calibrated Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3, further denoted as CBM; Kurz et al. 2009, Kull et al. 2019). Since then, CBM has been used to facilitate the estimation of carbon stock pool changes in forests for the successive NIR submissions. Specifically, the CBM model estimates are used to derive CO_2 emissions resulting from carbon stock changes in living (aboveground and belowground) biomass, dead organic matter including both deadwood and litter, and organic soil carbon in mineral soils (except land conversions). This aids the emission reporting for categories 4.A.1 Forest Land - remaining Forest Land, 4.A.2 Land converted to Forest Land, 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 (Tab. A3 9). Correspondingly, CBM was earlier (NIR 2022) used for emission estimations for the former KP LULUCF activities, namely Afforestation/Reforestation (AR), Deforestation (D) and Forest Management (FM), as well as the technical correction applicable to FM accounting under KP II (2013-2020). There is a retained methodological link for estimates under UNFCCC and that for the former KP LULUCF activities AR and D in this inventory submission (NIR 2024), which is detailed below.

Tab. A3 9 Methodological tier indicating use of CBM in estimating carbon pools under UNFCCC and KP LULUCF for the concerned land use categories and the former KP LULUCF activities. *Carbon stock changes in organic soil are not included (not estimated).

Emission category (UNFCCC) or Activity (KP LULUCF)	Carbon pool UNFCCC	Carbon pool KP LULUCF	Methodological tier and comment
4.A.1 FL remaining FL Forest Management	Living biomass	Aboveground biomass	T3, CBM
		Belowground biomass	T3, CBM
	Dead organic matter (DOM)	Deadwood	T3, CBM
		Litter	T3, CBM
	Soil (Mineral soils)*	Soil (Mineral soils)	T3, CBM
4.A.2 Land converted to FL Afforestation/Reforestation	Living biomass	Aboveground biomass	T3, CBM
		Belowground biomass	T3, CBM
	Dead organic matter (DOM)	Deadwood	T2, T3, CBM
		Litter	T2, T3, CBM
	Soil (Mineral soils)*	Soil (Mineral soils)	T2/T3, Soil carbon maps
4.B.2.1 FL converted to Cropland 4.C.2.1 FL converted to Grassland 4.D.2.1 FL converted to Wetland 4.E.2.1 FL converted to Settlements Deforestation	Living biomass	Aboveground biomass	T2/T3, CBM
		Belowground biomass	T2/T3, CBM
	Dead organic matter (DOM)	Deadwood	T2/T3, CBM
		Litter	T2/T3, CBM
	Soil (Mineral soils)*	Soil (Mineral soils)	T2/T3, Soil carbon maps
Harvested Wood Products	Harvested Wood Products	Harvested Wood Products	T2, Production approach

CBM represents a flexible modelling framework that has also been applied for carbon-accounting purposes in other European countries (Pilli et al., 2017, 2013). Additionally, Pilli et al. (2017, 2018) prepared an extensive database of model parameters and biomass equations applicable to European conditions, which was also used as a basis for this country-specific application. CBM is an inventory based, yield-data driven model that simulates the stand- and landscape-level carbon (C) dynamics of above- and below-ground biomass, and dead organic matter (DOM) including soil (Kurz et al., 2009; Fig. A3 10). In its spatial representation beyond single stands, it can be flexibly set up to represent administrative and climate regions. CBM was previously used to construct the Forest Reference Level (FRL) for the Czech Republic and its National Forest Accounting Plan under the LULUCF Regulation of EU 2018/841 (https://www.mzp.cz/cz/opatreni_v_ramci_lulucf). The current CBM calibration is in part similar, but in several aspects significantly enhanced, as described in this document. An overview of the emission categories and carbon pools affected by the improved methodological tier for the UNFCCC land use categories concerned as well as the corresponding former KP LULUCF activities is shown in Tab. A3 9.

CBM uses in total 21 carbon pools, which are linked to IPCC carbon pools as shown in Tab. A3 10 and in the conceptual diagram in Fig. A3 10.

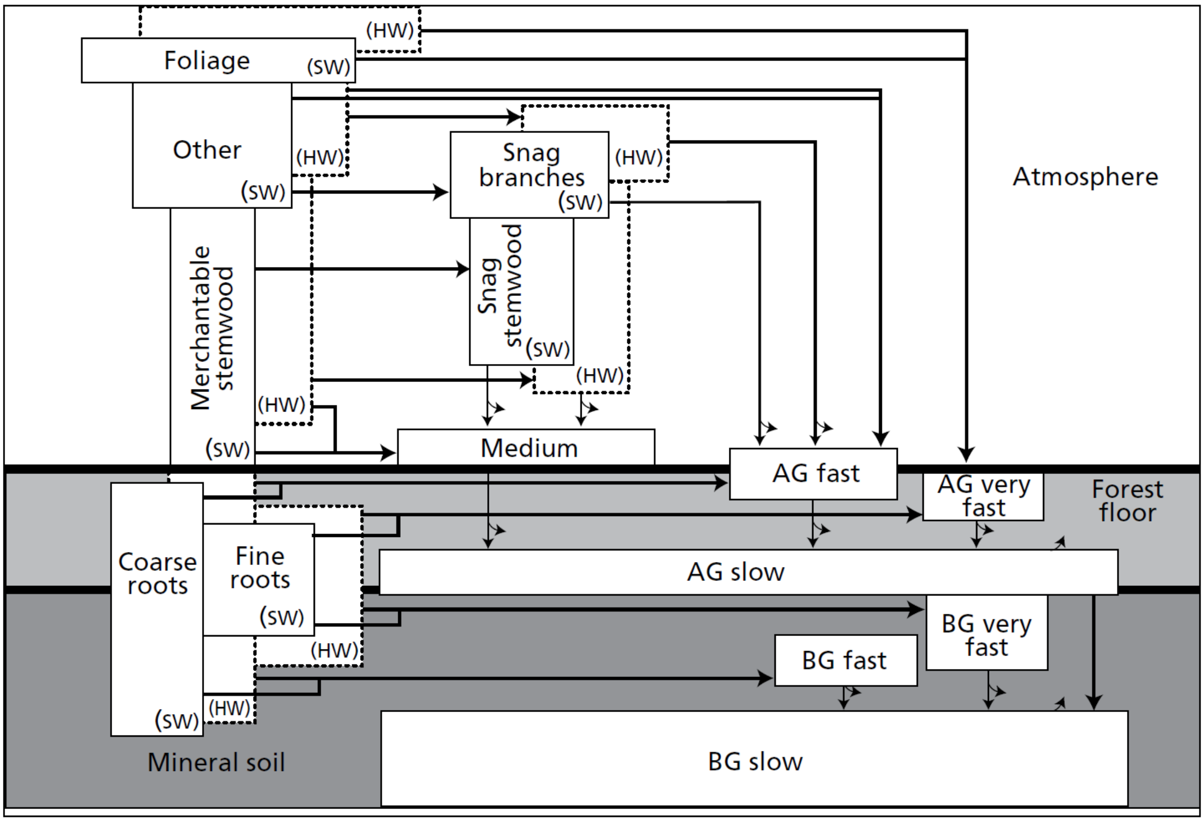

Fig. A3 10 Conceptual diagram of CBM carbon pools and their relationships (straight arrows showing transfers between pools, curved arrows showing transfer to atmosphere), with categorization of relative decay rates (very fast, fast, medium, slow), for softwoods (formulated and used from Kull et al. 2019).

Tab. A3 10 IPCC carbon pools and their equivalents in CBM (adapted from Kurz et al. 2009). *Merchantable size wood limit uses the Czech standard of min. 7 cm in diameter.

IPCC carbon pool	Pool name in CBM-CFS3	Description
Living Biomass		
Aboveground biomass	Merchantable stemwood and bark	Live stemwood of merchantable size* plus bark
	Other wood and bark	Live branches, stumps and small trees including bark
	Foliage	Live foliage
Belowground biomass	Coarse roots	Live roots, 5 mm and larger diameter
	Fine roots	Live roots, less than 5 mm diameter
Dead organic matter		
Deadwood	Snag stems DOM	Dead standing stemwood of merchantable size incl. bark
	Snag branches DOM	Dead branches, stumps and small trees
	Medium DOM	Coarse woody debris on the ground
	Belowground fast DOM	Dead coarse roots (diam. 5 mm and more) in mineral soil
Litter	Aboveground fast DOM	Fine and small woody debris and dead coarse (submerch. size) roots in the forest floor
	Aboveground fast DOM	F, H and O horizons
	Aboveground very fast DOM	L horizon incl. foliar litter and dead fine roots (<5 mm diam.)
Soil		
Soil organic matter	Belowground very fast DOM	Dead fine roots (<5 mm diam.) in the mineral soil
	Belowground slow DOM	Humified organic matter in the mineral soil

CBM simulates the transfer of carbon between pools and the atmosphere (Fig. A3 10). Specifically, it simulates mortality and litter fall representing transfers from biomass to other dead organic matter (DOM) pools resulting from tree, foliage, branch and root mortality (Kurz et al. 2009). The calibrated country-specific equations to convert volumes to biomass components, turnover and transfer rates between DOM pools are specified in the AIDB database (CBM-specific database in MS Access format, Kull et al. 2019). The detailed model handling of carbon turnover including DOM pools was one of the fundamental reasons for implementing this tier-3 modelling approach, to ensure that the complete carbon cycling in forest ecosystems is fundamentally captured. This is important specifically in the conditions of significantly changing wood harvest and mortality, which directly affect inputs into and emissions from the DOM pools. Decomposition of DOM pools is modelled using a temperature-dependent decay rate function (Kurz et al. 2009). This is the only climate-depended relationship used in CBM. The annual mean temperature to represent all forest regions in Czech Republic was set to 8.0 °C in the AIDB database of CBM. Disturbances including forest management interventions such as thinning, harvest and afforestation are each defined in a matrix describing the proportion of carbon transferred between pools, fluxes to the atmosphere, and transfers to the DOM pools and the timber sector.

A 3.6.2 Input data and calibration

In general, application of the CBM model application is set up so as to resemble the NIR reporting strategy (key input data use, stratification) adopted in the Czech emission inventory of the LULUCF sector. The CBM simulation run is set to start in 1990 and progresses in an annual time step until 2022, i.e., for the entire reporting period. The model integrates the key activity data as used in the emission inventory so far. These include land-use areas related to forests, data on growing stocks by tree species and age class from the national stand-wise inventory of FMP and the related volume increment data, and data on disturbances (management practices). At same time, CBM requires a specific calibration of biomass component functions, specifying turnover rates of biomass components and defining disturbance matrices describing the adopted forest management interventions and included natural disturbances.

A 3.6.2.1 Land area matrices and species groups

Activity data on land use areas of Forest Land, land use conversion to Forest Land (and the corresponding former KP LULUCF activity Afforestation/Reforestation, AR) and from Forest Land (former KP LULUCF Deforestation, D) are described in NIR Section 6.2 and 6.4.1. These activity data come from the Czech Office for Surveying, Mapping and Cadastre (COSMC).

Tree species grouping used in the entire inventory for category 4.A Forest Land and the AR, D activities representing land use change and forest management (FM) on 4.A.1 Forest land remaining Forest land, follows the country specific approach as described in Section 6.4.1. Namely, four groups of tree species are used as the basic forest strata in CBM: i-beech: all broadleaved species except oaks, ii-oak: all oak species, iii-pines: all pine species, iv-spruce: all conifers except pines. For land-use transitions involving forest land, CBM requires additional information on the share of tree species in its input file. For AR events (and the related 4.A.2 category), three species groups were included, specifically beech, oak and spruce, using area shares of 40, 10 and 50%, respectively. For D events (and the related land use categories 4.B.2.1, 4.C.2.1, 4.D.2.1 and 4.E.2.1), the spruce species group was exclusively used in CBM. This basically matched the observed species change in share for the reporting period (Fig. 6-6 in Section 6.4.1). Additionally, disturbance of salvage logging including species change (DIST 3, see section A.3.6.2.5) in category 4.A.1 (and FM) included species change involving pine and spruce. This allowed the fine-tuning of tree species share on forest land, replacing pine in favor of beech (55%) and oak (45%), and part of spruce in favor of beech (24%) and oak (3%), making the share of species consistent with the observed activity data on forest lands for the entire reporting period.

A 3.6.2.2 Growing stock volume and increment

The state of forest resources in terms of growing stock by age classes and species groups as of 1990 served as the initial year for the CBM run (Fig. A3 11) for the entire reporting period of 33 years (1990 to 2022). The forest area increased by AR activities decreased by D activities according to the known activity data described in Section A 3.6.2.1.

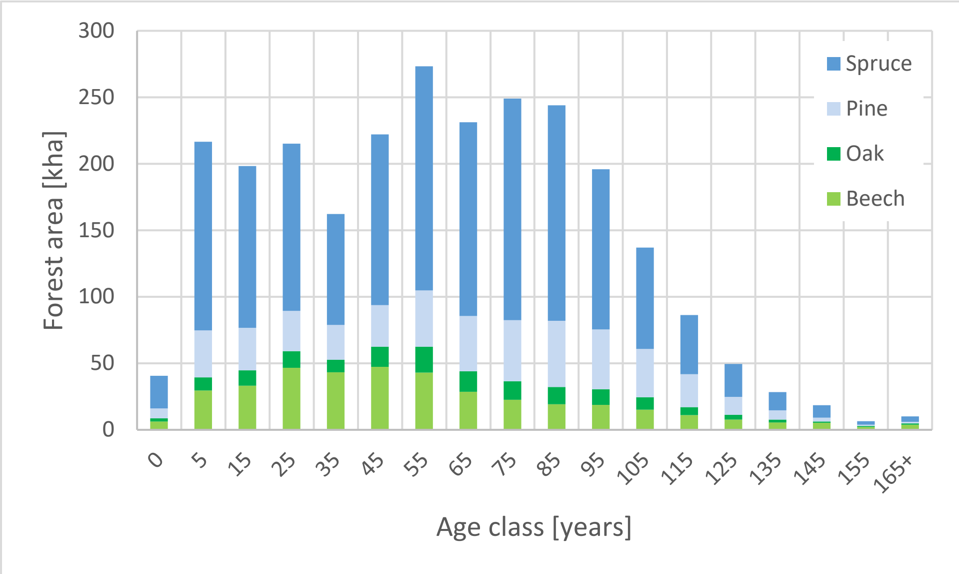

Fig. A3 11 Forest area by age class and tree species groups as of 1990, the initial year of the reporting period and CBM simulation.

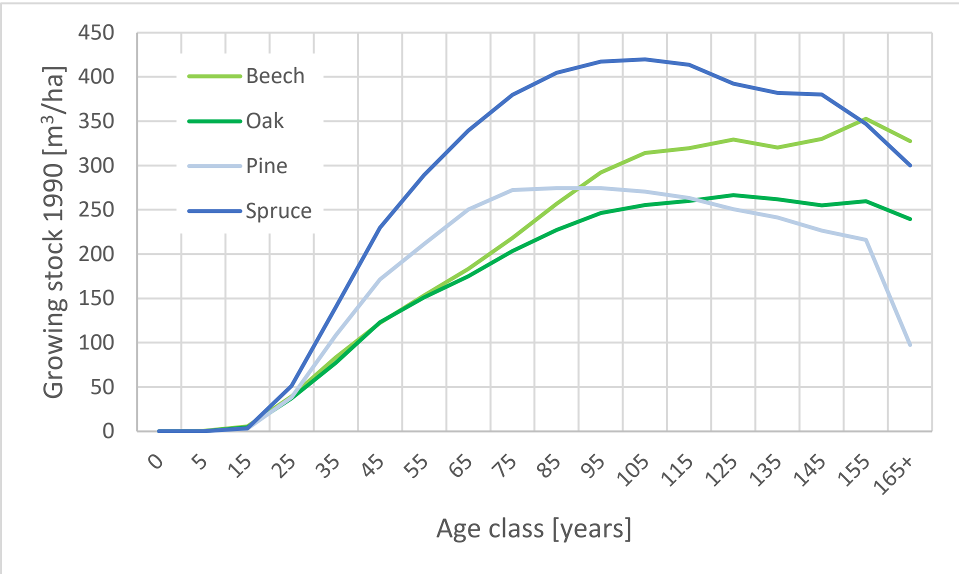

Fig. A3 12 Mean merchantable growing stock volume per hectare (from the database of FMP, FMI) and age class for individual tree species groups, as of 1990.

Volume increment data used in CBM are derived from the identical source as described in Section 6.4.2.2. CBM (CBM-CFS3) uses merchantable volume data over age to simulate growth. The entire CBM growth concept is described in detail by Kurz et al. 2009 and Pilli et al. 2013. In essence, the process involves two steps. First, it requires data on the growing stock per age class and tree species as the initial standing volume to run the simulation – in our case, the observed standing volume data per age class and tree species groups as of 1990 was used (Fig. A3 12). Second, the age-dependent gross merchantable volume curves resembling current yield tables (CYTs) are used to simulate growth. CYTs were expressed for individual species groups based on the official current annual increment estimates (shown in Fig. 6 11 and Fig. A3 13) as provided by Forest Management Institute, Brandys n. L. (FMI; Section 6.4.1). CYTs were fitted as a function of age, using the flexible combined exponential and power function (Sit 1994; Pilli et al., 2013), namely.

$$CYT_t = a \times t^b \times c^t \quad \text{(A3-16)}$$

where *t* is age (years), and *a*, *b*, *c* are the parameters to be fitted. These functions were fitted based on current increment data (CAI) as of 2004 (Fig. A3 13). CAI data were accumulated to form volume curves (CYTs) prior to fitting. The year 2004, representing the middle of the reporting period, was used for CAI and the corresponding CYT. Thereafter, a set of relative scaling factors applicable to individual tree species groups and the reporting period 1990 to 2021 (Fig. A3 15) were implemented within CBM to assure full coherence with the input activity data on growth, which are shown for the entire reporting period in Fig. 6. 11, Section 6.4.1.

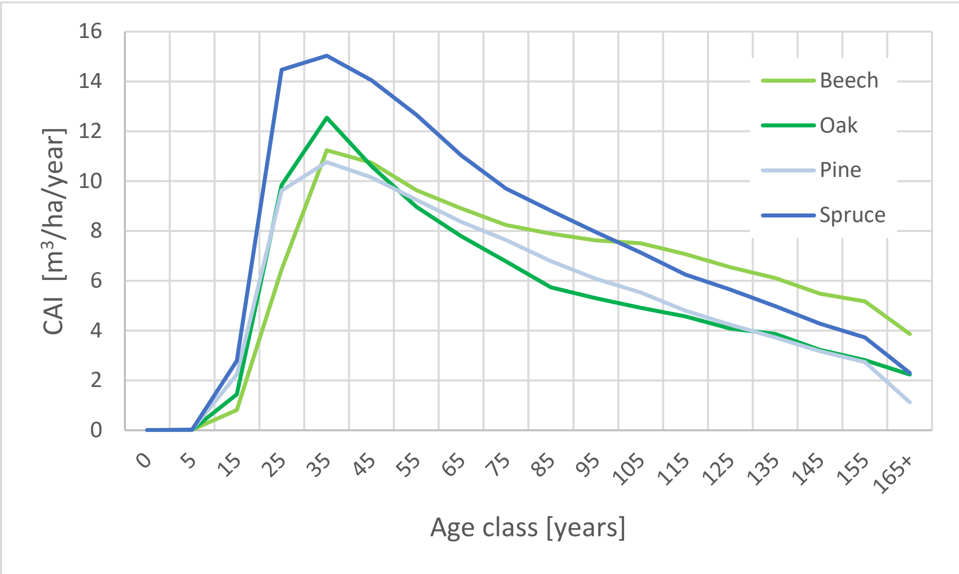

Fig. A3 13 Current annual increment (CAI) for tree species groups and age class as of 2004

Tab. A3 11 Species-specific parameterization of CYT curves according to equation A3-16, including the parameter estimate and asymptotic standard error (ASE).

Species group	Estimate	Parameter of eq. A3-16		
		a	b	c
Beech	Parameter estimate	0.123	2.092	0.990
	ASE	0.060	0.132	0.001
Oak	Parameter estimate	0.335	1.884	0.990
	ASE	0.182	0.150	0.001
Pine	Parameter estimate	0.216	2.001	0.989
	ASE	0.083	0.106	0.001
Spruce	Parameter estimate	0.399	1.925	0.989
	ASE	0.168	0.116	0.001

Fig. A3 14 Fitted gross volume curves (CYT) for tree species groups and age class as of 2004

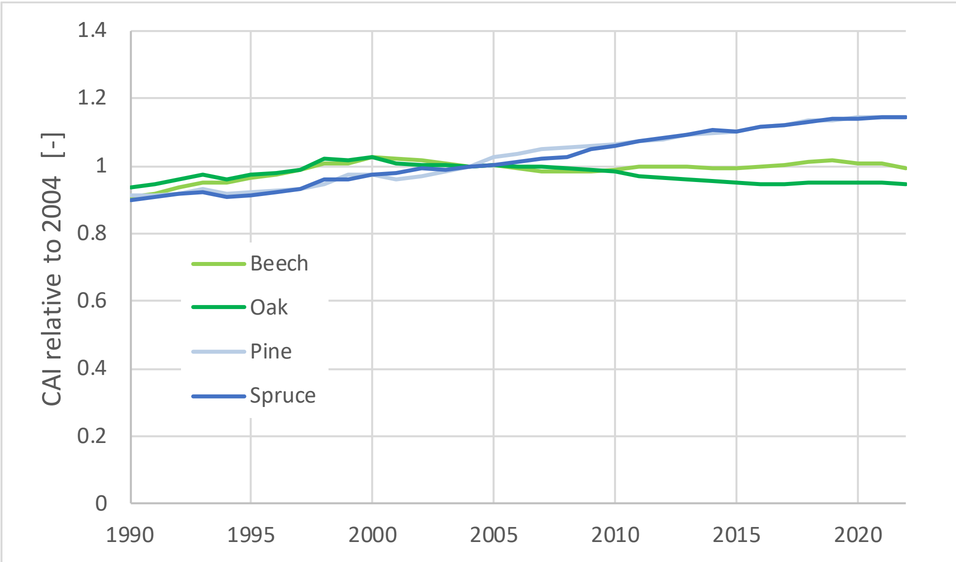

Fig. A3 15: Scaling factor applicable for CAI relative to 2004 for individual tree species groups and reporting/simulation period.

A 3.6.2.3 Biomass equations and CBM biomass component functions

The next essential step in CBM calibration is the implementation of appropriate biomass equations and conversion factors to facilitate growth estimation in carbon units and its distribution to individual tree parts and carbon pools. A complete, detailed description of these CBM processes is given in Kurz et al. 2009 and Kull et al. 2019. Here, we provide information on our country-specific application. To provide biomass estimates for individual tree parts, the set of relevant (national allometric studies and/or biomass compilations that include data from the Czech Republic) equations were used for beech (Vonderach et al. 2018, Wutzler et al., 2008 for leaves only), oak (Cienciala et al., 2008a), pine (Cienciala et al. 2006b), spruce (Vonderach et al. 2018) and complementarily birch (Marklund 1989, Repola 2008 for leaves only).

Data from the country-wide sample-based landscape inventory CzechTerra (Cienciala et al. 2016) were used to assess tree biomass components according to the above biomass equations and expressed on a per plot and ha basis. A threshold of at least n=5 trees per plot was used to qualify a CZT plot into the species -specific sample. These estimates were used to input calibrate biomass component functions according to the procedure described by Boudewyn et al. (2007; Fig. A3 16). Estimation of the belowground biomass component of living trees in CBM is calculated using equations and parameters defined for deciduous and coniferous species by Li et al. (2003).

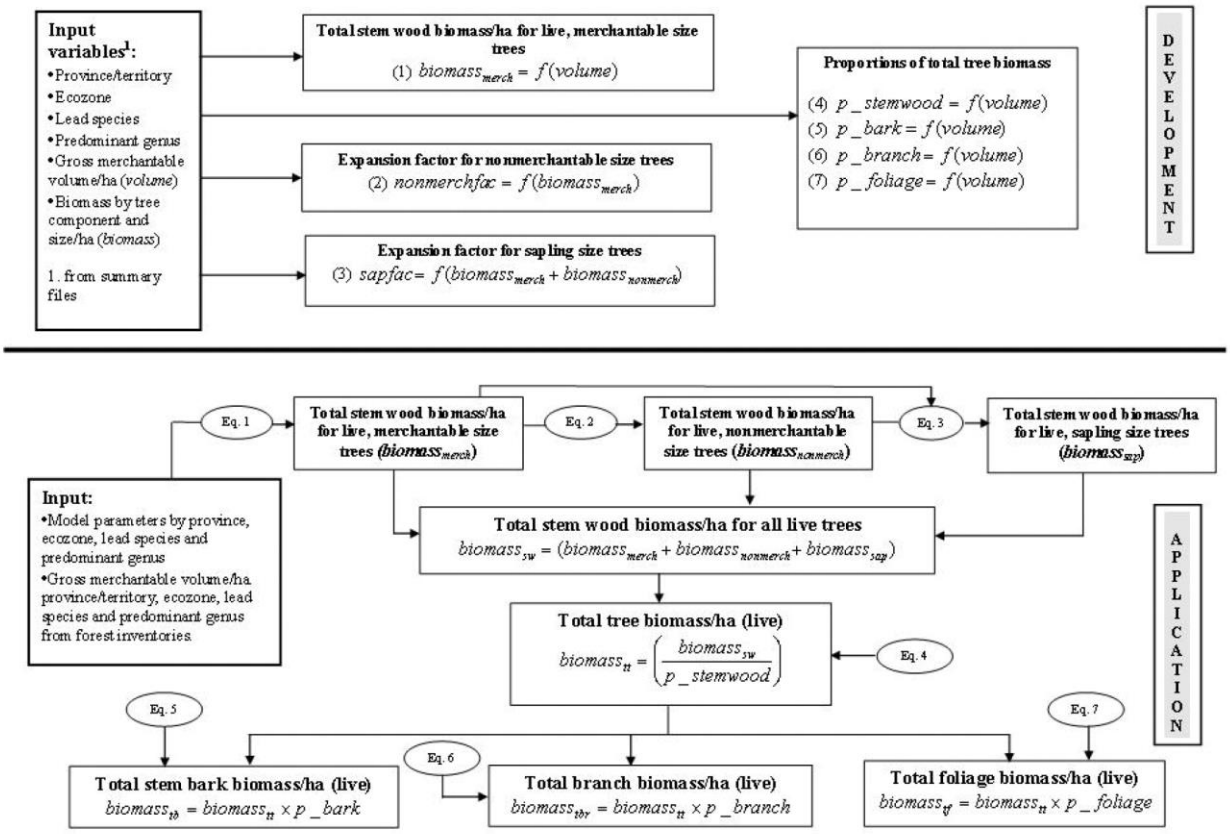

Fig. A3 16: Flowchart showing the development and application of biomass component functions in CBM (from Boudewyn et al. 2007). Note that the numbering of equations in the flowchart does not match that used in the NIR text, but the equation names do.

Tab. A3 12 Species-specific parameterization of merchantable biomass (*bm*) according to equation A3-17, including the parameter estimate, asymptotic standard error (ASE), coefficient of determination (R^2) and sample size (n).

Species	Estimate	Parameter of Eq. A3-17 a	b	R^2	n
Beech	Parameter estimate	0.592	1.001	1.000	111
	ASE	0.008	0.002		
Oak	Parameter estimate	0.653	0.980	0.997	134
	ASE	0.018	0.005		
Pine	Parameter estimate	0.372	1.025	0.994	194
	ASE	0.016	0.007		
Spruce	Parameter estimate	0.379	1.008	1.000	613
	ASE	0.002	0.001		
Birch	Parameter estimate	0.991	0.889	0.979	95
	ASE	0.079	0.017		

Of the seven equations outlined in the flowchart of Boudewyn *et al.* (2007, Fig. A3 16), we first parameterized Eq. 1. describing the dependence of merchantable biomass (*bm*, t/ha) on wood merchantable wood volume (*v*, m^3/ha under bark), defined by a min. threshold 7 cm (measured over bark) that excludes stumps, tree tops and non-merchantable trees. This relation is written as

$$bm = a \times v^b \qquad \text{(A3-17)}$$

where *a*, *b* are the parameters to be fitted. The results of the fit are shown in Tab. A3 12.

Next, using the CzechTerra landscape inventory data as described above, we parameterized the set of biomass proportion equations (Eqs. A3-18, A3-19, A3-20, A3-21), while the relations for the components of non-merchantable size trees and saplings (Eqs. 16, 17 in Fig. A3 16) were left unchanged as prescribed in Pilli et al. (2018). A multinominal modelling approach was used to derive the parameters of the proportion equations according to Boudewyn et al. (2007):

$$p_{stemwood} = \frac{1}{1 + e^{a1+a2\times vol+a3\times lvol} + e^{b1+b2\times vol+b3\times lvol} + e^{c1+c2\times vol+c3\times lvol}} \quad \text{(A3-18)}$$

$$p_{bark} = \frac{e^{a1+a2\times vol+a3\times lvol}}{1 + e^{a1+a2\times vol+a3\times lvol} + e^{b1+b2\times vol+b3\times lvol} + e^{c1+c2\times vol+c3\times lvol}} \quad \text{(A3-19)}$$

$$p_{branches} = \frac{e^{a1+a2\times vol+a3\times lvol}}{1 + e^{a1+a2\times vol+a3\times lvol} + e^{b1+b2\times vol+b3\times lvol} + e^{c1+c2\times vol+c3\times lvol}} \quad \text{(A3-20)}$$

$$p_{foliage} = \frac{e^{a1+a2\times vol+a3\times lvol}}{1 + e^{a1+a2\times vol+a3\times lvol} + e^{b1+b2\times vol+b3\times lvol} + e^{c1+c2\times vol+c3\times lvol}} \quad \text{(A3-21)}$$

where $p_{stemwood}$, p_{bark}, $p_{branches}$, $p_{foliage}$ are proportions of total tree biomass in stemwood, stembark, branches and foliage, respectively, *vol* is merchantable volume (m^3/ha under bark), *lvol* is the natural logarithm of (*vol+5*) and *a1*, *a2*, *a3*, *b1*, *b2*, *b3*, *c1*, *c2*, *c3* are model parameters to be fitted by region/ecozone (Czech Republic) and lead tree species. The resulting fits are shown in Tab. A3 13.

Tab. A3 13 Species-specific parameters of the biomass proportion functions (Eqs. A3-18, A3-19, A3-20, A3-21) for individual tree species and biomass components, volume limit (based on observations), root mean square error (RMSE) and plot sample size (n).

Cohort/ Species		1	2	3	Volume limit (m^3/ha)	Component	RMSE	n
Beech	a	-2.6365	-0.0002	0.0097	691	Stemwood	0.058	111
	b	0.9471	0.0004	-0.4944		Bark	0.005	
	c	-1.5996	0.0002	-0.4621		Branch	0.057	
						Foliage	0.005	
Oak	a	-1.5742	0.0002	-0.1218	485	Stemwood	0.056	134
	b	-0.1773	-0.0006	-0.1922		Bark	0.003	
	c	-1.9364	-0.0016	-0.2970		Branch	0.052	
						Foliage	0.006	
Pine	a	-2.1524	-0.0005	-0.1009	513	Stemwood	0.097	194
	b	2.9261	0.0031	-1.0478		Bark	0.008	
	c	0.4433	0.0014	-0.8340		Branch	0.094	
						Foliage	0.010	
Spruce	a	-2.0031	-0.0001	-0.0641	919	Stemwood	0.050	613
	b	0.0350	0.0003	-0.3474		Bark	0.004	
	c	0.2685	0.0003	-0.5069		Branch	0.029	
						Foliage	0.026	
Birch	a	-1.6944	0.0000	-0.0060	194	Stemwood	0.023	95
	b	-0.8568	0.0000	-0.1089		Bark	0.002	
	c	-2.5115	0.0002	-0.1950		Branch	0.020	
						Foliage	0.003	

The resulting biomass proportions for individual tree species as a function of merchantable wood volume are also visualized in Fig. A3 17.

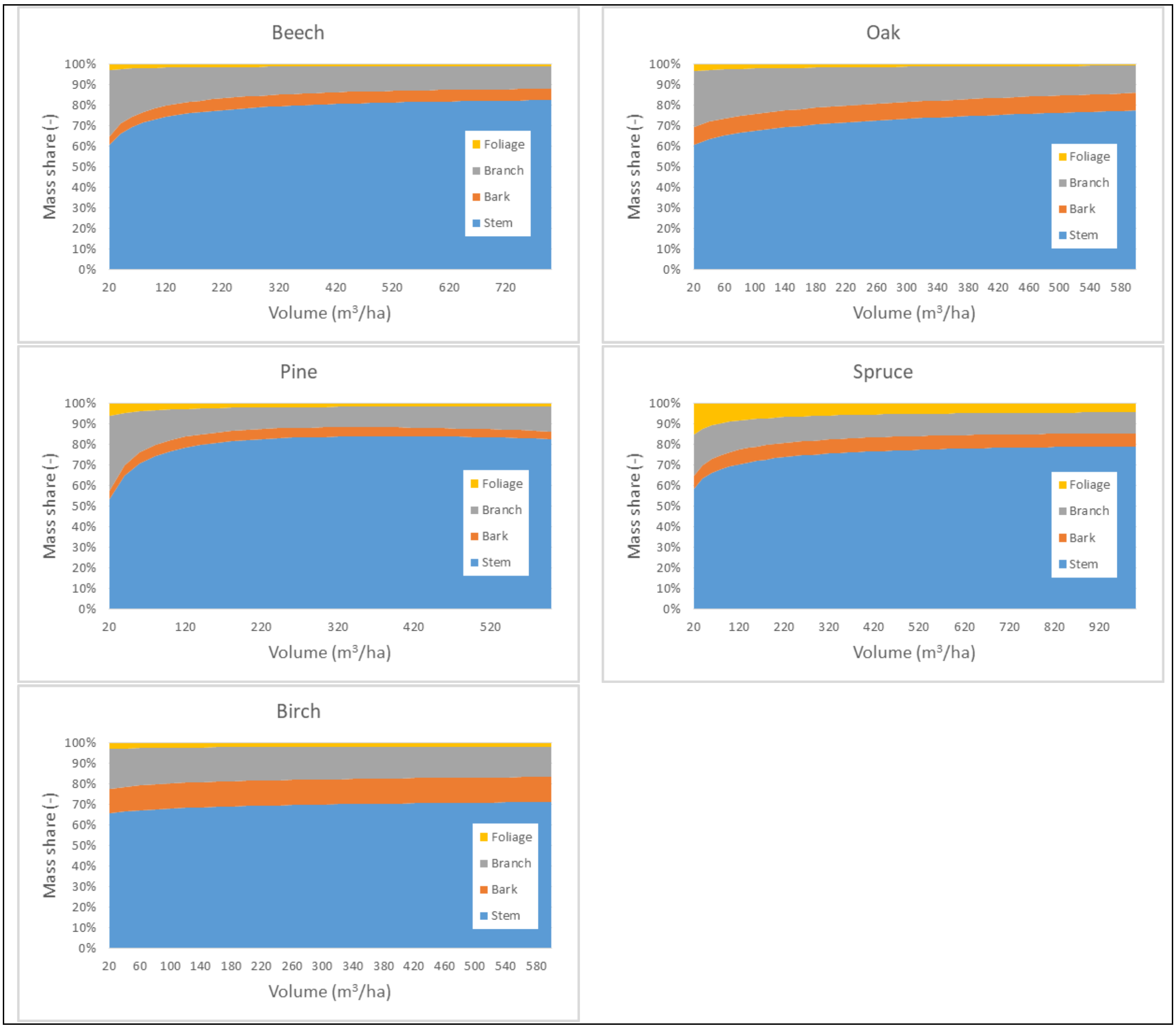

Fig. A3 17 Share of biomass for individual tree species from the parameterized proportion equations as in Tab. A3 13.

A 3.6.2.4 Turnover and transfer rates of carbon pools

The biomass turnover and litterfall transfer rates used in CBM are summarized in Tab. A3 14, according to pools illustrated in Fig. A3 10.

Tab. A3 14 Biomass turnover rates, designated DOM pools and litterfall transfer share (a – derived from NFI results as in Adolt et al. 2016; b – European AIDB by Pilli et al. 2018; c – Kurz et al. 1992; d – Li et al. 2003).

CBM pool	Turnover rates (%C/yr)	DOM pool receiving turnover	Literfall transfers (% transferred to DOM pool)
Merchantable stem (SW, HW)[a]	0.073	Snag stem	100
Other wood (SW, HW)[b]	1.15	Snag branches	25
		AG fast	75
Foliage (SW)[b]	11	AG very fast	100
Foliage (HW)[c]	95	AG very fast	100
Fine roots (HW, SW)[d]	64.1	Ag very fast	50
		BG very fast	50
Coarse roors (HW, SW)[d]	2	AG fast	50
		BG fast	50

A 3.6.2.5 Land use change accounting

CBM is designed to facilitate estimations of land use change impacts in term of areas and carbon pool changes (Kurz et al. 2009). Land use conversions representing afforestation and deforestation events are represented by their specific matrices (see below) and transition rules. All disturbance impacts following land use conversion are attributed to the new land-use class as required by IPCC guidelines. A mean reference soil carbon stock for the land use classes of Forest Land, Cropland, Grassland, Wetland and Settlements are estimated from the respective soil carbon maps used in this NIR, i.e., 65.3, 53.1, 63.1, 63.1 and 54 t/ha, respectively. A detailed description of CBM processes and assumptions related to land use conversions is provided by Kurz et al. (2009).

A 3.6.2.6 Forest management interventions and other disturbances

Changes in forest ecosystems are prescribed by disturbance matrices, which define the applied forest management interventions and natural disturbances in terms of the changes in carbon pools and transfers of carbon between them. The following set of disturbances were applied in CBM:

- DISTID 1 Wildfire – This represents ground fires affecting mainly the litter and deadwood layer with a slight effect on the main tree stand, used only to initialize DOM pools.
- DISTID 2 Thinning – Commercial thinning of merchantable-size trees in age classes 2-5 (species-dependent) resulting in a 10-30 % reduction in biomass carbon.
- DISTID 3a (Salvage A) Salvage with Clearcut – Stand replacing salvage harvesting induced by natural abiotic and biotic disturbances affecting continuous areas. All merchantable biomass is extracted. Used either with or without tree species changes following the harvest..
- DISTID 3b (Salvage B) Salvage without Clearcut - Salvage harvesting induced by natural (both abiotic and biotic) disturbances affecting disperse smaller areas not resulting in opened clearcut areas.
- DISTID 4 Final Cut – Commercial clearcut of mature forest stands leaving 5% of merchantable trees as reserved seed trees..
- DISTID 5 Slash and burn – Final cut disturbance used during the initialization of forest stands as the last event to build up DOM pools.
- DefCL (GL, SL) – Deforestation disturbances extracting wood or transforming living biomass to DOM pools. Transition of Forest Land (deforestation) to other IPCC land use classes (CL – Cropland, GL – Grassland, SL – Settlements). Salvage, uprooting and decay of biomass.
- DefWL - Deforestation disturbance transitioning forest land to wetlands, extracting wood, or transforming living biomass to DOM pools with salvage, uprooting and decay.

Scheduling the timing of timber harvest (thinning, salvaging, final cut) for each species group is organized in the model input file and disturbance event tables, which define the minimum forest age and biomass for clearcut, minimum and maximum age for thinning and the thinning interval. The harvested amount of each harvest type is prescribed for each time step (year) using the observed (reported) harvest data per species groups (see Section 6.4.2). Merchantable wood volume entering the requested disturbance quantity in the CBM input file was converted first to biomass using the prescribed species-specific wood densities (IPCC 2006) for beech and oak (0.58 t/m^3), pine (0.42 t/m^3) and spruce (0.40 t/m^3). Secondly, a carbon fraction of 0.5 was used for all species groups. Finally, a bark fraction is accounted for based on the parameterized biomass fractions described above (Section A 3.6.2.3). The species-specific bark shares on stem over bark based on these fractions are 0.068, 0.112, 0.061 and 0.087 for beech, oak, pine and spruce, respectively.

The individual disturbances (except Afforestation/Reforestation, which does not contain a specific redistribution of carbon between pools) are documented in detail by the corresponding disturbance matrices included below.

DISTID 1 Wildfire	SW merchantable	SW foliage	SW other	SW sub-merch	SW coarse roots	SW fine roots	HW merchantable	HW foliage	HW other	HW sub-merch	HW coarse roots	HW fine roots	Above ground very fast soil C	Below ground very fast soil C	Above ground fast soil C	Below ground fast soil C	Medium soil C	Above ground slow soil C	Below ground slow soil C	SW stem snag	SW branch snag	HW stem snag	HW branch snag	Black C	peat	CO2	CH4	CO	NO2	products
SW merchantable	0.98																			0.02										
SW foliage		0.98											0.02																	
SW other			0.98												0.02															
SW sub-merch				0.98											0.02															
SW coarse roots					0.98										0.01	0.01														
SW fine roots						0.98							0.01	0.01																
HW merchantable							0.98															0.02								
HW foliage								0.98					0.02																	
HW other									0.98						0.02															
HW sub-merch										0.98					0.02															
HW coarse roots											0.98				0.01	0.01														
HW fine roots												0.98	0.01	0.01																
Above ground very fast soil C													0.73					0.10								0.17				
Below ground very fast soil C														0.73					0.10							0.17				
Above ground fast soil C															0.73			0.10								0.17				
Below ground fast soil C																0.73			0.10							0.17				
Medium soil C																	0.88	0.05								0.07				
Above ground slow soil C																		0.99								0.01				
Below ground slow soil C																			1.00											
SW stem snag																	0.02			0.90						0.08				
SW branch snag															0.10						0.80					0.10				
HW stem snag																	0.02					0.90				0.08				
HW branch snag															0.10								0.80			0.10				
Black C																								1.00						
peat																								1.00						

DISTID 2 Thinning	SW merchantable	SW foliage	SW other	SW sub-merch	SW coarse roots	SW fine roots	HW merchantable	HW foliage	HW other	HW sub-merch	HW coarse roots	HW fine roots	Above ground very fast soil C	Below ground very fast soil C	Above ground fast soil C	Below ground fast soil C	Medium soil C	Above ground slow soil C	Below ground slow soil C	SW stem snag	SW branch snag	HW stem snag	HW branch snag	Black C	peat	CO2	CH4	CO	NO2	products
SW merchantable	0.75																0.05													0.20
SW foliage		0.75											0.25																	
SW other			0.75															0.15			0.10									
SW sub-merch				0.75														0.15			0.10									
SW coarse roots					0.75										0.10	0.15														
SW fine roots						0.75							0.10	0.15																
HW merchantable							0.75										0.05													0.20
HW foliage								0.75					0.25																	
HW other									0.75									0.15					0.10							
HW sub-merch										0.75								0.15					0.10							
HW coarse roots											0.75				0.10	0.15														
HW fine roots												0.75	0.10	0.15																
Above ground very fast soil C													1.00																	
Below ground very fast soil C														1.00																
Above ground fast soil C															1.00															
Below ground fast soil C																1.00														
Medium soil C																	1.00													
Above ground slow soil C																		1.00												
Below ground slow soil C																			1.00											
SW stem snag																				1.00										
SW branch snag																					1.00									
HW stem snag																						1.00								
HW branch snag																							1.00							
Black C																								1.00						
peat																									1.00					

DISTID 3(a) Salvage with clearcut	SW merchantable	SW foliage	SW other	SW sub-merch	SW coarse roots	SW fine roots	HW merchantable	HW foliage	HW other	HW sub-merch	HW coarse roots	HW fine roots	Above ground very fast soil C	Below ground very fast soil C	Above ground fast soil C	Below ground fast soil C	Medium soil C	Above ground slow soil C	Below ground slow soil C	SW stem snag	SW branch snag	HW stem snag	HW branch snag	Black C	peat	CO2	CH4	CO*	NO2	products
SW merchantable																	0.02													0.98
SW foliage													0.75													0.05		0.20		
SW other																		0.40			0.35					0.05		0.20		
SW sub-merch																		0.40			0.35					0.05		0.20		
SW coarse roots															0.40	0.60														
SW fine roots													0.40	0.60																
HW merchantable																	0.02													0.98
HW foliage													0.75													0.05		0.20		
HW other																		0.40					0.35			0.05		0.20		
HW sub-merch																		0.40					0.35			0.05		0.20		
HW coarse roots															0.40	0.60														
HW fine roots													0.40	0.60																
Above ground very fast soil C													1.00																	
Below ground very fast soil C														1.00																
Above ground fast soil C															1.00															
Below ground fast soil C																1.00														
Medium soil C																	1.00													
Above ground slow soil C																		1.00												
Below ground slow soil C																			1.00											
SW stem snag																				1.00										
SW branch snag																					1.00									
HW stem snag																						1.00								
HW branch snag																							1.00							
Black C																								1.00						
peat																									1.00					

DISTID 3b Salvage without clearcut	SW merchantable	SW foliage	SW other	SW sub-merch	SW coarse roots	SW fine roots	HW merchantable	HW foliage	HW other	HW sub-merch	HW coarse roots	HW fine roots	Above ground very fast soil C	Below ground very fast soil C	Above ground fast soil C	Below ground fast soil C	Medium soil C	Above ground slow soil C	Below ground slow soil C	SW stem snag	SW branch snag	HW stem snag	HW branch snag	Black C	peat	CO2	CH4	CO	NO2	products
SW merchantable	0.80																													0.20
SW foliage		0.80											0.20																	
SW other			0.80												0.10						0.10									
SW sub-merch				0.80											0.10						0.10									
SW coarse roots					0.80										0.05	0.15														
SW fine roots						0.80							0.05	0.15																
HW merchantable							0.80																							0.20
HW foliage								0.80					0.20																	
HW other									0.80						0.10								0.10							
HW sub-merch										0.80					0.10								0.10							
HW coarse roots											0.80				0.05	0.15														
HW fine roots												0.80	0.05	0.15																
Above ground very fast soil C													1.00																	
Below ground very fast soil C														1.00																
Above ground fast soil C															1.00															
Below ground fast soil C																1.00														
Medium soil C																	1.00													
Above ground slow soil C																		1.00												
Below ground slow soil C																			1.00											
SW stem snag																				1.00										
SW branch snag																					1.00									
HW stem snag																						1.00								
HW branch snag																							1.00							
Black C																								1.00						
peat																									1.00					

DISTID 4 Final cut	SW merchantable	SW foliage	SW other	SW sub-merch	SW coarse roots	SW fine roots	HW merchantable	HW foliage	HW other	HW sub-merch	HW coarse roots	HW fine roots	Above ground very fast soil C	Below ground very fast soil C	Above ground fast soil C	Below ground fast soil C	Medium soil C	Above ground slow soil C	Below ground slow soil C	SW stem snag	SW branch snag	HW stem snag	HW branch snag	Black C	peat	CO2	CH4	CO*	NO2	products
SW merchantable	0.03																0.02													0.95
SW foliage		0.03											0.97																	
SW other			0.03															0.40			0.31					0.01		0.25		
SW sub-merch				0.03														0.40			0.31					0.01		0.25		
SW coarse roots					0.03										0.37	0.60														
SW fine roots						0.03							0.37	0.60																
HW merchantable							0.03										0.02													0.95
HW foliage								0.03					0.97																	
HW other									0.03									0.40					0.31			0.01		0.25		
HW sub-merch										0.03								0.40					0.31			0.01		0.25		
HW coarse roots											0.03				0.37	0.60														
HW fine roots												0.03	0.37	0.60																
Above ground very fast soil C													1.00																	
Below ground very fast soil C														1.00																
Above ground fast soil C															1.00															
Below ground fast soil C																1.00														
Medium soil C																	1.00													
Above ground slow soil C																		1.00												
Below ground slow soil C																			1.00											
SW stem snag																				1.00										
SW branch snag																					1.00									
HW stem snag																						1.00								
HW branch snag																							1.00							
Black C																								1.00						
peat																									1.00					

DISTID 5 Slash and burn Stand initialization	SW merchantable	SW foliage	SW other	SW sub-merch	SW coarse roots	SW fine roots	HW merchantable	HW foliage	HW other	HW sub-merch	HW coarse roots	HW fine roots	Above ground very fast soil C	Below ground very fast soil C	Above ground fast soil C	Below ground fast soil C	Medium soil C	Above ground slow soil C	Below ground slow soil C	SW stem snag	SW branch snag	HW stem snag	HW branch snag	Black C	peat	CO2	CH4	CO	NO2	products
SW merchantable	0.05																													0.95
SW foliage		0.05											0.95																	
SW other			0.05												0.30						0.65									
SW sub-merch				0.05											0.95															
SW coarse roots					0.05										0.48	0.48														
SW fine roots						0.05							0.48	0.48																
HW merchantable							0.05																							0.95
HW foliage								0.05					0.95																	
HW other									0.05						0.30								0.65							
HW sub-merch										0.05					0.95															
HW coarse roots											0.05				0.48	0.48														
HW fine roots												0.05	0.48	0.48																
Above ground very fast soil C													1.00																	
Below ground very fast soil C														1.00																
Above ground fast soil C															1.00															
Below ground fast soil C																1.00														
Medium soil C																	1.00													
Above ground slow soil C																		1.00												
Below ground slow soil C																			1.00											
SW stem snag																	0.10									0.70				0.20
SW branch snag																					1.00									
HW stem snag																	0.10									0.70				0.20
HW branch snag																							1.00							
Black C																								1.00						
peat																									1.00					

DefCL, DefGL, DefSL Salvage uprooting and decay	SW merchantable	SW foliage	SW other	SW sub-merch	SW coarse roots	SW fine roots	HW merchantable	HW foliage	HW other	HW sub-merch	HW coarse roots	HW fine roots	Above ground very fast soil C	Below ground very fast soil C	Above ground fast soil C	Below ground fast soil C	Medium soil C	Above ground slow soil C	Below ground slow soil C	SW stem snag	SW branch snag	HW stem snag	HW branch snag	Black C	peat	CO2	CH4	CO	NO2	products
SW merchantable																	0.15													0.85
SW foliage														1.00																
SW other															1.00															
SW sub-merch															1.00															
SW coarse roots															1.00															
SW fine roots														1.00																
HW merchantable																	0.15													0.85
HW foliage														1.00																
HW other															1.00															
HW sub-merch															1.00															
HW coarse roots															1.00															
HW fine roots														1.00																
Above ground very fast soil C														1.00																
Below ground very fast soil C														1.00																
Above ground fast soil C															1.00															
Below ground fast soil C															1.00															
Medium soil C																	1.00													
Above ground slow soil C																			1.00											
Below ground slow soil C																			1.00											
SW stem snag																	0.50													0.50
SW branch snag															1.00															
HW stem snag																	0.50													0.50
HW branch snag															1.00															
Black C																								1.00						
peat																									1.00					

DefWL Hydroreservoir, salvage and decay	SW merchantable	SW foliage	SW other	SW sub-merch	SW coarse roots	SW fine roots	HW merchantable	HW foliage	HW other	HW sub-merch	HW coarse roots	HW fine roots	Above ground very fast soil C	Below ground very fast soil C	Above ground fast soil C	Below ground fast soil C	Medium soil C	Above ground slow soil C	Below ground slow soil C	SW stem snag	SW branch snag	HW stem snag	HW branch snag	Black C	peat	CO2	CH4	CO	NO2	products
SW merchantable																	0.15													0.85
SW foliage													1.00																	
SW other															1.00															
SW sub-merch															1.00															
SW coarse roots															0.50	0.50														
SW fine roots														1.00																
HW merchantable																	0.15													0.85
HW foliage													1.00																	
HW other															1.00															
HW sub-merch															1.00															
HW coarse roots															0.50	0.50														
HW fine roots														1.00																
Above ground very fast soil C														1.00																
Below ground very fast soil C														1.00																
Above ground fast soil C																1.00														
Below ground fast soil C																1.00														
Medium soil C																	1.00													
Above ground slow soil C																		1.00												
Below ground slow soil C																			1.00											
SW stem snag																	0.50													0.50
SW branch snag															1.00															
HW stem snag																	0.50													0.50
HW branch snag															1.00															
Black C																								1.00						
peat																									1.00					

A 3.6.3 CBM verification – consistency with Tier 2 estimates

Biomass carbon stock changes in Forest Land remaining Forest Land (category 4.A.1) qualify as the key category in the Czech NIR, similarly as in other comparable countries. However, this is not the only reason considerable attention was paid to these estimates. The earlier country-specific Tier 2 (T2) methodology estimates for this category used until NIR 2021 may serve to check the consistency of the currently used CBM-aided Tier-3 (T3) estimates. Both T2 and T3 approaches use the same basic activity data, such as forest areas, categorization by four major tree species, current annual increment, harvest intensity, and the fundamental species-specific tree biomass equations. Nevertheless, the implementation of these data and calculations used differ substantially in these two approaches, and hence they can be fully considered as independent.

Specifically, a comparison is presented here of carbon stock changes using three complementary statistical tests (all tests using Systat v. 13.2, Systat Inc., USA), namely linear regression statistics, a two sample (group) t-test, and a paired t-test. The comparison includes the CRF-submitted earlier (NIR 2023 and NIR 2021) data of carbon stock changes in living biomass for the category 4.A.1 Forest Land remaining Forest Land, with data limited to the same period of 1990-2019 (n=30). The linear regression (Fig. A3 18) showed a tight, significant ($p<0.001$) relationship, with an adjusted coefficient of determination of $R^2=0.99$, and intercept and slope parameters of $p_1=-141.1$ and $p_2=0.988$, respectively. The two samples were not statistically different by two sample t-test ($p=0.654$), meaning the difference between the samples was not large enough with respected to the overall data variability. The more stringent paired t-test, however, revealed a mean difference of 159.6 kt C/y between the samples, with the T3 estimates being more conservative (lower). However, this comparison between the T2 and T3 estimates provides an overall confidence that the T2 and T2 approaches for estimating carbon stock changes in living biomass are comparable and consistent. This also applies for the absolute values, which do not differ substantially, especially with respect to the uncertainties related to T2 estimates (54% as reported in NIR 2021).

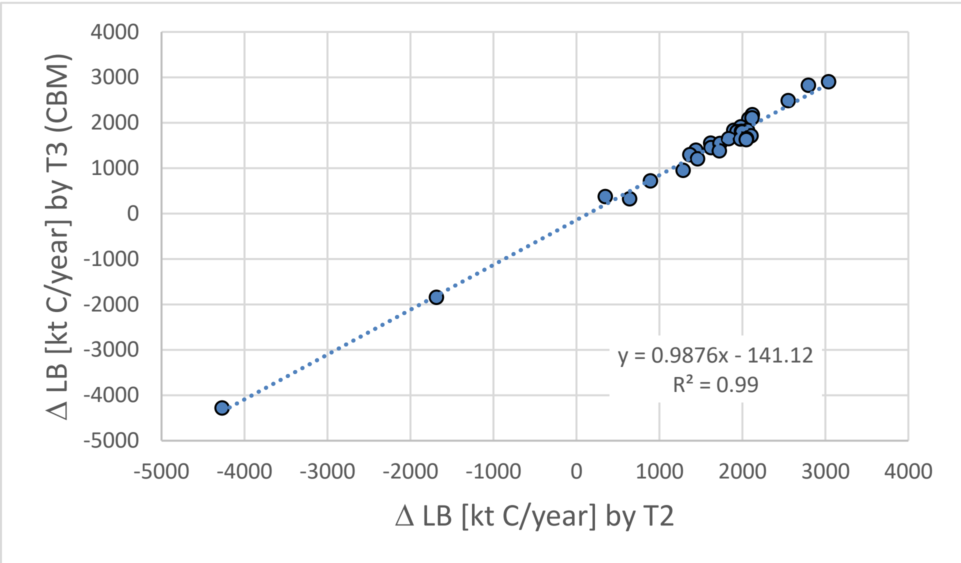

Fig. A3 18 A regression (and its statistics) between the estimates of carbon stock change in living biomass (D LB) by the Tier 2 (T2; x axis) approach as used in NIR 2021 and by the Tier 3 approach by CBM (T3; y axis) as implemented by the earlier (NIR 2023) inventory.

A complementary, additional consistency check of biomass estimates by CBM was provided in Chapter 11(12) containing the final accounting of the former KP LULUCF activities as presented in the NIR 2022 submission. It contains an evaluation of Tier 2 (NIR 2021) and Tier 3 (CBM, NIR 2022) estimates for total carbon stock changes for the LULUCF activities of Afforestation/Reforestation, Deforestation and Forest Management. They include both living biomass and –where applicable – DOM carbon pools of litter and deadwood, and mineral soil. Chapter 12.3.1.4 of the NIR 2022 submission summarized the effect of implementing Tier 3 estimates aided by CBM for the former KP LULUCF activities AR and D relative to the carbon stock estimates by Tier 2 methods used until NIR 2021. It stated that there were no significant differences for AR when comparing the independent estimates applicable for all carbon pools except soil, which was methodologically unchanged). Similarly, a tight correspondence was found between the two (Tier 3 and Tier 2) estimates of carbon stock changes under D events. These checks provided coherency substantiation for both living biomass and dead organic matter (litter and deadwood) carbon pools. That submission (NIR 2022) and the final carbon and emission accounting under KP was endorsed by the latest UNFCCC review (see the Czech ARR 2022).

A 3.6.4 CBM verification – consistency with spatially stratified CBM runs

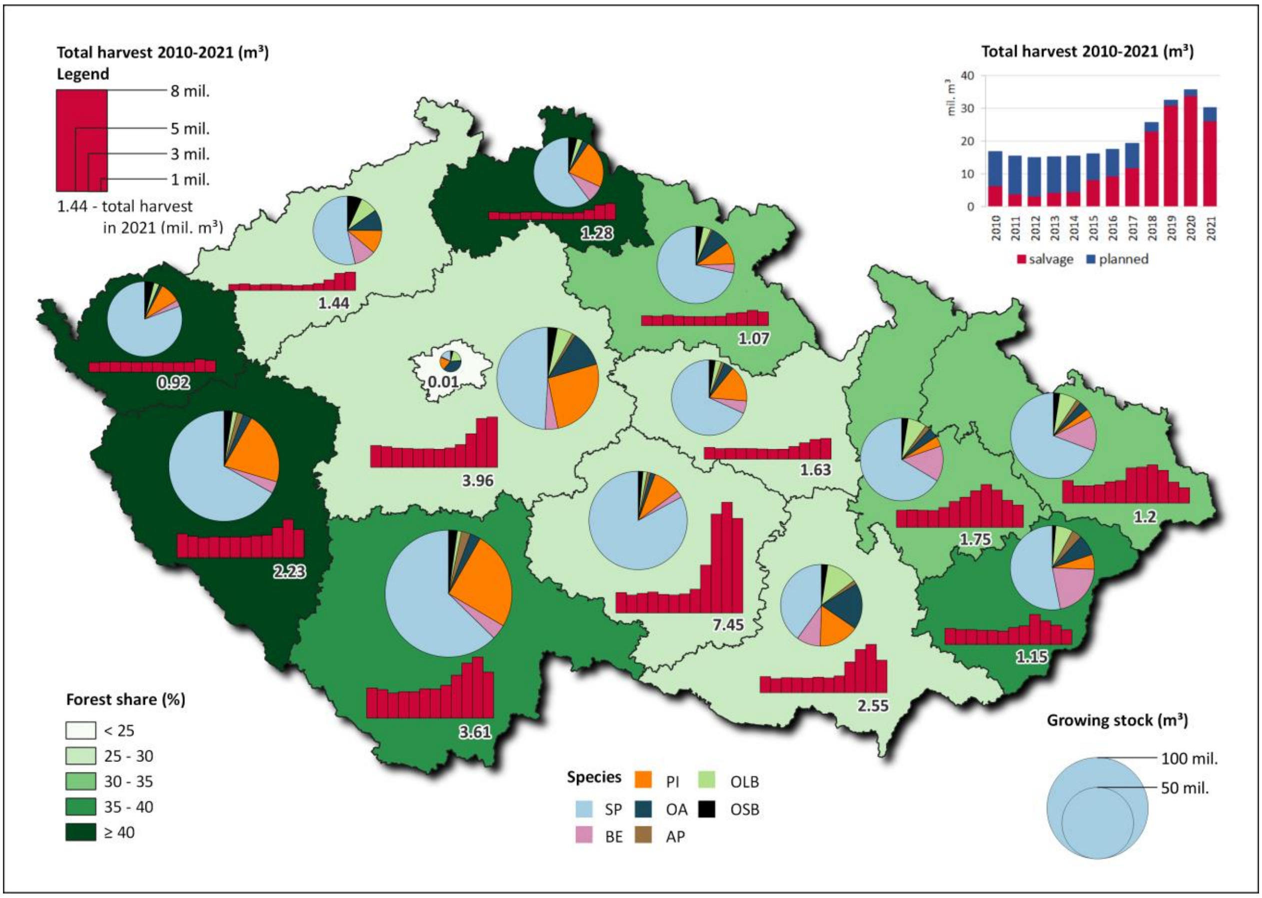

Fig. A3 19 Selected input data for the spatially stratified CBM run: species composition and harvest intensity by CZ NUTS3 regions and individual years 2010 to 2021, including the information of total harvest (salvage and planned, upper right), forest share (%, bottom left), and volume quantity of standing stock as of 2021 (bottom right). Abbreviation of species groups: SP – spruce, BE – beech, PI – pine, OA – oaks, AP - silver fir, OLB – other long-lived broadleaves, OSB – other short-lived broadleaves.

A different type of consistency check for the CBM estimates was conducted for the earlier NIR (2023) and retained here. Namely, we checked the default CBM estimate as described in that inventory report with estimates originating from a regionally-stratified CBM simulation using the *Nomenclature des Unites Territoriales Statistiques* CZ-NUTS3 country categorization of 14 regions (IFER 2022). At the same time, instead of four species strata as used in the default CBM run, we used a more detailed categorization using seven species groups – in addition to beech, oak, pine and spruce, fir, other long-lived broadleaves and short-lived broadleaves tree categories were also included. This resulted in 98 individual “species group by region” combinations. That study (Cienciala and Melichar 2022) covered the period from 2010 to 2030, of which 2010-2021 also included the explicit available input data coherent with those used in the comparable earlier emission inventory (NIR 2023). Aside from the more detailed spatial and tree species stratification, the study of Cienciala and Melichar (2022) differed in base-year data, using the year 2010 for calibration of the growth curves (A3-16) as well as for the initial state of the forest resources (growing stock by age classes for the strata used), while the default NIR calibration year was 2004 and the starting state of forest resources of 1990. Next, the harvest intensity was specific for each region and species (Fig. A3 19). This fundamental model input set-up makes the two runs suitable for a consistency check.

The two model estimates for the components of aboveground biomass (AGB) and belowground biomass (BGB) carbon stock changes are shown in Fig. A3 20. There was a very strong correlation between these two independent CBM estimates (R^2=1 in both cases). There were no significant differences in the means as shown by the two-sample t-test (p=0.909), though the paired t-test did identify a small mean difference of -129.7 kt C/year for total living biomass (AGB+BGB). This is, relative to the quantities concerned, a fractional difference that is explained mostly (but not only) by differences in handling of increments in the two model set-ups. Hence, this consistency check also indicates the robustness of the CBM set-up and consistency in its performance.

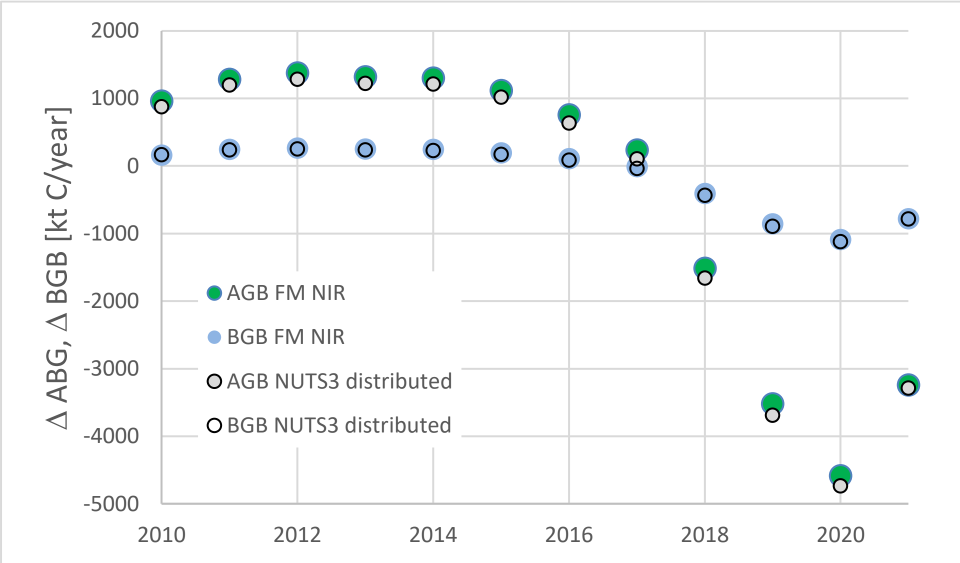

Fig. A3 20 A two CBM model runs estimating AGB and BGB carbon pool changes for the period 2010-2021 – comparing the outputs of the default run for Forest Management (FM) with the spatially distributed CBM set-up that also used a different species stratification and calibration year for increment. The two runs (FM vs. Distributed) are barely graphically distinguishable, as the results for AGB and BGB mostly overlap (retained from NIR 2023).

A 3.6.1 Additional verification

As noted in NIR Chapter 6.4.6, the inventory team plans an implementation of the regionally (NUTS3) distributed CBM-model application assessing carbon stock changes in forestry. Apart from assessing and crosschecking the regional differences, it would also effectively link to the projections of emissions in LULUCF that were also prepared by the LULUCF inventory team for the related EU policy requirements that primarily aim at discerning the effect of adaptation measures in the sector.

The inventory team works on additional calibration of dead organic matter carbon pools, including litter and dead wood. For this, the latest national forest inventory (NFI3) results that are gradually (2023/2024) being released by FMI, Brandýs n. Labem (e.g., Máslo et al. 2023) will be used. This also links to the initiated collaboration of IFER and FMI on a full utilization of NFI in the emission inventory of the LULUCF sector (Chapter 6.4.6).

Regarding the soil carbon pool, the inventory team will use the results of the current project funded by the Technology Agency of the Czech Republic (SS06010148) that revise the available activity data on forest soil carbon stock in the country. These emerging data sources should permit a further tuning and verification of the currently used calibration for CBM-CFS3 as used in the Czech emission inventory.

A 3.7 Collection of F-gases activity data in the Czech Republic

Emissions of F-gases (HFCs, PFCs, SF_6, NF_3) in the Czech Republic are at relatively low levels due to the absence of large industrial sources. Furthermore, all F-gases in the Czech Republic are imported, so there are no fugitive emissions from manufacturing. For the needs of inventory, three independent data sources are used. A methodology of data verification utilized to prevent duplicate values is described in this chapter.

The methodology is divided into three parts. The first describes the sources of F-gas activity data available in the Czech Republic. The second introduces a designed process of data verification, in particular a comparison of data sources. And the last describes an automatic system of data sorting according to their area of application.

A 3.7.1 Description of data sources

For the inventory, three sources of activity data are used:

- ISPOP (the "Integrated system of reporting obligations"),
- F-gas register (a questionnaire on the production, import, export, feedstock use and destruction of the substances listed in Annexes I or II of the F-gas regulation),
- Custom data (a database on the cross-border movements of goods).

ISPOP provides data about the import, export and disposal of F-gases considering the EU market. The reporting obligation is enshrined in Act No. 73/2012. The threshold for submitting data to ISPOP by importers, exporters and users is 200 t CO_2 eq. of F-gases. Manufacturers do not report those F-gases that are already charged into equipment. In ISPOP, only base gases are reported. If manufacturers need to report blends of F-gases, they have to calculate the amount of each F-gas contained therein.

Elementary reported information contains:

- the name of the company,
- the type of the activity (Import, Export, Disposal),
- the name of the F-gas,
- the amount of the gas [kg],
- the amount of the gas [t CO_2 eq.],
- the dispatch country / destination country (not disposed gases),
- the name of the company which handed over the F-gas for destruction (only for disposed gases).

The F-gas register provides data about imported, exported and disposed amounts of F-gases. The reporting obligation is enshrined in EU regulation No. 517/2014. Information in the F-gas register is related to the trade between EU countries and non-EU countries. The threshold for submitting data to the F-gas register is more than 1 t of F-gases or 1 000 t of CO_2 eq. of F-gases. This threshold refers to the sum of F-gases, not each imported/exported F-gas separately.

Two types of report can be distinguished. In the first the amount of bulk F-gases is reported, while in the second the amount of equipment containing F-gases is reported. In the second type of report, information about the average specific charge into equipment is also included.

Elementary reported information contains:

- the name of the company,

- the type of activity (Import, Export, Disposal),
- the name of the F-gas,
- the amount of the F-gas [t],
- the area of the application,
- the number of products (only for F-gases in equipment),
- the average charging amount (only for F-gases in equipment).

Custom data provides information about the movement of goods across the borders of the Czech Republic. The Czech Statistical Office is responsible for this database. These data provide information about imported and exported F-gases that are classified according to the combined nomenclature, which is regularly updated. Thanks to the latest update, performed in 2016, comparisons of the database with other sources are now more accurate.

Reporting rules are different for movement within the EU and for movement from/to non-EU countries; the first is covered by the Intrastat system, and the second by the Extrastat system.

In **Intrastat**, the movement of Union goods between Member States of the European Union is monitored. The reporting obligation is enshrined in EC regulation No. 638/2004. Data are provided by companies (reporting units) who reached a threshold 12 million CZK of traded goods, which is calculated from the beginning of each year. If a company reaches the threshold for the first time, they start to provide their data from the beginning of the month when they reached the threshold (CzSO 2020b).

Extrastat is based on collecting data from customs declarations (Single Administrative Documents - SADs) (CzSO 2020b). Any trade with a non-EU country must be reported in these documents, therefore the import and export of bulk F-gases (specified in combined nomenclature) is covered.

Elementary reported information contains:

- the name of the company,
- the type of activity (Import, Export),
- the name of the F-gas,
- the amount of the F-gas [kg],
- the name of the country of origin.

A 3.7.2 Comparison of the data sources

It can be seen from the description of sources that the data from the Intrastat and ISPOP, and the Extrastat and F-gas registers can partially overlap. However, since the reporting conditions slightly differ and each company applies its own reporting approach, the sources do not overlap completely. This highlighted the need for a sorting system. Therefore, a mathematical model was designed, with all available data imported into the model and compared. Finally, data from all sources are summed together.

Comparison of ISPOP and Intrastat data

While comparing ISPOP and Intrastat data, there are some issues that need to be noted:

- In ISPOP information about base gases is reported, while in Intrastat mainly blends are reported,
- in the case of imported goods, in ISPOP information about the country of dispatch is provided, while in Intrastat information about the country of origin is provided,
- in Intrastat, data can be reported only for part of the year and not for the whole year.

Because of these issues, the comparison of the two data sources is rather complicated. To help solve this, the largest importers of F-gases, the Kovoslužba and Schiessl companies, were contacted and provided more detailed information. Kovoslužba declared that the data reported to Instastat comes from the same sources as the data reported to ISPOP, thus differences are caused only by the issues mentioned above. In the case of Schiessl, there is another issue that results in differences between Intrastat and ISPOP data. Their company in the Czech Republic is a central distribution center for the Czech Republic, Slovakia, Germany and Austria, therefore in ISPOP gases are reported that are distributed not only to the Czech Republic but to all these countries. According to the information provided, the amounts of F-gases that are placed on the Czech market are reported as imported goods in Intrastat.

The final system of data comparison and selection was based on a detailed data analysis of the largest importers and on information provided by selected companies. Preference is given in the system to data from ISPOP (except for data from Schiessl), since it is ensured that companies provide data for the whole year and that any existing F-gas can be reported, whereas in Intrastat only F-gases from combined nomenclature can be reported. Therefore, only data where there is no risk of duplication are selected from Intrastat according to the following procedure.

The data from Intrastat are divided into three groups:

1. pure HFC gases;
2. blends of HFC gases;
3. unspecified gases (for the need of the inventory) – these are not taken into account.

Then, each value in Intrastat is compared with data from ISPOP, and it is determined whether the company reports in ISPOP and whether it reports the given gas. As can be seen, only pure HFC gases can be fully compared with ISPOP data. Therefore, different scenarios are made for every situation that may arise, as shown in Table A3 15.

Tab. A3 15 Overview of possible situations and their solutions

Will the value be taken into count?	Can the company be found in ISPOP? / Does the company report the given gas?		
	YES / YES	YES / NO	NO / NO
HFC gases	×	✓	✓
blends	NA	×	✓
unspecified gases	NA	×	×

With the exception of data from Schiessl, every gas reported in Intrastat – import is taken into account.

Comparison of F-gas register and Extrastat data

In the case of the F-gas register and Extrastat, differences between these databases do not cause serious issues for the purposed considered here. Their comparison is therefore less complicated than for ISPOP and Intrastat, and gives accurate results despite the fact that there are fewer criteria that can be compared between these two sources. Since only a few companies report exported F-gases to non-EU countries, data sources can be compared using only a visual check. The comparison process described below is thus only meant for import.

Comparison process:

1. A search for potential duplicate values is performed for the F-gas register database

   For each value in the F-gas register, a potential duplicate value in Extrastat is searched according to the following criteria:

   - The name of the company
   - The name of the gas or blend

2. Comparisons of found values

   If the value in F-gas register and value found from Extrastat are the same, they are automatically considered to be duplicates. If values differ, the decision is based on expert judgment.

3. Removal of duplicates

   Duplicate values are excluded from calculations of overall values from the F-gas register.

Since data sources provide information not only about the amount of F-gases but also some additional information, several options for data sorting by application have been devised, generally based on two principles. The first, used for all data sources, is based on information about the companies. Some reporting companies are distributors of products containing F-gases, and according to the type of products they offer, the area of F-gas application can be identified. The second principle is according to the area of application itself. This is only applicable to the F-gas register, since manufacturers only directly provide information about the area of application in this register.

Based on these principles, F-gases are automatically sorted into three groups:

1. F-gases used for mobile air conditioning (CRF category 2.F.1.e)
2. F-gases used for fire protection (CRF category 2.F.3)
3. Other F-gases

As can be seen, there is still a large group of unsorted F-gases remaining, and more detailed research will be needed to sort these F-gases. However, on the basis of the data available, activity data could be recalculated back to the year 2016 (the year when the combined nomenclature classification was updated, allowing custom data to be fully compared).

The calculation of F-gas consumption is now more accurate and a risk of potential calculation errors is reduced. As can be seen from Figure A3 21 with values from 2018, the largest amount of data on the share of consumed F-gases are from ISPOP. The graph also shows the amount of F-gases excluded from the calculation of total consumption.

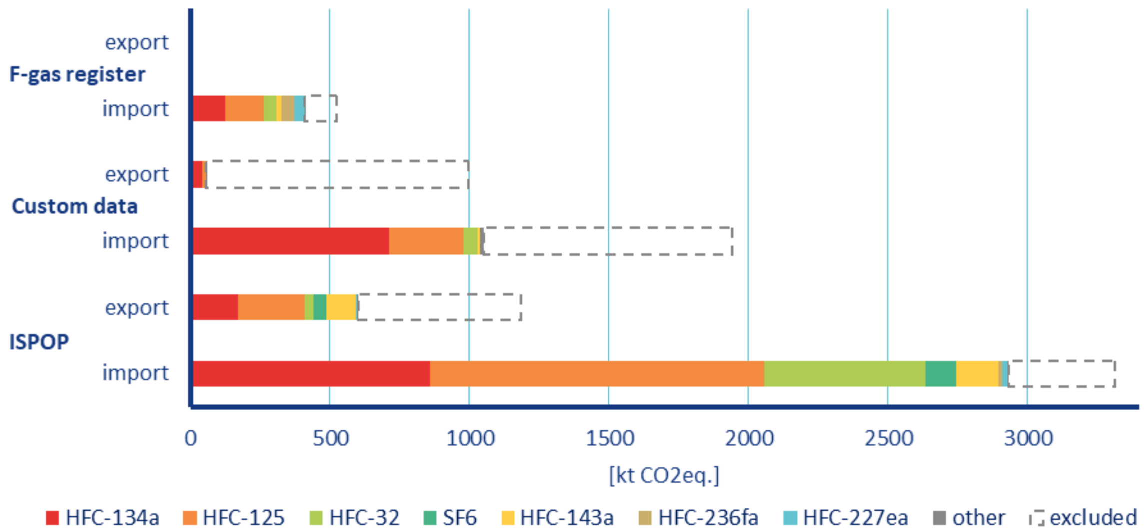

Fig. A3 21 Amounts of imported and exported F-gases in 2018 divided according to the data sources

Due to the system described above, the risk of double-counting is eliminated to a minimum. Furthermore, F-gases within CRF category 2.F.1.e and 2.F.3 are automatically sorted. Since the F-gas activity data are more accurate, F-gas emissions estimates are more accurate as well.

Annex 4 The national energy balance for the most recent inventory year

Following tables present energy balance for the Czech Republic for 2022.

Tab. A4 1 Energy balance for solid fuels 2022

SOLID FUELS	Coking Coal [kt/year]	Bituminous Coal [kt/year]	Lignite/Brown Coal [kt/year]	Coke Oven Coke [kt/year]	Coal Tar [kt/year]
Indigenous Production	864	820	33 388	2 351	97
Total Imports (Balance)	2 882	1 702	22	257	225
Total Exports (Balance)	591	336	977	594	21
International Marine Bunkers	0	0	0	0	0
Stock Changes (National Territory)	45	63	220	-8	-3
Inland Consumption (Calculated)	3 199	2 299	32 654	2 006	298
Statistical Differences	175	33	75	-26	-3
Transformation Sector	3 023	1 940	30 076	1 687	2
Main Activity Producer Electricity Plants	0	768	22 735	0	0
Main Activity Producer CHP Plants	0	921	5 133	0	0
Main Activity Producer Heat Plants	0	7	61	0	1
Autoproducer Electricity Plants	0	0	0	0	0
Autoproducer CHP Plants	0	9	1 851	0	2
Autoproducer Heat Plants	0	0	24	0	0
Patent Fuel Plants (Transformation)	0	0	0	0	0
Coke Ovens (Transformation)	3 023	0	0	101	0
BKB Plants (Transformation)	0	0	270	0	0
Gas Works (Transformation)	0	0	2	0	0
Blast Furnaces (Transformation)	0	235	0	1 586	0
Coal Liquefaction Plants (Transformation)	0	0	0	0	0
Non-specified (Transformation)	0	0	0	0	0
Energy Sector	0	0	367	0	0
Own Use in Electricity, CHP and Heat Plants	0	0	0	0	0
Coal Mines	0	0	367	0	0
Patent Fuel Plants (Energy)	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0
BKB Plants (Energy)	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0
Petroleum Refineries	0	0	0	0	0
Coal Liquefaction Plants (Energy)	0	0	0	0	0
Non-specified (Energy)	0	0	0	0	0
Distribution Losses	1	2	5	0	0
Total Final Consumption	0	324	2 130	346	298
Total Non-Energy Use	0	3	0	0	297
Final Energy Consumption	0	321	2 130	346	1
Industry Sector	0	139	862	327	1
Iron and Steel	0	0	13	260	0
Chemical (including Petrochemical)	0	0	621	0	0
Non-Ferrous Metals	0	0	1	4	0
Non-Metallic Minerals	0	121	10	53	1
Transport Equipment	0	0	6	0	0
Machinery	0	1	10	1	0
Mining and Quarrying	0	0	0	0	0
Food, Beverages and Tobacco	0	16	87	7	0
Paper, Pulp and Printing	0	0	105	0	0
Wood and Wood Products	0	0	0	0	0
Construction	0	0	2	0	0
Textiles and Leather	0	0	1	0	0
Non-specified (Industry)	0	0	7	0	0
Transport Sector	0	0	0	0	0
Other Sectors	0	182	1 269	19	0
Commercial and Public Services	0	1	48	0	0

SOLID FUELS	Coking Coal [kt/year]	Bituminous Coal [kt/year]	Lignite/Brown Coal [kt/year]	Coke Oven Coke [kt/year]	Coal Tar [kt/year]
Residential	0	180	1 207	18	0
Agriculture/Forestry	0	1	14	0	0
Fishing	0	0	0	0	0
Non-specified (Other)	0	0	0	0	0

Tab. A4 2 Energy balance for solid fuels 2022

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	157	0	18 783	17 680	3 872
Total Imports (Balance)	244	0	0	0	0
Total Exports (Balance)	129	0	0	0	0
International Marine Bunkers	0	0	0	0	0
Stock Changes (National Territory)	-4	0	0	0	0
Inland Consumption (Calculated)	276	0	18 783	17 680	3 872
Statistical Differences	-1	0	-2	-1	0
Transformation Sector	0	0	5 828	6 320	686
Main Activity Producer Electricity Plants	0	0	0	0	0
Main Activity Producer CHP Plants	0	0	5 828	6 320	482
Main Activity Producer Heat Plants	0	0	0	0	0
Autoproducer Electricity Plants	0	0	0	0	0
Autoproducer CHP Plants	0	0	0	0	205
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	0	7 306	6 148	1
Own Use in Electricity, CHP and Heat Plants	0	0	0	0	1
Coal Mines	0	0	0	0	0
Patent Fuel Plants (Energy)	0	0	0	0	0
Coke Ovens (Energy)	0	0	7 306	2 429	0
BKB Plants (Energy)	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	3 720	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	1	0	461	964	69
Total Final Consumption	276	0	5 189	4 248	3 117
Total Non-Energy Use	0	0	0	0	800
Final Energy Consumption	276	0	5 189	5 504	2 316
Industry Sector	77	0	5 189	5 504	2 316
Iron and Steel	0	0	5 096	5 504	894
Chemical (including Petrochemical)	0	0	0	0	1 401
Non-Ferrous Metals	0	0	0	0	0
Non-Metallic Minerals	63	0	92	0	22
Transport Equipment	0	0	0	0	0
Machinery	0	0	0	0	0
Mining and Quarrying	10	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

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]
Transport Sector	0	0	0	0	0
Other Sectors	199	0	0	0	0
Commercial and Public Services	19	0	0	0	0
Residential	180	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 2022

LIQUID FUELS	Crude Oil [kt/year]	Refinery Feedstocks [kt/year]	Additives Oxygenates [kt/year]
Indigenous Production	76		2
From Other Sources			492
From Other Sources - Solid fuels			
From Other Sources - Natural Gas			
From Other Sources - Renewables			492
Backflows		142	
Primary Product Receipts			
Refinery Gross Output			
Inputs of Recycled Products			
Refinery Fuel			
Total Imports (Balance)	7 425	9	1
Total Exports (Balance)			
International Marine Bunkers			
Interproduct Transfers			
Products Transferred		93	
Direct Use			453
Stock Changes (National Territory)	-44	9	
Refinery Intake (Calculated)	7 457	253	42
Gross Inland Deliveries (Calculated)	0		
Statistical Differences	0	0	0
Gross Inland Deliveries (Observed)	0	0	
Refinery Intake (Observed)	7 457	253	42

Tab. A4 4 Energy balance for liquid fuels 2022

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	129		355		917		1 398		0		0	
Refinery Fuel	115		0		0		0		0		0	
Total Imports (Balance)	0		177		105		560		10		2	
Total Exports (Balance)	0		112				473		36		0	
International Marine Bunkers	0		0		0		0		0		0	
Stock Changes (National Territory)	0		2		-20		-18		3		0	
Gross Inland Deliveries (Calculated)	14		422		1 002		1 588		98		2	
Statistical Differences	0		0		0		0		0		0	
Gross Inland Deliveries (Observed)	14		422		1 002		1 588		98		2	
Refinery Intake (Observed)	0		0		0		0		0		0	
Non-energy use in Petrochemical industry	0		247		1 002		0		0		0	
	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energ y Use
Transformation Sector	14	0	11	0	0	0	0	0	0	0	0	0
Main Activity Producer Electricity Plants												
Autoproducer Electricity Plants												
Main Activity Producer CHP Plants	14		8				0					
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	161	250	0	1 002	1 588	0	98	0	2	0
Transport Sector	0	0	85	0	0	0	1 588	0	98	0	2	0
International Aviation												
Domestic Aviation											2	0
Road			85				1 588		98			
Rail												
Domestic Navigation												
Pipeline Transport												
Non-specified (Transport)												
Industry Sector	0	0	24	250	0	1 002	0	0	0	0	0	0
Iron and Steel												
Chemical (including Petrochemical)			3	250		1 002						
NonFerrous Metals												
NonMetallic Minerals			2									
Transport Equipment			2									
Machinery			3									
Mining and Quarrying												
Food, Beverages and Tobacco			3									
Paper, Pulp and Printing			2									
Wood and Wood Products			2									
Construction			3									
Textiles and Leather			2									
Non-specified (Industry)			2									
Other Sectors	0	0	52	0	0	0	0	0		0	0	0
Commercial and Public Services			6									
Residential			43									
Agriculture/Forestry			3									
Fishing												
Non-specified (Other)												

*Sum of Biogasoline and Motor gasoline.

Tab. A4 5 Energy balance for liquid fuels 2022

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	117		0		3 156		0		97		111	
Refinery Fuel	0		0		0		0		0		0	
Total Imports (Balance)	169		2		2 299		28		20		10	
Total Exports (Balance)	0		0		735		43		13		56	
International Marine Bunkers	0		0		0		0		0		0	
Stock Changes (National Territory)	-12		0		26		-2		0		-6	
Gross Inland Deliveries (Calculated)	274		2		5 091		315		88		58	
Statistical Differences	0		0		0		0		0		0	
Gross Inland Deliveries (Observed)	274		2		5 091		315		88		58	
Refinery Intake (Observed)	0		0		0		0		0		0	
Non-energy use in Petrochemical industry	0		0		0		0		0		0	
	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use
Transformation Sector	0	0	0	0	0	0	0	0	5	0	19	0
Main Activity Producer Electricity Plants									1		1	
Autoproducer Electricity Plants												
Main Activity Producer CHP Plants									1		6	
Autoproducer CHP Plants									1			
Main Activity Producer Heat Plants									1		12	
Autoproducer Heat Plants									1			
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	3	0	0	0	0	0	0	0
Coal Mines					3							
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	274	0	2	0	5 088	0	315	0	83	0	39	0
Transport Sector	260	0	0	0	4 723	0	294	0	78	0	0	0
International Aviation	256											
Domestic Aviation	4											
Road					4 720		288					
Rail							6		78			
Domestic Navigation					3							
Pipeline Transport												
Non-specified (Transport)												
Industry Sector	0	0	0	0	40	0	2	0	4	0	29	0
Iron and Steel												
Chemical (including Petrochemical)											2	
Non-Ferrous Metals									1			
Non-Metallic Minerals											4	
Transport Equipment											3	
Machinery											2	
Mining and Quarrying											4	
Food, Beverages and Tobacco									1		4	
Paper, Pulp and Printing											3	
Wood and Wood Products									1		3	
Construction					38		2		1		3	
Textiles and Leather											0	
Non-specified (Industry)					2						1	
Other Sectors	14	0	2	0	325	0	19	0	1	0	10	0
Commercial and Public Services	2				7						5	
Residential												
Agriculture/Forestry					309		19		1		5	
Fishing												
Non-specified (Other)	12		2		9							

**Sum of Biodiesel and Transport diesel.

Tab. A4 6 Energy balance for liquid fuels 2022

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		28		576		4		82		747	
Refinery Fuel	0		0		0		0		82		0	
Total Imports (Balance)	16		180		231		17		5		151	
Total Exports (Balance)	0		51		327		5		1		125	
International Marine Bunkers	0		0		0		0		0		0	
Stock Changes (National Territory)	1		3		-11		0		0		-9	
Gross Inland Deliveries (Calculated)	17		150		469		16		4		701	
Statistical Differences	0		0		0		0		0		0	
Gross Inland Deliveries (Observed)	17		150		469		16		4		701	
Refinery Intake (Observed)	0		0		0		0		0		0	
Non-energy use in Petrochemical industry	0		0		0		0		0		336	
	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use	Energy Use	Non Energy Use
Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0
Main Activity Producer Electricity Plants												
Autoproducer Electricity Plants												
Main Activity Producer CHP Plants												
Autoproducer CHP Plants												
Main Activity Producer Heat Plants												
Autoproducer Heat Plants												
Gas Works (Transformation)												
For Blended Natural Gas												
Coke Ovens (Transformation)												
Blast Furnaces (Transformation)												
Petrochemical Industry												
Patent Fuel Plants (Transformation)												
Non-specified (Transformation)												
Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines												
Oil and Gas Extraction												
Coke Ovens (Energy)												
Blast Furnaces (Energy)												
Gas Works (Energy)												
Own Use in Electricity, CHP and Heat Plants												
Non-specified (Energy)												
Distribution Losses												
Total Final Consumption	0	17	0	150	0	469	0	16	0	4	127	432
Transport Sector	0	0	0	142	0	0	0	0	0		0	
International Aviation												
Domestic Aviation												
Road				136								
Rail				6								
Domestic Navigation												
Pipeline Transport												
Non-specified (Transport)												
Industry Sector	0	17	0	8	0	469	0	16	0	4	127	432
Iron and Steel												
Chemical (including Petrochemical)		1									127	432
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								2				
Construction						469						
Textiles and Leather												
Non-specified (Industry)		16		8				14		1		
Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0
Commercial and Public Services												
Residential												
Agriculture/Forestry												
Fishing												
Non-specified (Other)												

Tab. A4 7 Energy balance for Natural Gas 2022 [TJ] in GCV

Indigenous Production	8 568
Associated Gas	5 714
Non-Associated Gas	0
Colliery Gas	2 854
From Other Sources	48
Total Imports (Balance)	334 473
Total Exports (Balance)	0
International Marine Bunkers	0
Stock Changes (National Territory)	-48 028
Inland Consumption (Calculated)	295 062
Statistical Differences	-506
Inland Consumption (Observed)	295 568
Recoverable Gas	0
Opening Stock Level (National Territory)	65 385
Closing Stock Level (National Territory)	113 412
Opening stock level (Held abroad)	5 197
Closing stock level (Held abroad)	
Memo:	
Gas Vented	0
Gas Flared	0
Memo: Cushion Gas	
Cushion Gas Closing Stock Level	48 265
Memo: From other sources	
From Other Sources - Oil	0
From Other Sources - Coal	0
From Other Sources - Renewables	48

Transformation Sector	65 332
Main Activity Producer Electricity Plants	15 151
Autoproducer Electricity Plants	23
Main Activity Producer CHP Plants	22 893
Autoproducer CHP Plants	2 093
Main Activity Producer Heat Plants	17 202
Autoproducer Heat Plants	7 970
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	4 372
Coal Mines	0
Oil and Gas Extraction	110
Oil Refineries	4 261
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	3 955
Transport Sector	4 171
Road	3 726
of which Biogas	1 087
Pipeline Transport	445
Non-specified (Transport)	0
Industry Sector	92 704
Iron and Steel	6 691
Chemical (including Petrochemical)	12 898
Non-Ferrous Metals	2 381
Non-Metallic Minerals	21 537
Transport Equipment	8 405
Machinery	10 177
Mining and Quarrying	1 860
Food, Beverages and Tobacco	12 017
Paper, Pulp and Printing	5 056
Wood and Wood Products	598
Construction	2 715
Textiles and Leather	4 544
Non-specified (Industry)	3 823
Other Sectors	122 273
Commercial and Public Services	42 857
Residential	77 317
Agriculture/Forestry	1 897
Fishing	7
Non-specified (Other)	194

**The value for Road is stated in TJ in NCV.

Annex 5 Any additional information, as applicable

Information provided in A5.1 – A5.2 are related to emission estimation in Energy sector.

A 5.1 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.

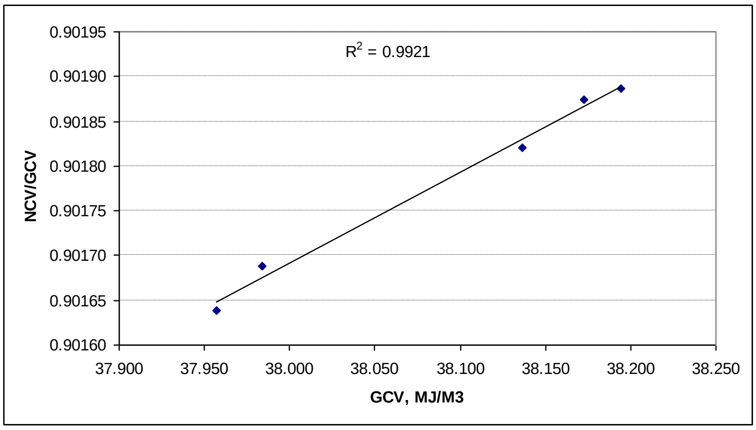

Fig. A5 1 Regression line corresponds with the data shown in Tab. A5-1.

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)

A 5.2 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/Nm³	16.935	17.108	16.847	16.040	16.459	17.210	17.162	
GCV, MJ/NM³	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/Nm³	17.177	16.832	17.056	17.218	17.312	16.946	0.353	2.1%
GCV, MJ/NM³	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.

A 5.3 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 - 2019. 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	18 405	18 405	21 420	21 781	21 846	22 122	22 252
Coking Coal	28 468	28 468	28 468	28 468	28 468	28 468	28 468
Lignite	12 000	12 000	12 000	12 000	12 180	12 540	12 693
Coke Oven Coke	27 009	27 009	27 457	27 457	27 457	27 457	27 457
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	21 556	23 981	24 373	21 229	21 962	23 011	23 643
Coking Coal	28 608	28 608	28 527	28 392	28 596	28 752	28 971
Lignite	12 045	12 073	12 811	12 392	12 423	12 411	12 371
Coke Oven Coke	28 241	28 241	28 894	28 488	28 735	28 742	28 712
Coal Tar	NE	NE	NE	NE	NE	36 979	36 979
BKB	22 924	24 080	24 620	24 912	24 243	23 766	25 667
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

NCV [kJ/kg]	1997	1998	1999	2000	2001	2002	2003
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	23 167	22 399	22 444	22 795	23 455	22 455	23 033
Coking Coal	28 745	28 818	29 148	29 279	29 326	29 381	29 385
Lignite	12 539	12 676	12 680	12 448	12 592	12 414	12 526
Coke Oven Coke	27 991	27 911	28 805	28 472	28 512	28 690	27 865
Coal Tar	36 979	37 336	35 400	37 000	37 000	37 161	36 936
BKB	24 025	22 919	23 500	23 591	22 000	24 000	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	23 007	23 278	22 791	22 280	21 485	21 915	21 302
Coking Coal	29 207	29 373	29 244	29 468	29 536	29 509	29 580
Lignite	12 083	12 159	12 019	11 996	11 938	11 955	12 091
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	42 949

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 3e Net calorific values for fossil fuels

NCV [kJ/kg]	2018	2019	2020	2021	2022
Anthracite	28 000	26 607	27 342	27 482	26 889
Bituminous Coal	22 109	22 775	22 208	22 102	21 899
Coking Coal	29 592	29 498	29 504	29 411	29 343
Lignite	12 166	12 097	12 272	12 406	12 140
Coke Oven Coke	28 971	28 953	28 821	28 677	28 285
Coal Tar	36 214	36 237	38 888	38 613	38 050
BKB	21 959	20 452	22 224	21 976	21 333
Crude Oil	42 800	42 500	42 500	42 500	42 500
Refinery gas	46 023	46 023	46 023	46 023	46 023
LPG	45 945	45 945	45 945	45 945	45 945
Naphtha	43 600	43 600	43 600	43 600	43 600
Motor gasoline	44 432	44 646	44 625	44 387	44 479
Aviation gasoline	43 790	43 790	43 790	43 790	43 790
Biogasoline	27 000	27 000	27 000	27 000	27 000
Kerosene Jet Fuel	43 300	43 300	43 300	43 300	43 300
Other kerosene	42 800	42 800	42 800	42 800	42 800
Road diesel	42 935	42 957	43 037	43 219	43 175
Heating and other gas oil	42 600	42 600	42 600	42 600	42 600
Biodiesel	37 000	37 000	37 000	37 000	37 000
Fuel oil - low sulphur	39 500	39 500	39 500	39 500	39 500
Fuel oil - high sulphur	39 500	39 500	39 500	39 500	39 500
Residual Fuel Oil	39 500	39 500	39 500	39 500	39 500
Petroleum coke	39 400	39 400	39 400	39 400	39 400
Other products*)	39 001	29 290	38 778	38 493	38 931

**) 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	34 235
NCV [MJ/m^3]	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Natural Gas	34 227	34 264	34 405	34 371	34 295	34 424	34 484	34 574	34 679
NCV [MJ/m^3]	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**			
Natural Gas	34 627	34 627	34 588	34 611	34 596	35 026			

***) 15 °C, 101.3 kPa*

A 5.4 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 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%) means that all carbon in fuel is incinerated. This is safe assumption that might not lead to underestimation of emission from the source category, but it will make much harder to correctly estimate uncertainty, however. We argue that using less than 100% as oxidation gives much better starting point should we do proper uncertainty assessment that is planned for next submission. Also there is an existence of various measurement showing unburned carbon in bottom ash of the waste incinerator.

Tab. A5 5b Selected studies focusing of carbon in bottom ash

Study	Value of TOC in bottom ash	Note
Rendek E. et al. (2006a)	3.74 – 0.88 (wt %)	5 WI facilities
Ferrari S. et al. (2001)	17.3 - 6.0 g/kg	11 WI facilities
Van Zomeren, A., Comans R.N.J. (2009)	29.4- 19.8 g/kg	3 WWI
Rendek E. et al. (2006b)	1.5 (wt %)	Sample mix
Bjurström H. (2014)	3.9 (wt %)	Multiple samples, averaged
Straka P. et al.(2014)	0.64 – 22.06 (wt %)	10 facilities

National studies are limited (only one focused on unburnt carbon from biomaterials), however all the studies show that OFj is less than 1. Overview of reviewed studies is in Tab A5 5b. Please note that studies in table reviewed several facilities and/or samples from various places. They 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 we 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.

A 5.5 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

A 5.6 Completeness 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 (2022 submission)

CRF	Sector	4. 3. 2024	Comment
1 ENERGY			
1	Energy	P	
1.A.A	Fuel Combustion Sectoral approach	P	
1.A.1	Energy Industries	C	
1.A.3	Transport	P	OK, NA for caloric value is missing
1.A.4	Other sector	C	
1.A.5	Non-specified	C	
1.A.6	Information item	C	
1.A.B	Fuel combustion reference approach	C	
1.A.C	Comparison of CO_2 emissions from fuel combustion	C	
1.A.D	Feedstock, reductants and other non-energy use of fuels	C	
1.B	Fugitive emissions from fuels	P	
1.B.1	Solid fuels	C	
1.B.2	Oil and natural gas and other emissions from energy production	P	1.B.2.a.1 and 1.B.2.a.1 has NE without doc box info or cell info
1.C	Carbon dioxide transport and storage	C	
1.C.1	Transport of CO_2	C	
1.C.2	Injection and storage	C	
1.C.3	Other	C	
1.D	Memo items	C	
1.D.2	Multilateral operations	C	
1.D.3	CO_2 emissions from biomass	C	
1.D.4	CO_2 captured	C	
2 IPPU			
2	Industrial processes and product use	P	
2.A	Mineral industry	P	
2.A.1	Cement production	C	
2.A.2	Lime production	C	
2.A.3	Glass production	C	
2.A.4	Other process uses of carbonates	P	2a4c orange,OK
2.B	Chemical industry	P	OK
2.B.1	Ammonia productin	C	
2.B.2	Nitric acid production	C	
2.B.3	Adipic acid production	C	
2.B.4	Caprolactam, glyoxal and glyoxylic acid production	C	
2.B.5	Carbide production	P	OK
2.B.6	Titanium dioxide production	C	
2.B.7	Soda ash production	C	
2.B.8	Petrochemical and carbon black production	P	2b8g orange, OK
2.B.9	Flourochemical production	P	
2.B.10	Other	P	OK
2.C	Metal industry	P	
2.C.1	Iron and steel production	P	
2.C.2	Ferroalloys production	C	

2.C.3	Aluminium production	P	NKs are missing
2.C.4	Magnesium production	P	NKs are missing
2.C.5	Lead production	C	
2.C.6	Zinc production	C	
2.C.7	Other	C	
2.D	Non-energy products from fuels and solvent use	C	
2.E	Electronics industry	P	
2.E.1	Integrated circuit or semiconductor	P	OK
2.E.2	TFT flat panel display	P	OK
2.E.3	Photovoltaics	P	OK
2.E.4	Heat transfer fluid	P	NE missing info
2.E.5	Other	C	
2.F	Product use as substitudes for ozon depleting substances	P	
2.F.1	Refrigeration and air conditioning	P	OK. all subs green, but shows orange
2.F.2	Foam blowing agents	P	NKs missing in PFCs
2.F.3	Fire protection	P	OK. all subs green, but shows orange
2.F.4	Aerosols	P	OK. all subs green, but shows orange
2.F.5	Solvents	P	NKs missing in PFCs
2.F.6	Other applications	P	NKs missing in PFC and HFC
2.G	Other product manufacture and use	P	
2.G.1	Electrical equipment	P	Nks missing
2.G.2	SF6 and PFCs from other product uses	P	NKs missing PFC
2.G.3	N_2O from product uses	P	OK
2.G.4	Other	P	OK
2.H	Other	P	OK
2.H.1	Pulp and paper	P	OK
2.H.3	Other	P	OK
3 AGRICULTURE			
3	Agriculture	P	
3.1	Livestock	C	
3.A	Enteric fermentation	C	
3.B	Manure management	C	
3.C	Rice cultivation	C	
3.D	Agricultural soils	P	OK, other
3.E	Prescribed burning of savannas	C	
3.F	Field burning of agricultural residues	C	
3.G	Liming	C	
3.H	Urea application	C	
3.I	Other carbon-containing fertilizers	C	
3.J	Other	C	
4 LULUCF			
4	LULUCF	P	OK, wildfires and biomass burning are orange
4.1	Land Transition Matrix	C	
4 (IV)	Indirect N_2O emissions, managed soils	C	
4.A	Forest land	P	
4.B	Cropland	P	
4.C	Grassland	P	
4.D	Wetlands	P	
4.E	Settlements	P	
4.F	Other land	P	
4.G	Harvested wood products	C	
4.H	Other	C	
5 WASTE			
5	Waste	P	
5.A	Solid waste disposal	P	
5.B	Biological treatment of solid waste	C	
5.C	Incineration and open burning of waste	P	OK. hazardous W orange, but has doc box info
5.D	Wastewater treatment and discharge	C	
5.E	Other	C	
5.F	Memo Items	P	OK. all subs green, but shows orange
6 OTHER			

6	Other	C	

The following table shows categories that are not estimated (NE) including relevant explanations of the reasons. Categories that are included elsewhere (IE) are shown in similar way.

Tab. A5 7 Sources and sink not estimated ("NE")

GHG	Sector[1]	Source/sink category[1]	Explanation
CH4	Energy	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.a Oil/1.B.2.a.1 Exploration	Exploration in the Czech Republic is very random. Rough estimate to justify NE is under TofS; 0.005kt. See NIR ch 3.3.2.1.1, (Exploration 1.B.2.a.iii.1)
CH4	Energy	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.a Oil/1.B.2.a.5 Distribution of Oil Products	Emission factor is not available. Emissions are expected to be very low.Relevant EF was not found in existing IPCC methodology.
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.ii Post-Mining Activities	Relevant data for emission factors are not available. Emissions are expected to be very low. Relevant EF was not found in existing IPCC methodology.
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.iii Abandoned Underground Mines	Relevant data for emission factors are not available. Emissions are expected to be very low. Relevant EF was not found in existing IPCC methodology.
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.2 Surface Mines/1.B.1.a.2.i Mining Activities	Relevant data for emission factors are not available. Emissions are expected to be very low. Relevant EF was not found in existing IPCC methodology.
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.2 Surface Mines/1.B.1.a.2.ii Post-Mining Activities	Relevant data for emission factors are not available. Emissions are expected to be very low. Relevant EF was not found in existing IPCC methodology.

GHG	Sector[1]	Source/sink category[1]	Explanation
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation	Relevant EF was not found in existing IPCC methodology
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.a Oil/1.B.2.a.1 Exploration	Exploration in the Czech Republic is very random. Rough estimate to justify NE is under TofS; 0.005kt. See NIR ch 3.3.2.1.1, (Exploration 1.B.2.a.iii.1)
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.a Oil/1.B.2.a.4 Refining / Storage	Emission factor is not available. Emissions are expected to be very low.Relevant EF was not found in existing IPCC methodology.
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.a Oil/1.B.2.a.5 Distribution of Oil Products	Emission factor is not available. Emissions are expected to be very low.Relevant EF was not found in existing IPCC methodology.
CO2	Waste	5.A Solid Waste Disposal/5.A.1 Managed Waste Disposal Sites/5.A.1.a Anaerobic	Emissions of CO2 are of biogenic origin and are acounted for in AFOLU sector.
N2O	Energy	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.a Oil/1.B.2.a.4 Refining / Storage	Emission factor is not available. Emissions are expected to be very low.Relevant EF was not found in existing IPCC methodology.
N2O	Waste	5.D Wastewater Treatment and Discharge/5.D.2 Industrial Wastewater	Reliable data is not available. Emissions are expected to be very low. Rough estimate 8.85 kt is under TofS. See EJ-G-2024-001.
Unspecified mix of HFCs and PFCs	Industrial Processes and Product Use	2.E Electronics Industry/2.E.4 Heat Transfer Fluid 2.E Electronics Industry/2.E.4 Heat Transfer Fluid/Unspecified mix of HFCs and PFCs	Reliable data is not available. Emissions are expected to be very low.

[1]Indicate omitted source/sink category

Tab. A5 8 Sources and sinks reported elsewhere ("IE")

GHG	Source/sink category	Allocation used by the Party	Explanation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Biomass		Reported in 1A1a i Electricity generation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Gaseous Fuels		Reported in 1A1a i Electricity generation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Liquid Fuels		Reported in 1A1a i Electricity generation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Other Fossil Fuels		Reported in 1A1a i Electricity generation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Solid Fuels		Reported in 1A1a i Electricity generation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Biomass		Reported in 1A1a i Electricity generation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Liquid Fuels		Reported in 1A1a i Electricity generation

CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Other Fossil Fuels		Reported in 1A1a i Electricity generation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Solid Fuels		Reported in 1A1a i Electricity generation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Gaseous Fuels 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants		Reported in 1A1a i Electricity generation
CH4	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.b Natural Gas/1.B.2.b.6 Other		Reported in 1B2b4 and 1B2b5
CH4	5.B Biological Treatment of Solid Waste/5.B.2 Anaerobic Digestion at Biogas Facilities/5.B.2.a Municipal Solid Waste		Data reported under Energy sector, 1.A.1.a
CH4	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Fossil liquid waste		Data reported under 5.C.1.2.b Other (Hazardous Waste)
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Gaseous Fuels		Reported in 1A1a i Electricity generation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Liquid Fuels		Reported in 1A1a i Electricity generation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Other Fossil Fuels		Reported in 1A1a i Electricity generation

CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Solid Fuels		Reported in 1A1a i Electricity generation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation		Reported in 1A1a i Electricity generation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Biomass		Reported in 1A1a i Electricity generation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Liquid Fuels		Reported in 1A1a i Electricity generation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Other Fossil Fuels		Reported in 1A1a i Electricity generation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Solid Fuels		Reported in 1A1a i Electricity generation
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Gaseous Fuels 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants		Reported in 1A1a i Electricity generation
CO2	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.b Natural Gas/1.B.2.b.6 Other		Reported in 1B2b4 and 1B2b5

CO2	2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.a Steel	CO2 calculated under 2.C.1.f Metallurgical coke	All CO2 from 2.C.1 is calculated from coke consumption in the blast furnaces
CO2	2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.b Pig Iron	CO2 calculated under 2.C.1.f Metallurgical coke	All CO2 from 2.C.1 is calculated from coke consumption in the blast furnaces
CO2	2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.d Sinter	CO2 calculated under 2.C.1.f Metallurgical coke	All CO2 from 2.C.1 is calculated from coke consumption in the blast furnaces
CO2	5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)/Fossil liquid waste		Data reported under 5.C.1.2.b Other (Hazardous Waste)
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Biomass		Reported in 1A1a i Electricity generation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Gaseous Fuels		Reported in 1A1a i Electricity generation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Liquid Fuels		Reported in 1A1a i Electricity generation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Other Fossil Fuels		Reported in 1A1a i Electricity generation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.ii Combined heat and power generation/Solid Fuels		Reported in 1A1a i Electricity generation

N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Biomass		Reported in 1A1a i Electricity generation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Liquid Fuels		Reported in 1A1a i Electricity generation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Other Fossil Fuels		Reported in 1A1a i Electricity generation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Solid Fuels		Reported in 1A1a i Electricity generation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants/Gaseous Fuels 1.AA Fuel Combustion - Sectoral approach/1.A.1 Energy Industries/1.A.1.a Public Electricity and Heat Production/1.A.1.a.iii Heat plants		Reported in 1A1a i Electricity generation

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