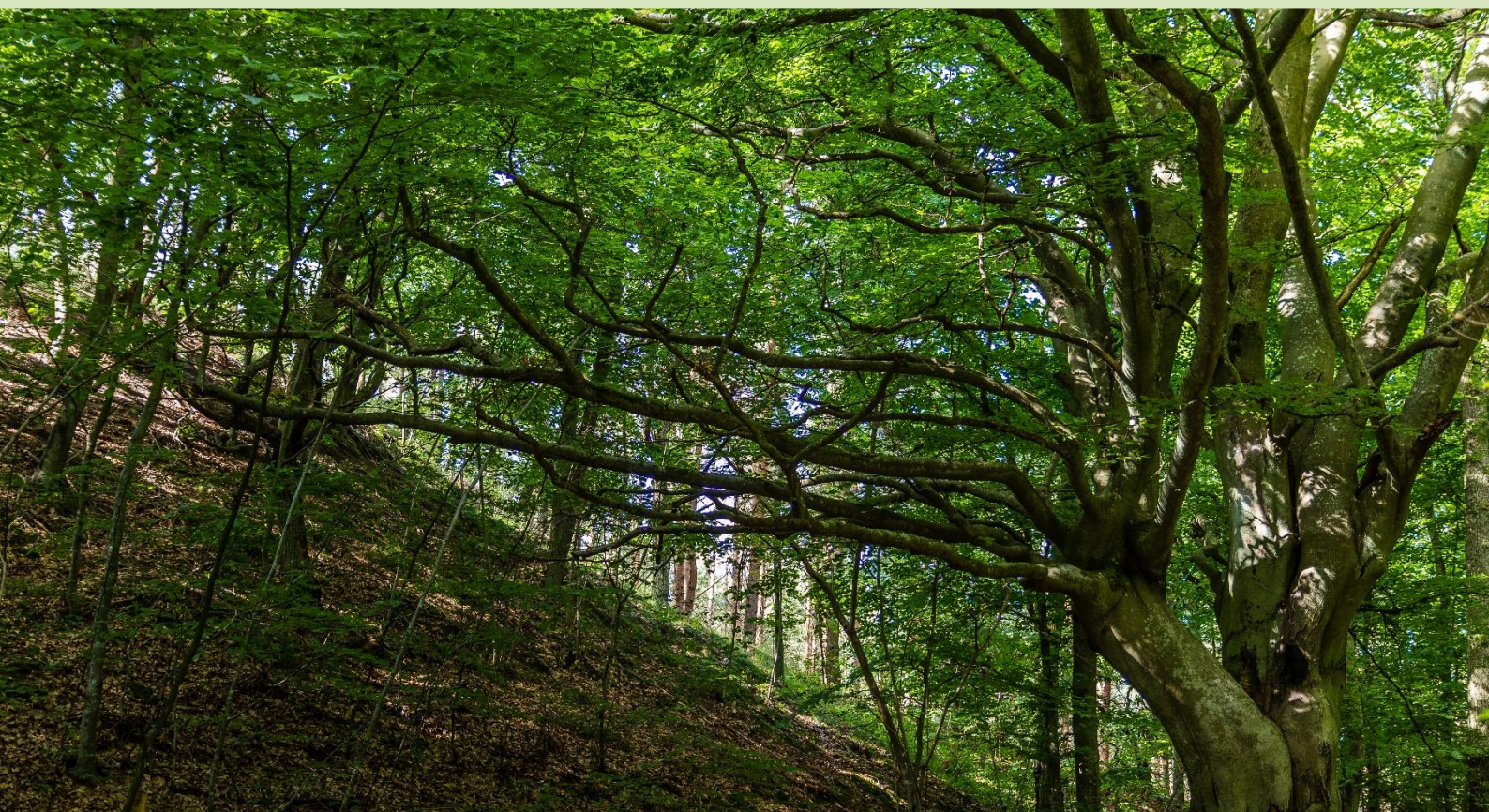


**POLAND'S
NATIONAL INVENTORY REPORT
2023**

GREENHOUSE GAS INVENTORY FOR 1988-2021

**Submission under the United Nations
Framework Convention on Climate Change**



Poland's National Inventory Report 2023

Greenhouse Gas Inventory for 1988-2021

Submission under the UN Framework Convention on Climate Change

Report elaborated by:

National Centre for Emission Management (KOBiZE)

at the Institute of Environmental Protection – National Research Institute



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Emissions Management**
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EXECUTIVE SUMMARY

ES.1. Background information on greenhouse gas inventories, climate change

Poland contributes to the activities towards climate change mitigation undertaken by the international community – as a signatory to the United Nations Framework Convention on Climate Change since 1994 and to the Kyoto Protocol – since 2002. In the first commitment period under the Kyoto Protocol, Poland committed to reduce greenhouse gas emissions in 2008–2012 by 6%, compared to the base year. In the second commitment period, established in the Doha Amendment, the European Union, its Member States and Iceland committed to reduce their average annual greenhouse gas emissions in the years 2013–2020 under the joint fulfilment of commitments. The common reduction target was expressed as a commitment to achieve average annual emissions of 80% of the total emissions of all countries in the base years¹. Poland actively contributed in reducing GHG emissions since the base year within the EU effort in the second Kyoto Protocol commitment period.

According to the provisions of Article 4.6 of the UNFCCC and decision 9/CP.2 Poland uses 1988 as the base year for the estimation and reporting of GHG inventories for the main gases (CO₂, CH₄ and N₂O). Different base years have been established for other groups of gases: 1995 for HFCs, PFCs and sulphur hexafluoride (SF₆) and 2000 for the nitrogen trifluoride (NF₃).

The underlying report, presenting the results of national greenhouse gas inventory for 2021 in line with the trend since 1988, has been prepared according to the *Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention* contained in the decision 24/CP.19. The only modification here is employment of the Global Warming Potentials from the Fifth IPCC Assessment Report on Climate Change (AR5) in line with other EU countries and Regulation 2018/1999 cited below.

The national inventory covers the emission of the following GHGs and groups of gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆), nitrogen trifluoride (NF₃) which are reported in five categories: 1. *Energy*, 2. *Industrial Processes and Product Use* (IPPU), 3. *Agriculture*, 4. *Land Use, Land Use Change and Forestry* (LULUCF) and 5. *Waste*. Also information on emissions of sulphur dioxide (SO₂) and the following GHG precursors: carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOC) is reported in CRF tables.

Methodologies used to calculate emissions and sinks of GHGs are those published by the Intergovernmental Panel on Climate Change (IPCC) in 2006, namely *2006 Guidelines for National Greenhouse Gas Inventories* what is in accordance with the provisions of the decision 24/CP.19. Pursuant to these guidelines, country specific methods have been used where appropriate giving more accurate emission data.

At the same time the underlying report has been elaborated for the purpose of Poland's obligations resulting from Regulation (EU) 2018/1999 of the European Parliament and of 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 as well as Commission Implementing Regulation (EU) 2020/1208 of 7 August 2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) No 749/2014.

¹ Poland's Fourth Biennial Report under UNFCCC. 2019: <https://unfccc.int/BRs>

The unit responsible for compiling the GHG inventory for the purpose of the European Union and the UNFCCC regulations, according to the provisions of the Act of 17 July 2009 on the system to manage the emissions of greenhouse gases and other substances (*Journal of laws 2019, item 1447 with further changes*), is the National Centre for Emissions Management (KOBIZE) in the Institute of Environmental Protection – National Research Institute, supervised by the Minister of Climate and Environment.

ES.2. Summary of national emission and removal related trends

The GHG emissions for the base year (see chapter ES.1) and for 2021, expressed as CO₂ equivalent, are presented in table S.1. In 2021 the total national emission of GHG amounted to 399.94 million tonnes of CO₂ eq, excluding GHG emissions and removals from category 4 (*Land use, land use change and forestry – LULUCF*). Compared to the base year, the 2021 emissions have decreased by 30.8%.

Table S.1. National emissions of greenhouse gases for years 1988 and 2021

GHG	Emission in CO ₂ eq. [kt]		(2021-1988)/1988 [%]
	1988	2021	
CO ₂ (with LULUCF)	452 685.79	309 731.76	-31.58
CO ₂ (without LULUCF)	472 037.75	331 576.28	-29.76
CH ₄ (with LULUCF)	76 371.79	42 712.42	-44.07
CH ₄ (without LULUCF)	76 316.70	42 704.71	-44.04
N ₂ O (with LULUCF)	31 508.33	22 358.76	-29.04
N ₂ O (without LULUCF)	29 801.12	20 616.67	-30.82
HFCs	NO,NA	4 937.26	100.00
PFCs	132.31	10.08	-92.38
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF ₆	NA,NO	92.60	100.00
NF ₃	NA,NO	NA,NO	NA,NO
TOTAL net emission (with LULUCF)	560 698.22	379 842.88	-32.26
TOTAL without LULUCF	578 287.88	399 937.61	-30.84

NA - Not applicable, NO - Not occurring

Carbon dioxide is the main GHG in Poland with the share of 82.9% in national emissions in 2021. Methane and nitrous oxide contribute respectively with: 10.7% and 5.2% share. All F-gases are responsible for 1.3% of total GHG emissions. Percentage share of GHG in national total emissions (excluding category 4. *LULUCF*) in 2021 is presented at figure S.1.

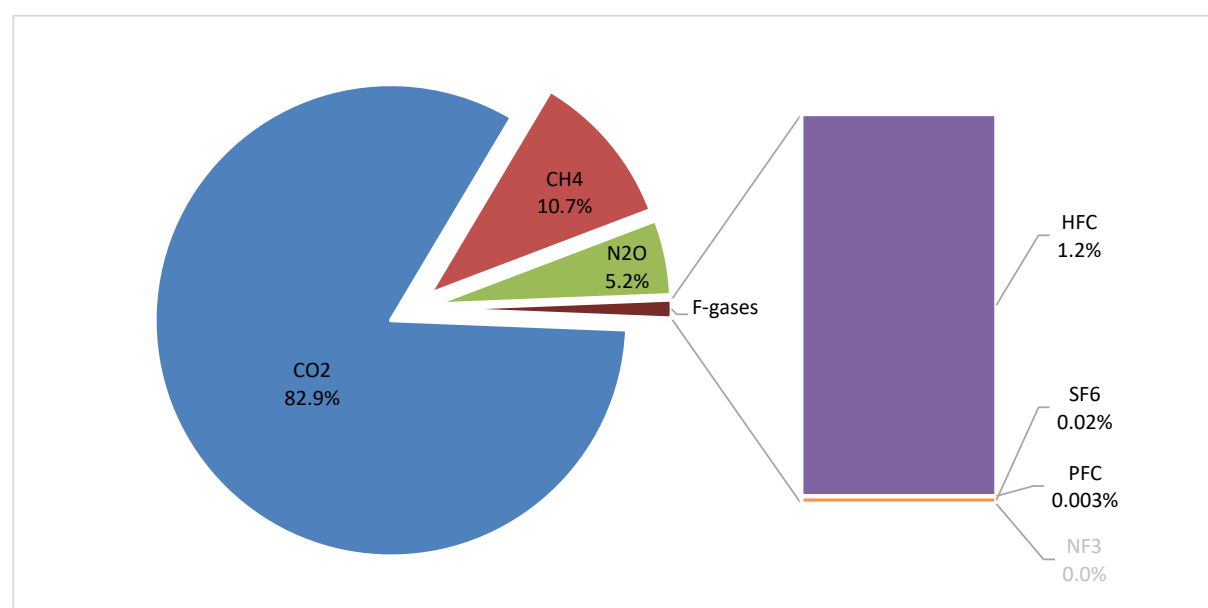


Figure S.1. Percentage share of greenhouse gases in national total emission in 2021 (excluding category 4. *LULUCF*)

The GHGs trend for period between 1988 and 1990 indicates significant decrease triggered by substantial economic changes, especially in heavy industry. This was the time when political transformation from centrally planned to free market economy began. This drop in emissions continued up to 1992 and then emissions started to rise with a peak in 1996 as a result of development in heavy industry and other sectors and dynamic economic growth. Slow decline in emissions (up to 2002) characterized the succeeding years, when still energy efficiency policies and measures were implemented, and then slight increase up to 2007 caused by animated economic development. In 2008-2011 stabilisation in emissions has been noted with distinct decrease in 2009 related to world economic slow-down. In 2012–2014 GHG emissions in Poland slowly decreased then starting to rise in the next years (tab. S.2 and fig. S.2). The main cause of significant increase of GHGs emissions in 2016–2017, besides economic animation, was substantial rise of fuels use in road transport driven by effective combat against grey zone at fuel market started in 2016, but also favourable fuel prices and increase in vehicles amount.

After 2018, the GHG emissions decreased by 6% in 2019 and by a further 4% in 2020 compared to the previous year. The main reason for the decrease in emissions between 2019 and 2020 was the lower consumption of fuels combustion in stationary sources (hard coal by over 6% and lignite by over 8%) and in transport (gasoline by nearly 7% and diesel by nearly 3%). In addition to the energy sector, emissions from the industrial processes sector have also decreased. This is mainly the result of a decrease in metallurgy production (reduction in the production of converter steel by 20%, pig iron by over 18% and sinter by about 24%). In 2020, the production of lime was also lower by more than 5% compared to 2019. A decrease in emissions was also recorded in the waste sector, where the amount of municipal waste landfilled decreased (by nearly 5%) and municipal waste thermally utilised of without energy recovery (by almost 22%). In 2021, national emissions increased again (by nearly 8%) compared to the previous year and exceeded 400 million tons of equivalent CO₂. The most significant increase in GHG emissions was recorded in the fuel combustion sector - by 10%. The reason was higher fuel consumption: hard coal by 10.6%, lignite by 19.0% and natural gas by 10.3% in stationary sources, as well as higher use of gasoline by 10.6%, diesel oil by 8.3% and CNG by 42.5% in transport sector.

Table S.3. National emissions of greenhouse gases for 1988–2021 by gases [kt CO₂ eq.]

GHG	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO ₂ (with LULUCF)	452 685.79	428 675.31	346 757.44	350 940.19	362 709.08	356 088.63	351 667.73	343 871.21	341 119.23	331 303.81	297 502.51	290 476.05	282 169.11	286 092.77	270 064.79	280 755.11	274 685.01
CO ₂ (without LULUCF)	472 037.75	452 483.52	376 925.18	373 944.99	364 860.03	365 560.26	360 641.68	363 012.43	377 701.08	367 653.77	339 495.50	329 686.12	317 934.08	313 980.06	306 630.42	319 449.29	324 371.97
CH ₄ (with LULUCF)	76 371.79	76 151.27	70 004.36	65 696.56	64 558.95	62 963.82	61 815.80	60 310.75	59 410.23	58 844.36	56 451.94	54 790.61	52 490.14	54 316.51	52 243.55	52 450.95	51 705.00
CH ₄ (without LULUCF)	76 316.70	76 096.15	69 949.23	65 671.81	64 263.90	62 905.38	61 754.13	60 268.00	59 321.14	58 799.63	56 425.10	54 736.83	52 447.01	54 294.32	52 209.32	52 320.68	51 679.04
N ₂ O (with LULUCF)	31 508.33	32 698.64	29 455.32	25 310.33	23 611.53	24 220.21	24 141.91	24 879.75	24 713.55	24 737.31	24 520.91	23 986.90	24 039.02	24 077.66	22 750.34	22 539.44	22 938.70
N ₂ O (without LULUCF)	29 801.12	31 013.07	27 836.37	23 758.49	21 961.19	22 726.93	22 704.04	23 498.22	23 348.61	23 450.11	23 287.73	22 770.07	22 886.28	23 018.41	21 707.35	21 445.63	21 965.55
HFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	166.58	259.00	346.42	417.65	581.29	1 022.57	1 504.78	2 048.48	2 617.09	3 150.17
PFCs	132.31	132.54	127.47	126.97	120.97	130.16	137.27	154.52	144.84	156.87	158.19	153.19	160.87	181.35	189.91	184.09	187.51
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
SF ₆	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	13.67	30.02	24.53	23.61	24.67	24.22	23.77	23.56	24.00	21.35	23.04
NF ₃	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
TOTAL (with LULUCF)	560 698.22	537 657.76	446 344.59	442 074.05	451 000.53	443 402.81	437 776.39	429 412.83	425 671.38	415 412.39	379 075.86	370 012.27	359 905.48	366 196.62	347 321.06	358 568.03	352 689.43
TOTAL (without LULUCF)	578 287.88	559 725.27	474 838.25	463 502.25	451 206.08	451 322.72	445 250.79	447 129.76	460 799.21	450 430.42	419 808.84	407 951.71	394 474.58	393 002.47	382 809.47	396 038.14	401 377.28

Table S.3. (cont.) National emissions of greenhouse gases for 1988–2021 by gases [kt CO₂ eq.]

GHG	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CO ₂ (with LULUCF)	274 342.63	294 196.86	300 452.92	294 572.62	281 037.67	300 922.11	294 865.54	286 745.41	280 517.31	275 619.80	282 374.71	285 951.59	298 156.66	298 048.75	298 101.11	282 235.85	309 731.76
CO ₂ (without LULUCF)	323 329.98	337 234.61	336 581.80	330 297.76	316 681.21	334 792.45	334 188.18	326 494.90	322 390.69	310 083.03	313 261.61	324 091.51	337 305.74	336 571.40	318 166.81	303 019.61	331 576.28
CH ₄ (with LULUCF)	51 814.22	51 641.74	50 371.84	49 877.46	48 112.07	47 773.64	46 188.38	45 653.62	45 844.90	45 189.30	45 979.00	45 481.96	45 879.66	46 465.02	43 562.38	43 247.06	42 712.42
CH ₄ (without LULUCF)	51 776.88	51 599.72	50 350.27	49 855.31	48 085.46	47 759.43	46 170.03	45 607.73	45 834.03	45 169.28	45 941.23	45 468.05	45 871.75	46 444.82	43 534.50	43 188.11	42 704.71
N ₂ O (with LULUCF)	23 137.70	23 406.92	24 164.53	23 757.83	20 876.82	20 494.44	20 755.08	20 839.90	20 991.82	20 705.04	20 767.71	21 247.04	22 248.24	22 530.09	21 503.37	22 236.81	22 358.76
N ₂ O (without LULUCF)	22 206.21	22 517.65	23 293.38	22 887.71	20 009.43	19 600.62	19 867.94	19 935.73	20 090.45	19 742.96	19 062.05	19 516.79	20 495.88	20 775.91	19 760.05	20 469.86	20 616.67
HFCs	3 761.45	4 440.19	4 888.19	5 364.00	5 653.31	5 598.16	6 104.97	6 344.77	5 965.81	6 501.19	5 583.52	5 689.62	5 772.79	5 579.88	5 304.57	5 114.48	4 937.26
PFCs	171.47	176.86	168.68	149.21	18.66	17.72	16.84	16.00	15.20	14.44	13.71	13.03	12.38	11.76	11.17	10.61	10.08
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF ₆	27.62	34.22	32.12	33.88	38.76	36.45	40.22	43.21	49.00	54.41	79.39	80.78	84.97	110.67	93.54	92.29	92.60
NF ₃	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
TOTAL (with LULUCF)	353 255.10	373 896.79	380 078.27	373 755.00	355 737.29	374 842.53	367 971.02	359 642.90	353 384.03	348 084.17	354 798.06	358 464.02	372 154.70	372 746.17	368 576.14	352 937.10	379 842.88
TOTAL (without LULUCF)	401 273.62	416 003.24	415 314.43	408 587.86	390 486.81	407 804.83	406 388.18	398 442.34	394 345.19	381 565.30	383 941.52	394 859.78	409 543.49	409 494.44	386 870.64	371 894.95	399 937.61

ES.3. Overview of source and sink category emission estimates and trends

Total GHG emissions presented in CO₂ equivalent for the base year and for 2021 together with change between 2021 and 1988 by main categories are given in tables S.4, S.5 and figure S.2. In all categories emission reduction has been observed while in LULUCF sector increase in carbon sink has been noted. The highest drop in emissions has occurred in 5. *Waste* sector (by 74.4%) in result of significant development of waste treatment technologies and policies, including wastewater treatment evolution, as well as recycling advancement associated with decline of treatment by disposal on land. The second sector with highest GHG emission reduction is 3. *Agriculture* (by 32.0%) what was caused by significant structural and economic changes after 1989 in this sector, including diminishing animal and crop production (i.e. cattle population drop from 10 million to 6 million or sheep population – from 4 million to 0.3 million in 1988-2021). Next category with high emission reduction in 1988-2021 is 1. *Energy* (by about 29.9%) what was caused by transformation of heavy industry in Poland as well as by decreasing coal use and mining and energy efficiency measures implemented.

Table S.4. GHG emissions according to main sectors in base year and in 2021

	Total [kt eq. CO ₂]		(2021-1988)/1988 [%]
	1988	2021	
TOTAL with LULUCF	560 698.22	379 842.88	-32.26
TOTAL without LULUCF	578 287.88	399 937.61	-30.84
1. Energy	479 481.46	336 170.52	-29.89
2. Industrial Processes and Product Use	29 865.86	24 557.99	-17.77
3. Agriculture	50 057.03	34 035.26	-32.01
4. Land-Use, Land-Use Change and Forestry	-17 589.66	-20 094.72	14.24
5. Waste	18 260.61	4 674.72	-74.40
INDIRECT CO ₂ EMISSIONS	622.92	499.12	-19.87

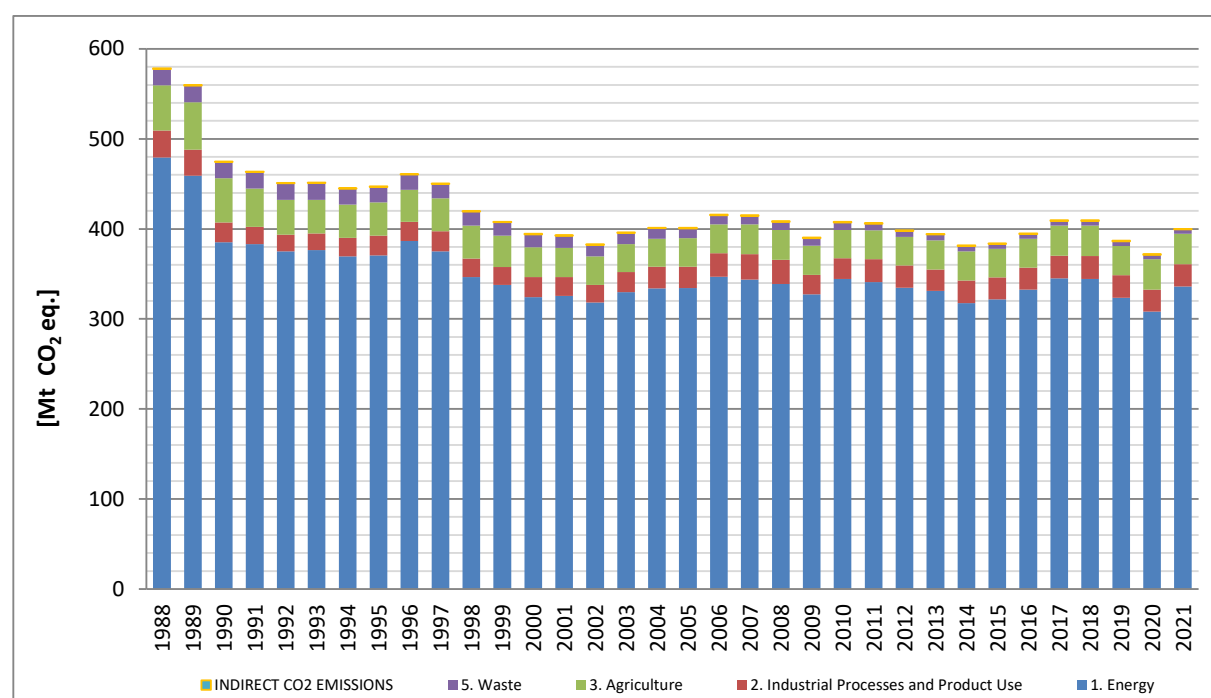


Figure S.2. Trend of aggregated GHGs emissions (excluding category 4) for 1988–2021 according to source categories

Table S.5. National emissions of greenhouse gases for 1988–2021 by source categories [kt CO₂ eq.]

IPCC sector	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1. Energy	479 481.46	458 968.42	385 148.74	383 017.81	375 133.35	376 603.71	369 480.85	370 528.99	386 532.38	375 143.55	346 579.14	337 945.90	324 336.88	325 632.23	318 365.13	329 719.38	333 975.19
2. Industrial Processes and Product Use	29 865.86	28 937.48	21 971.96	19 265.17	18 546.07	18 531.93	20 750.83	22 146.46	21 305.53	22 207.52	20 613.30	19 633.11	22 224.44	20 799.45	19 460.17	22 281.43	23 939.20
3. Agriculture	50 057.03	52 757.76	49 291.34	42 514.51	38 641.17	37 212.72	36 922.29	36 724.76	35 755.94	36 562.43	36 457.19	34 988.94	33 205.86	32 615.28	31 664.66	31 190.86	31 251.47
4. Land-Use, Land-Use Change and Forestry	-17 589.66	-22 067.52	-28 493.66	-21 428.21	-205.56	-7 919.91	-7 474.40	-17 716.93	-35 127.83	-35 018.03	-40 732.98	-37 939.44	-34 569.11	-26 805.85	-35 488.41	-37 470.10	-48 687.85
5. Waste	18 260.61	18 481.28	18 142.28	18 382.55	18 536.05	18 588.99	17 673.56	17 331.66	16 789.69	16 098.84	15 740.14	14 963.85	14 225.54	13 476.00	12 811.86	12 346.91	11 633.57
INDIRECT CO ₂ EMISSIONS	622.92	580.34	283.93	322.21	349.45	385.38	423.26	397.88	415.67	418.09	419.07	419.92	481.86	479.50	507.66	499.56	577.85
TOTAL (with LULUCF)	560 698.22	537 657.76	446 344.59	442 074.05	451 000.53	443 402.81	437 776.39	429 412.83	425 671.38	415 412.39	379 075.86	370 012.27	359 905.48	366 196.62	347 321.06	358 568.03	352 689.43
TOTAL (without LULUCF)	578 287.88	559 725.27	474 838.25	463 502.25	451 206.08	451 322.72	445 250.79	447 129.76	460 799.21	450 430.42	419 808.84	407 951.71	394 474.58	393 002.47	382 809.47	396 038.14	401 377.28

Table S.5. (cont.) National emissions of greenhouse gases for 1988–2021 by source categories [kt CO₂ eq.]

IPCC sector	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1. Energy	334 317.08	346 972.09	343 730.09	338 729.65	327 237.60	344 423.02	340 815.26	334 726.44	331 295.54	317 593.86	321 729.78	332 453.13	345 196.89	344 374.23	323 527.89	307 991.99	336 170.52
2. Industrial Processes and Product Use	23 732.01	26 006.52	28 400.56	27 118.76	21 733.19	22 878.65	25 634.54	24 631.25	23 623.32	25 102.81	24 351.84	24 551.53	25 068.73	25 563.41	25 081.19	24 516.29	24 557.99
3. Agriculture	31 659.42	32 148.73	32 843.79	32 939.52	32 256.88	31 659.66	31 989.59	31 826.63	32 464.68	32 364.07	31 705.48	32 067.10	33 359.59	33 688.37	32 595.16	34 051.67	34 035.26
4. Land-Use, Land-Use Change and Forestry	-48 018.52	-42 106.45	-35 236.16	-34 832.86	-34 749.52	-32 962.30	-38 417.15	-38 799.44	-40 961.15	-33 481.13	-29 143.46	-36 395.76	-37 388.80	-36 748.27	-18 294.50	-18 957.85	-20 094.72
5. Waste	11 000.17	10 213.96	9 678.38	9 069.25	8 599.15	8 275.63	7 359.36	6 716.42	6 498.00	6 003.98	5 608.23	5 243.51	5 377.97	5 377.94	5 182.12	4 752.48	4 674.72
INDIRECT CO ₂ EMISSIONS	564.93	661.95	661.60	730.68	660.00	567.87	589.42	541.61	463.65	500.58	546.19	544.52	540.32	490.49	484.28	582.52	499.12
TOTAL (with LULUCF)	353 255.10	373 896.79	380 078.27	373 755.00	355 737.29	374 842.53	367 971.02	359 642.90	353 384.03	348 084.17	354 798.06	358 464.02	372 154.70	372 746.17	368 576.14	352 937.10	379 842.88
TOTAL (without LULUCF)	401 273.62	416 003.24	415 314.43	408 587.86	390 486.81	407 804.83	406 388.18	398 442.34	394 345.19	381 565.30	383 941.52	394 859.78	409 543.49	409 494.44	386 870.64	371 894.95	399 937.61

Carbon dioxide emissions

The CO₂ emissions (excluding category 4) in 2021 were estimated as 331.58 million tonnes. This is 29.8% lower than in the base year. CO₂ emission (excluding category 4) accounted for 82.9% of total GHG emissions in Poland in 2021. The main CO₂ emission source is *Fuel Combustion* (1.A) subcategory. This sector contributed to the total CO₂ emission with 92.4% share in 2021. The shares of the main subcategories were as follows: *Energy industries* – 48.1%, *Manufacturing Industries and Construction* – 9.0%, *Transport* – 20.4% and *Other Sectors* – 14.9%. *Industrial Processes* contributed to the total CO₂ emission with 5.7% share in 2021. *Mineral industry* (especially *Cement Production*) is the main emission source in this sector (fig. S.3). The net CO₂ emissions/removals in LULUCF sector in 2021, was calculated to be approximately – 21.8 million tonnes what means that removals prevail emissions significantly in this sector.

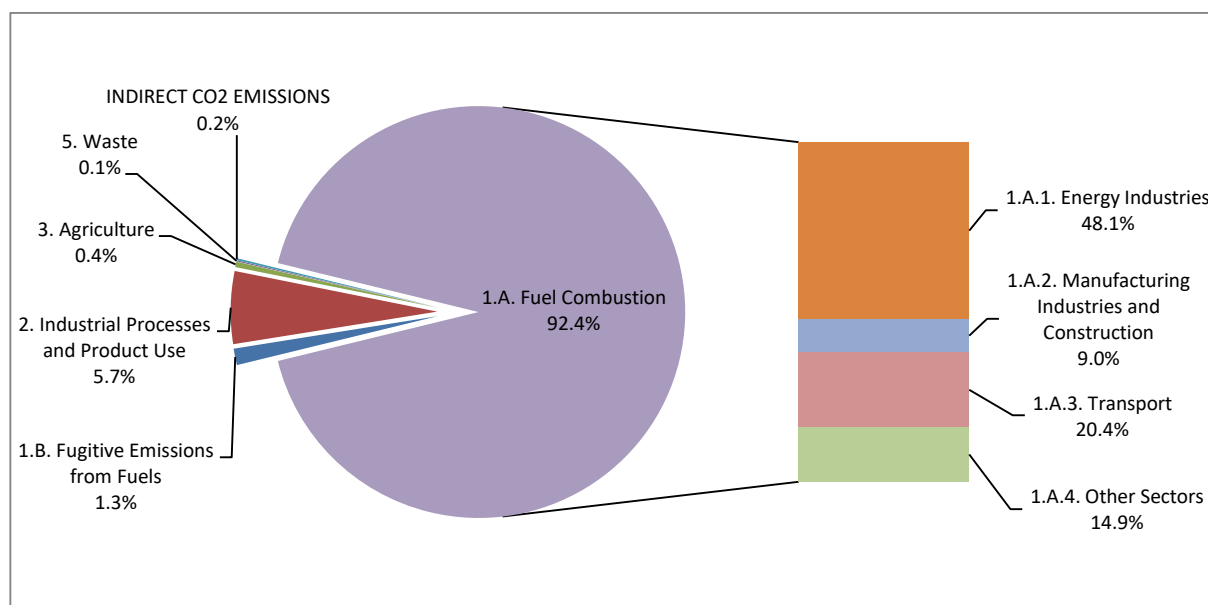


Figure S.3. Carbon dioxide emission (excluding category 4) in 2021 by sector

Methane emissions

The CH₄ emission (excluding category 4) amounted to 1 525.17 kt in 2021 i.e. 42.70 million tonnes of CO₂ equivalents. Compared to the base year, the emission in 2021 was lower by 44.0%. The contribution of CH₄ to the national total GHG emission amounted to 10.7% in 2021. Three of the main CH₄ emission sources include the following categories: *Fugitive Emissions from Fuels*, *Agriculture* and *Fuel Combustion*. They contributed with 44.0%, 37.5% and 10.0% share to the national methane emission in 2021, respectively. The emission from the first mentioned sector came from coal and lignite mines (37.1% of total CH₄ emission) and Oil and Natural Gas system (6.9% of total CH₄ emission). The emission from *Enteric Fermentation* (3.A) dominated in *Agriculture* and amounted to app. 34.2% of total CH₄ emission in 2021. Waste disposal sites were responsible for 3.1% of the total methane emission and *Wastewater Handling* for 4.8% of total CH₄ emission (fig. S.4).

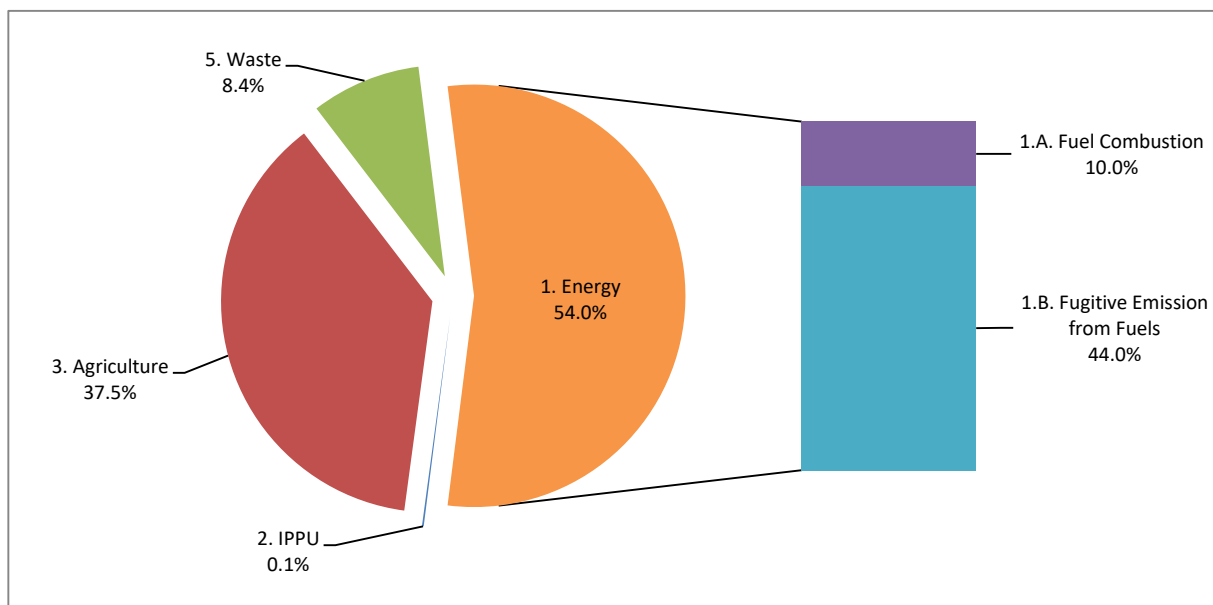


Figure S.4. Methane emission (excluding category 4) in 2021 by sector

Nitrous oxide emissions

The nitrous oxide emissions (excluding category 4) in 2021 amounted to 77.80 kt i.e. 20.62 million tonnes of CO₂ equivalent. The emission was app. 30.8% lower than the respective figure for the base year. N₂O emission constituted 5.2% of the national total GHG emission in 2021. The main N₂O emission sources and their shares in total N₂O emission in 2021 were as follows: *Agricultural Soils* – 68.0%, *Manure Management* – 12.5%, *Fuel Combustion* – 12.6%, *Domestic wastewater treatment* – 3.3% and *Chemical Industry* – 2.2% (fig. S.5).

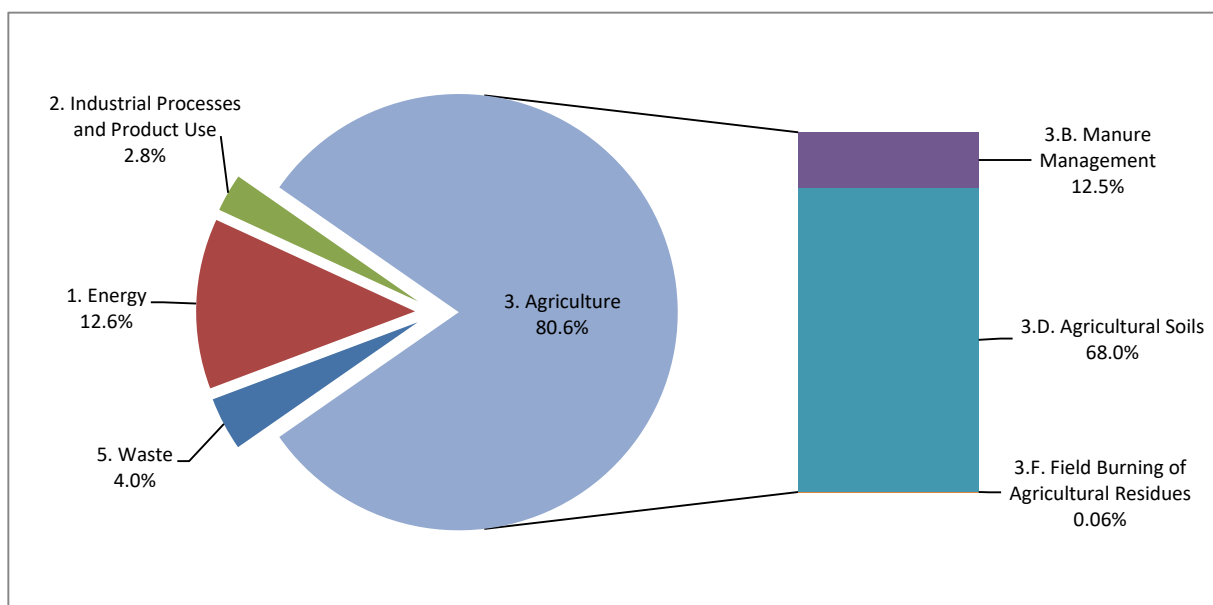


Figure S.5. Nitrous oxide emission (excluding category 4) in 2021 by sector

Emissions of fluorinated gases

The total emission of industrial gases (HFCs, PFCs and SF₆) in 2021 was estimated at 5 039.94 kt CO₂ eq., and accounted for 1.3% of total GHG emissions in 2021. Industrial gases emissions were by 3709.1% higher comparing to the base year (table S.1). This significant growth in HFCs emission is mainly due to the increase in emission from refrigeration and air conditioning equipment. Shares of HFCs, PFCs and SF₆ emissions in total 2021 emission were respectively as follows: 1.23%, 0.003% and 0.02%. NF₃ emissions did not occur.

1. INTRODUCTION

1.1. Background information on greenhouse gas inventories, climate change

Poland contributes to the activities towards climate change mitigation undertaken by the international community – as a signatory to the United Nations Framework Convention on Climate Change since 1994 and to the Kyoto Protocol – since 2002. In the first commitment period under the Kyoto Protocol, Poland committed to reduce greenhouse gas emissions in 2008–2012 by 6%, compared to the base year. In the second commitment period, established in the Doha Amendment, the European Union, its Member States and Iceland committed to reduce their average annual greenhouse gas emissions in the years 2013–2020 under the joint fulfilment of commitments. The common reduction target was expressed as a commitment to achieve average annual emissions of 80% of the total emissions of all countries in the base years². Poland actively contributed in reducing GHG emissions since the base year within the EU effort in the second Kyoto Protocol commitment period.

According to the provisions of Article 4.6 of the UNFCCC and decision 9/CP.2 Poland uses 1988 as the base year for the estimation and reporting of GHG inventories for the main gases (CO₂, CH₄ and N₂O). Different base years have been established for other groups of gases: 1995 for HFCs, PFCs and sulphur hexafluoride (SF₆) and 2000 for the nitrogen trifluoride (NF₃).

The underlying report presenting the results of national greenhouse gas inventory for 2021, in line with the trend since 1988, is prepared according to the *Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention* contained in the decision 24/CP.19.

The national inventory covers the following GHGs and groups of gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆), nitrogen trifluoride (NF₃) and are reported in five categories: 1. *Energy*, 2. *Industrial Processes and Product Use* (IPPU), 3. *Agriculture*, 4. *Land Use, Land Use Change and Forestry* (LULUCF) and 5. *Waste*. Also information on emissions of sulphur dioxide (SO₂) and the following GHG precursors: carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOC) is reported in the CRF tables.

Methodologies used to calculate emissions and sinks of GHGs are those published by the Intergovernmental Panel on Climate Change (IPCC) in 2006, namely *2006 Guidelines for National Greenhouse Gas Inventories* what is in accordance with the provisions of the decision 24/CP.19. According to these guidelines country specific methods have been used where appropriate giving more accurate emission data.

At the same time the underlying report has been elaborated for the for the purpose of Poland's obligations resulting from Regulation (EU) 2018/1999 of the European Parliament and of 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 as well as Commission Implementing Regulation (EU) 2020/1208 of 7 August 2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) No 749/2014.

² Poland's Eight National Communication and Fifth Biennial Report under UNFCCC. 2022 <https://cop23.unfccc.int/BR5>

The unit responsible for compiling the GHG inventory for the purpose of the European Union and the UNFCCC regulations, according to the provisions of the Act of 17 July 2009 on the system to manage the emissions of greenhouse gases and other substances (*Journal of laws 2019, item 1447 as amended*), is the National Centre for Emissions Management (KOBIZE) in the Institute of Environmental Protection - National Research Institute, supervised by the Minister of Climate and Environment.

1.2. Description of the institutional arrangements for inventory preparation, including the legal and procedural arrangements for inventory planning, preparation and management

The **Act of 17 July 2009 on the system to manage the emissions of greenhouse gases and other substances** (*Journal of Laws 2022, item 1092 as amended*) established a legal base to manage the national emissions cap for greenhouse gases or other substances in a way that should ensure that Poland complies with the EU and international commitments and will allow for cost-effective reductions of the emission. Pursuant to the above mentioned law, the National Centre for Emissions Management (Krajowy Ośrodek Bilansowania i Zarządzania Emisjami – KOBIZE) established in the Institute of Environmental Protection – National Research Institute in Warsaw:

- carries out tasks associated with functioning of the national system to balance and forecast emissions, including managing a National Emission Database,
- elaborates methodologies to estimate emissions for individual types of installations or activities and methodologies to estimate emission factors per unit of produced good, fuel used or raw material applied,
- elaborates emission reports and projections for GHG and air pollutants,
- manages the national registry for Kyoto Protocol units,
- acts as the national EU Emission Trading Scheme administrator.

The Minister of Climate and Environment supervises the activity and performance of the National Centre for Emissions Management.

According to Article 11 of above mentioned Act, the National Centre prepares and submits to the Minister of Climate and Environment, 30 days before the deadlines established in the European Union law or international environmental agreements, annual greenhouse gas inventories carried out in accordance with the UNFCCC guidelines and annual inventories of the substances listed in the Convention on Long-range Transboundary Air Pollution (UNECE CLRTAP). Prior to the submission, the elaborated inventories undergo internal process of the official scrutiny and approval carried out by the Ministry of Climate and Environment.

The emission calculation, choices of activity data, emission factors and methodology are performed by the Emission Inventory and Reporting Unit in the National Centre for Emissions Management. To ensure consistency of the reported data the inventories established on a yearly basis for the purpose of both conventions: CLRTAP and UNFCCC and the EU obligations apply the same activity data sets covering first of all energy balances, but also industrial and agricultural production, land use and waste management.

The National Centre collaborates with a number of individual experts as well as institutions when compiling inventories. Among the latter are: Statistics Poland (GUS), Agency of Energy Market (ARE), Institute of Ecology of Industrial Areas in Katowice (IETU), Polish Geological Institute - National Research Institute (PIG PIB), State Mining Authority (WUG) as well as Office for Forest Planning and Management (BULGiL). These institutions are mainly involved in providing activity data for inventory estimates.

The experts of the National Centre have access to different emission and activity data sources, among which the most important are:

- individual data of entities participating in the European Union Emission Trading System (EU-ETS). These independently verified data are included in the GHG inventory for some IPCC subcategories (e.g. in some subsectors in industrial processes);
- data submitted by entities to the E-PRTR database pursuant to Regulation (EC) no 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC;
- aggregated data collected by operators under Article 3(6) of Regulation (EC) No 842/2006;
- emission data submitted by individual entities to the National Emission Database – the biggest database with individual emission reports available in Poland.

Since early 2000s, data from individual entities in the EU member States are gathered and publicized in the European Pollutant Release and Transfer Register (E-PRTR, earlier called EPER – European Pollutant Emission Register). The usefulness of E-PRTR data for the inventory preparation needs is limited, as in most cases the register contains only fragmentary information based on part of the installations belonging to a given sector or emitting certain greenhouse gas. Nevertheless, they can be helpful to a certain extent in a process of data cross-checking, what is possible especially if the E-PRTR data cover a whole sector or gas. Polish national inventory system includes this database as a potential source of valuable data and the inventory team has been granted full access to the Polish PRTR reporting system.

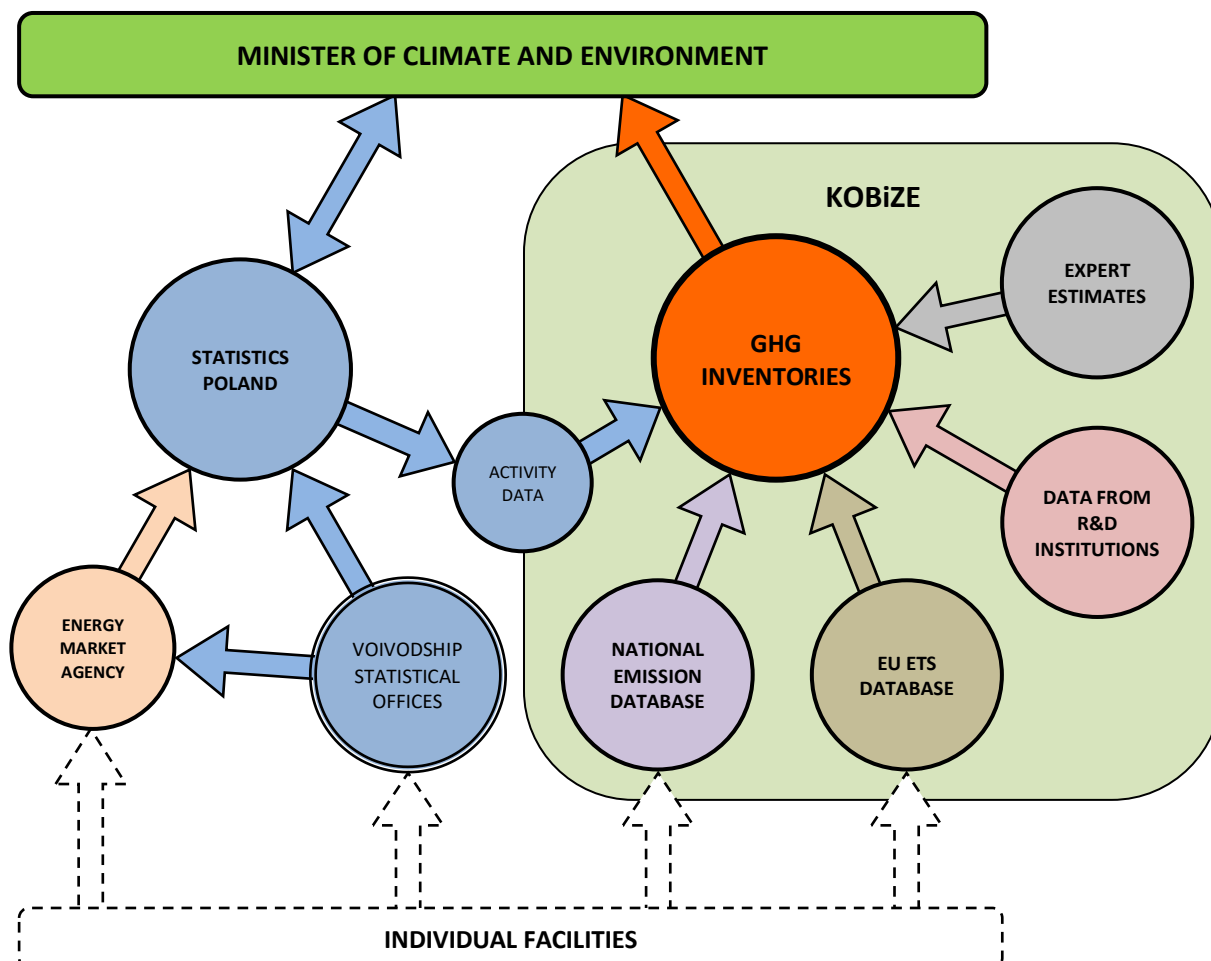


Figure 1.1. National GHG emissions inventory system scheme

Also the National Emission Database, that contains ca. 40 thousand reports yearly on about 80 different GHGs and pollutants, is helpful in the inventory preparation process, it cannot however replace the inventory assessments as such, as it doesn't cover all the emission sources (i.a. it doesn't contain individual transport and households) and the methodology for emission calculation is not homogenous.

The three existing independent emission databases mentioned above enable crosschecking of emission data and improving their quality. This is even more possible as two of them (the EU ETS database and the National Emission Database) are run by the same institution that also prepares the inventories (KOBIZE in the Institute of Environmental Protection) and – as was said – the third one (E-PRTR) is open to the public.

The National Centre for Emissions Management, as the entity directly responsible for GHG inventory preparation, is also in charge of co-ordination and implementation of QA/QC procedures within inventory. The QA/QC programme has been elaborated in line with the *2006 IPCC Guidelines* to assure high quality of the Polish annual greenhouse gas inventory. The QA/QC programme contains tasks, responsibilities as well as time schedule for performance of the QA/QC procedures. The following elements of the Quality Assurance and Quality Control system have been addressed:

- Inventory agency responsible for coordinating QA/QC activities,
- QA/QC plan,
- General QC procedures (*Tier 1* method),
- Source category-specific QC procedures (*Tier 2*),
- QA review procedures,
- Reporting, documentation and archiving procedures.

For more detailed information on QA/QC procedures see Annex 7.

1.3. Inventory preparation and data collection, processing and storage

The GHG emission estimates are based on methodologies elaborated by the Intergovernmental Panel on Climate Change (IPCC) and recommended by the UNFCCC, while emissions of precursor gases (CO, NO_x, NMVOCs) as well as SO_x, according to methodology elaborated by EMEP/EEA. Wherever necessary and possible, domestic methodologies and emission factors have been developed to reflect country specific conditions. The most important features of the inventory preparation and archiving can be briefly summarized in the following way:

- activity data are mostly taken from official public statistics (GUS, EUROSTAT) or, when required data are not directly available, (commissioned) research reports or expert estimates are used instead; in very detailed categories, estimates made by individual industries or market players can be also useful if available,
- emission factors for the main emission categories are mostly taken from reports on domestic research; IPCC default data are used in cases where the emission factors are highly uncertain (e.g. CH₄ and N₂O emission from stationary combustion), or when particular source category contribution to national total is insignificant,
- all activity data, emission factors and resulting emission data are stored in a database in KOBIZE, which is constantly updated and extended to meet the ever changing requirements for emission reporting, with respect to UNFCCC and CLTRAP as well as their protocols.

1.4. Brief general description of methodologies and data sources used

The GHG emissions and removals inventory presented in this report follow the recommended by decision 24/CP.19 the *2006 IPCC Guidelines for national inventories* [IPCC 2006]. According to these guidelines country specific methods have been used where appropriate giving more accurate emission data especially in case of key categories. For categories where emissions do not occur or are not estimated the abbreviations NO and NE were used in tables. More detail description of methodologies used in Polish GHG inventory is given in sections 3–7.

The non-CO₂ GHG emissions from fuel combustion (1.A. category) were estimated based on fuel consumption estimates and respective emission factors. Data on fuel consumption for stationary

sources with disaggregation into fuel type and source category come from official fuel balances elaborated by Statistics Poland and reported to Eurostat pursuant to Article 4 of Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics.

Table 1.1. Hard coal consumption in 2021

National fuel balance	Hard coal (Eurostat)	
	kt	TJ
In	67 667	1 642 285
From national sources	55 285	1 334 357
1) Indigenous production	55 006	1 327 339
2) Transformation output or return	278	7 018
3) Stock decrease	0	0
Import	12 382	307 928
Out	67 667	1 642 285
National consumption	69 975	1 678 043
1) Transformation input	55 499	1 321 174
a) input for secondary fuel production	12 500	369 770
b) fuel combustion	42 999	951 403
2) Direct consumption	14 476	356 870
Non-energy use	101	2 569
Combusted directly	14 375	354 301
Combusted in Poland	57 374	1 305 704
Stock increase	-8 744	-222 937
Export	6 429	167 838
Losses and statistical differences	7	19 341
Net calorific value	MJ/kg	22.76

One of the steps of emission inventorying from the 1.A. *Energy* category is preparation of energy budgets for main fuels (energy carriers). These budgets are prepared based on the national energy balances published by Statistics Poland and Agency of Energy Market. The tables of the national energy balance include detailed information on the ins and outs of all the energy carriers used in Poland, as well as information on their conversions to other energy carriers and on their direct consumption. The data for international bunker are also assessed.

The example data on quantity of coal combusted in whole country in a given year (tab. 1.1) is used for calculation of the average net calorific value of this fuel. This calculated net calorific value provides then the basis for the estimation of country specific CO₂ emission factor based on empirical formula that applies the relationship between net calorific value and elemental carbon content in fuel (see chapter 3.1.1). This factor can be used for estimation of the potential CO₂ emission from coal combustion. The amount of fuel combusted in a given year, calculated in fuel budget, can be compared with total consumption of this fuel in all sectors. It is one of the ways of verifying of sectoral approach.

Basic information on activity data regarding IPCC categories comes from Eurostat and Statistics Poland (GUS) databases. The activity data that are not available in the GUS have been worked out in experts studies commissioned specifically for the GHG emission inventory purposes.

Eurostat database containing domestic data provided by GUS is the main source of activities for *Energy* sector, covering stationary and mobile sources. Detail information on fuel use is given in Annex 4 and Annex 2.2 while the data on fuel consumption in *Transportation* subcategory is presented in Chapter 3.2.8.

1.5. Brief description of key categories

The source/sink categories in all sectors are identified to be *key categories* on the basis of their contribution to the total level and/or trend assessment established in accordance with 2006 IPCC GLs following quantitative Approach 1 and qualitative criteria. In 2021, 30 sources were identified as Poland's key categories excluding LULUCF and 38 including LULUCF, while in 1988 - 22 and 27 respectively with the application of quantitative approach. Analysis with use of qualitative criteria identified no additional categories as key sources.

About 78% of GHG emissions in 2021 (excluding LULUCF) were generated in the sector 1.A *Fuel combustion*, of which three biggest source categories are: 1.A.1 *Energy Industries (Solid fuels)*, 1.A.3.b *Road Transportation (Fossil fuels)* and 1.A.4 *Other Sectors (Solid fuels)*. This sector is of significant influence on a country's total GHG emissions in terms of both: level and trend of emissions.

Table 1.2 presents the general information on identified key categories in the national inventory for 2021. Those categories contribute to over 96.2% of the total GHG emission (without LULUCF). The complete tables with level and trend assessments for 1988 and 2021 are given in Annex 1.

Table 1.2. Key category analysis results in 2021 (without LULUCF)

No.	IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)			Comments
1	1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	L	T		
2	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	L	T		
3	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	L	T		
4	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	L	T		
5	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	L			
6	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	L	T		
7	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	L	T		
8	1.A.3.b Road Transportation	CO2	L	T		
9	1.A.3.c Railways	CO2		T		
10	1.A.4 Other Sectors - Biomass	CH4	L	T		
11	1.A.4 Other Sectors - Gaseous Fuels	CO2	L	T		
12	1.A.4 Other Sectors - Liquid Fuels	CO2	L	T		
13	1.A.4 Other Sectors - Solid Fuels	CO2	L	T		
14	1.A.4 Other Sectors - Solid Fuels	CH4	L	T		
15	1.B.1 Fugitive emissions from Solid Fuels	CH4	L	T		
16	1.B.1 Fugitive emissions from Solid Fuels	CO2	L			
17	1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH4		T		
18	1.B.2.d Fugitive Emissions from Fuels - Other	CO2	L	T		
19	2.A.1 Cement Production	CO2	L	T		
20	2.A.4 Other Process Uses of Carbonates	CO2	L	T		
21	2.B.1 Ammonia Production	CO2	L	T		
22	2.B.2 Nitric Acid Production	N2O		T		
23	2.C.1 Iron and Steel Production	CO2	L	T		
24	2.F.1 Refrigeration and Air conditioning	F-gases	L	T		
25	3.A Enteric Fermentation	CH4	L	T		
26	3.B Manure Management	N2O	L			
27	3.D.1 Direct N2O Emissions From Managed Soils	N2O	L	T		
28	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	L			
29	5.A Solid Waste Disposal	CH4		T		
30	5.D Wastewater Treatment and Discharge	CH4	L			

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

Uncertainty evaluation made for 2021 is based on calculations and national expert's judgments/ estimations as well as opinions expressed by international experts during the review led by UNFCCC Secretariat in the years 2007-2012.

The estimate of emission uncertainty for the year 2021 was made using *Tier 1* approach. The uncertainty ranges varied significantly among various source categories and are presented within

sectoral chapters 3-7. More details, including sectoral information on uncertainty ranges, are given in Annex 8.

1.7. General assessment of the completeness

The Polish GHG emission inventory includes calculation of emissions from all relevant sources recommended by the mandatory guidelines. Only CO₂ from *Coal Mining and Handling* (1.B.1.a) is not considered due to the lack of data at this level of aggregation.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

2.1. Description and interpretation of emission trends for aggregated greenhouse gas emissions

For carbon dioxide, net emission is calculated by subtracting from the total CO₂ emission – the emissions and removals from category 4. *Land Use, Land Use Change and Forestry* (LULUCF). According to the IPCC methodology, CO₂ emissions are given with and without contributions from category 4. Also following IPCC, emission of CO₂ from biomass, is not included in the national total.

For non-CO₂ gases, the inventory results can also be presented (table 2.1) in units of CO₂ equivalents by applying values of the so called Global Warming Potentials - GWP. GWPs applied since this inventory are as following: for methane is 28, and for nitrous oxide 265. Carbon dioxide is the main GHG in Poland with the 82.9% (excluding category 4) share in 2021, while the methane contributes with 10.7% (excluding category 4) to the national total. Nitrous oxide contribution is 5.2% (excluding category 4) and all industrial GHG together contribute 1.3%. Percentage shares of individual GHGs in national total emissions in 2021 are presented in table 2.1. and figure 2.1.

Table 2.1. Greenhouse gas emissions in 2021 in CO₂ eq.

Pollutant	2021	
	Emission in CO ₂ eq. [kt]	Share [%]
CO ₂ (with LULUCF)	309 731.76	81.54
CO ₂ (without LULUCF)	331 576.28	82.91
CH ₄ (with LULUCF)	42 712.42	11.24
CH ₄ (without LULUCF)	42 704.71	10.68
N ₂ O (with LULUCF)	22 358.76	5.89
N ₂ O (without LULUCF)	20 616.67	5.15
HFCs	4 937.26	1.30
PFCs	10.08	0.00
Mix of HFC & PFC	NA,NO	NA,NO
SF ₆	92.60	0.02
NF ₃	NA,NO	NA,NO
TOTAL net emission (with LULUCF)	379 842.88	100.00
TOTAL without LULUCF	399 937.61	100.00

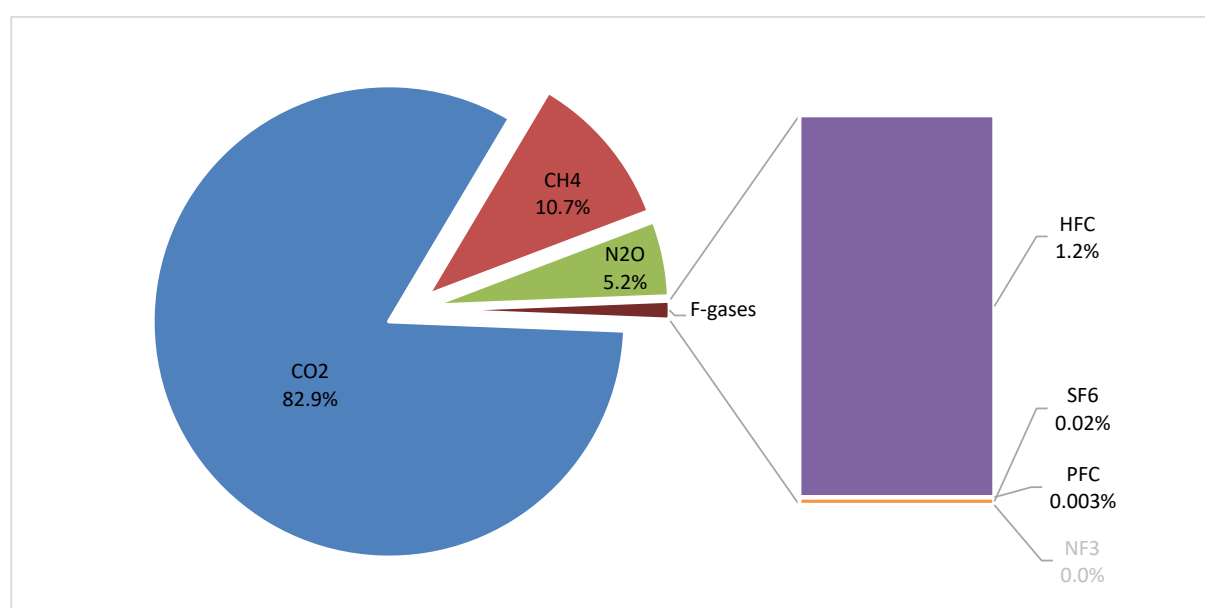


Figure 2.1. Percentage share of greenhouse gases in national total emission in 2021 (excluding LULUCF)

Emissions of main GHGs in 2021, disaggregated into main source sub-sectors, are given in table 2.2. Respective values for the fluorinated industrial gases are presented in table 2.3. Discussion of these results is given in the following sections.

Table 2.2. Emissions of CO₂, CH₄ and N₂O in 2021 [kt]

GHG	CO ₂	CH ₄	N ₂ O
TOTAL without LULUCF	331 576.28	1 525.17	77.80
TOTAL with LULUCF	309 731.76	1 525.44	84.37
1. Energy	310 508.39	823.51	9.83
A. Fuel Combustion	306 225.28	152.59	9.82
1. Energy Industries	159 531.72	1.12	2.49
2. Manufacturing Industries and Construction	29 829.41	4.31	0.59
3. Transport	67 559.43	3.69	2.60
4. Other Sectors	49 304.71	143.47	4.15
5. Other	IE, NO	IE, NO	IE, NO
B. Fugitive Emissions from Fuels	4 283.11	670.92	0.00
1. Solid Fuels	2 449.08	565.76	NA
2. Oil and Natural Gas	1 834.03	105.16	0.00
2. Industrial Processes and Product Use	18 882.09	2.03	2.18
A. Mineral Industry	11 914.85	NA	NA
B. Chemical Industry	4 553.47	1.61	1.73
C. Metal Industry	2 072.75	0.42	NA
D. Other Production	341.02	NE	NE
G. Other	NO	NO	0.45
3. Agriculture	1 412.12	571.58	62.71
A. Enteric Fermentation	NA	520.95	NA
B. Manure Management	NA	49.50	9.73
D. Agricultural Soils	NA	NA	52.94
F. Field Burning of Agricultural Residues	NA	1.13	0.04
G. Liming	871.08	NA	NA
H. Urea application	399.14	NA	NA
I. Other carbon-containing fertilizers	141.90	NA	NA
4. Land Use, Land-Use Change and Forestry	-21 844.52	0.28	6.57
A. Forest Land	-22 240.28	0.23	0.56
B. Cropland	1 699.99	IE, NO	0.04
C. Grassland	-282.60	0.05	0.00
D. Wetlands	1 585.91	0.00	0.00
E. Settlements	2 269.49	NA, NO	5.97
F. Other Land	NA, NO	NA, NO	NA, NO
G. HWP	-4 877.03	NA, NO	NA, NO
5. Waste	274.56	128.04	3.08
A. Solid Waste Disposal	NO, NA	46.55	NO, NA
B. Biological Treatment of Solid Waste	NO, NA	7.55	0.45
C. Incineration and Open Burning of Waste	274.56	0.00	0.02
D. Wastewater Treatment and Discharge	NO, NA	73.95	2.60
INDIRECT CO ₂ EMISSIONS	499.12	NO	NO

Table 2.3. Emissions of industrial gases: HFCs, PFCs and SF₆ in 2021 [kt eq. CO₂]

2021	HFCs	PFCs	SF ₆	Total in eq. CO ₂
Total Industrial gases [kt eq. CO ₂]	4 937.26	10.08	92.60	5 039.94
C. Metal Industry	NE	0.00	0.00	0.00
4. Magnesium production	NE	0.00	0.00	0.00
F. Consumption of Halocarbons and SF ₆	4 937.26	10.08	NO	4 947.35
1. Refrigeration and Air Conditioning Equipment	4 771.17	NO	NO	4 771.17
2. Foam Blowing	75.01	NO	NO	75.01
3. Fire Extinguishers	90.69	10.08	NA	100.77
4. Aerosols	0.08	NA	NA	0.08
5. Solvents	0.30	NA	NA	0.30
G. Other product manufacture and use	NO	NO	92.60	92.60
1. Electrical equipment	NO	NO	92.60	92.60

As a supplement to the tables 2.2 and 2.3, table 2.4 includes percentage contributions of main source sectors to the national totals in 2021 for CO₂, CH₄ and N₂O.

The GHGs trend for period between 1988 and 1990 indicates significant decrease triggered by substantial economic changes, especially in heavy industry. This was the time when political transformation from centrally planned to free market economy began. This drop in emissions continued up to 1992 and then emissions started to rise with a peak in 1996 as a result of development in heavy industry and other sectors and dynamic economic growth. Slow decline in emissions (up to 2002) characterized the succeeding years, when still energy efficiency policies and measures were implemented, and then slight increase up to 2007 caused by animated economic development. In 2008-2011 stabilisation in emissions has been noted with distinct decrease in 2009 related to world economic slow-down. In 2012–2014 GHG emissions in Poland slowly decreased then starting to rise in the next years (tab. 2.5–2.6). The main cause of significant increase of GHGs emissions in 2016–2017, besides economic animation, was substantial rise of fuels use in road transport driven by effective combat against grey zone at fuel market started in 2016, but also favourable fuel prices and increase in vehicles amount.

After 2018, the GHG emissions decreased by 6% in 2019 and by a further 4% in 2020 compared to the previous year. The main reason for the decrease in emissions between 2019 and 2020 was the lower consumption of fuels combustion in stationary sources (hard coal by over 6% and lignite by over 8%) and in transport (gasoline by nearly 7% and diesel by nearly 3%). In addition to the energy sector, emissions from the industrial processes sector have also decreased. This is mainly the result of a decrease in metallurgy production (reduction in the production of converter steel by 20%, pig iron by over 18% and sinter by about 24%). In 2020, the production of lime was also lower by more than 5% compared to 2019. A decrease in emissions was also recorded in the waste sector, where the amount of municipal waste landfilled decreased (by nearly 5%) and municipal waste thermally utilised without energy recovery (by almost 22%). In 2021, national emissions increased again (by nearly 8%) compared to the previous year and exceeded 400 million tons of equivalent CO₂. The most significant increase in GHG emissions was recorded in the fuel combustion sector - by 10%. The reason was higher fuel consumption: hard coal by 10.6%, lignite by 19.0% and natural gas by 10.3% in stationary sources, as well as higher use of gasoline by 10.6%, diesel oil by 8.3% and CNG by 42.5% in transport sector (tables 2.5 and 2.6).

Table 2.4. Percentage shares of individual source sectors in 2021 emissions

Percentage share of emissions of source sectors in current year without LULUCF	Share [%]		
	CO ₂	CH ₄	N ₂ O
TOTAL	100.00	100.00	100.00
1. Energy	93.65	53.99	12.63
A. Fuel Combustion	92.35	10.00	12.63
1. Energy Industries	48.11	0.07	3.20
2. Manufacturing Industries and Construction	9.00	0.28	0.76
3. Transport	20.38	0.24	3.34
4. Other Sectors	14.87	9.41	5.33
5. Other	IE, NO	IE, NO	IE, NO
B. Fugitive Emissions from Fuels	1.29	43.99	0.003
1. Solid Fuels	0.74	37.10	NA
2. Oil and Natural Gas	0.55	6.90	0.003
2. Industrial Processes and Product Use	5.69	0.13	2.81
A. Mineral Industry	3.59	NA	NA
B. Chemical Industry	1.37	0.11	2.23
C. Metal Industry	0.63	0.03	NA
D. Other Production	0.10	NE	NE
G. Other	NO	NO	0.58
3. Agriculture	0.43	37.48	80.61
A. Enteric Fermentation	NA	34.16	NA
B. Manure Management	NA	3.25	12.51
D. Agricultural Soils	NA	NA	68.04
F. Field Burning of Agricultural Residues	NA	0.07	0.06
G. Liming	0.26	NA	NA
H. Urea application	0.12	NA	NA
I. Other carbon-containing fertilizers	0.04	NA	NA
4. Land Use, Land-Use Change and Forestry	-	-	-
A. Forest Land	-	-	-
B. Cropland	-	-	-
C. Grassland	-	-	-
D. Wetlands	-	-	-
E. Settlements	-	-	-
F. Other Land	-	-	-
G. HWP	-	-	-
5. Waste	0.08	8.40	3.95
A. Solid Waste Disposal	NO,NA	3.05	NO,NA
B. Biological Treatment of Solid Waste	NO,NA	0.49	0.58
C. Incineration and Open Burning of Waste	0.08	0.00	0.03
D. Wastewater Treatment and Discharge	NO,NA	4.85	3.34
INDIRECT CO ₂ EMISSIONS	0.15	NO	NO

Table 2.5. National emissions of greenhouse gases for 1988–2021 by gases [kt CO₂ eq.]

GHG	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO ₂ (with LULUCF)	452 685.79	428 675.31	346 757.44	350 940.19	362 709.08	356 088.63	351 667.73	343 871.21	341 119.23	331 303.81	297 502.51	290 476.05	282 169.11	286 092.77	270 064.79	280 755.11	274 685.01
CO ₂ (without LULUCF)	472 037.75	452 483.52	376 925.18	373 944.99	364 860.03	365 560.26	360 641.68	363 012.43	377 701.08	367 653.77	339 495.50	329 686.12	317 934.08	313 980.06	306 630.42	319 449.29	324 371.97
CH ₄ (with LULUCF)	76 371.79	76 151.27	70 004.36	65 696.56	64 558.95	62 963.82	61 815.80	60 310.75	59 410.23	58 844.36	56 451.94	54 790.61	52 490.14	54 316.51	52 243.55	52 450.95	51 705.00
CH ₄ (without LULUCF)	76 316.70	76 096.15	69 949.23	65 671.81	64 263.90	62 905.38	61 754.13	60 268.00	59 321.14	58 799.63	56 425.10	54 736.83	52 447.01	54 294.32	52 209.32	52 320.68	51 679.04
N ₂ O (with LULUCF)	31 508.33	32 698.64	29 455.32	25 310.33	23 611.53	24 220.21	24 141.91	24 879.75	24 713.55	24 737.31	24 520.91	23 986.90	24 039.02	24 077.66	22 750.34	22 539.44	22 938.70
N ₂ O (without LULUCF)	29 801.12	31 013.07	27 836.37	23 758.49	21 961.19	22 726.93	22 704.04	23 498.22	23 348.61	23 450.11	23 287.73	22 770.07	22 886.28	23 018.41	21 707.35	21 445.63	21 965.55
HFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	166.58	259.00	346.42	417.65	581.29	1 022.57	1 504.78	2 048.48	2 617.09	3 150.17
PFCs	132.31	132.54	127.47	126.97	120.97	130.16	137.27	154.52	144.84	156.87	158.19	153.19	160.87	181.35	189.91	184.09	187.51
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
SF ₆	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	13.67	30.02	24.53	23.61	24.67	24.22	23.77	23.56	24.00	21.35	23.04
NF ₃	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
TOTAL (with LULUCF)	560 698.22	537 657.76	446 344.59	442 074.05	451 000.53	443 402.81	437 776.39	429 412.83	425 671.38	415 412.39	379 075.86	370 012.27	359 905.48	366 196.62	347 321.06	358 568.03	352 689.43
TOTAL (without LULUCF)	578 287.88	559 725.27	474 838.25	463 502.25	451 206.08	451 322.72	445 250.79	447 129.76	460 799.21	450 430.42	419 808.84	407 951.71	394 474.58	393 002.47	382 809.47	396 038.14	401 377.28

Table 2.5. (cont.) National emissions of greenhouse gases for 1988–2021 by gases [kt CO₂ eq.]

GHG	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CO ₂ (with LULUCF)	274 342.63	294 196.86	300 452.92	294 572.62	281 037.67	300 922.11	294 865.54	286 745.41	280 517.31	275 619.80	282 374.71	285 951.59	298 156.66	298 048.75	298 101.11	282 235.85	309 731.76
CO ₂ (without LULUCF)	323 329.98	337 234.61	336 581.80	330 297.76	316 681.21	334 792.45	334 188.18	326 494.90	322 390.69	310 083.03	313 261.61	324 091.51	337 305.74	336 571.40	318 166.81	303 019.61	331 576.28
CH ₄ (with LULUCF)	51 814.22	51 641.74	50 371.84	49 877.46	48 112.07	47 773.64	46 188.38	45 653.62	45 844.90	45 189.30	45 979.00	45 481.96	45 879.66	46 465.02	43 562.38	43 247.06	42 712.42
CH ₄ (without LULUCF)	51 776.88	51 599.72	50 350.27	49 855.31	48 085.46	47 759.43	46 170.03	45 607.73	45 834.03	45 169.28	45 941.23	45 468.05	45 871.75	46 444.82	43 534.50	43 188.11	42 704.71
N ₂ O (with LULUCF)	23 137.70	23 406.92	24 164.53	23 757.83	20 876.82	20 494.44	20 755.08	20 839.90	20 991.82	20 705.04	20 767.71	21 247.04	22 248.24	22 530.09	21 503.37	22 236.81	22 358.76
N ₂ O (without LULUCF)	22 206.21	22 517.65	23 293.38	22 887.71	20 009.43	19 600.62	19 867.94	19 935.73	20 090.45	19 742.96	19 062.05	19 516.79	20 495.88	20 775.91	19 760.05	20 469.86	20 616.67
HFCs	3 761.45	4 440.19	4 888.19	5 364.00	5 653.31	5 598.16	6 104.97	6 344.77	5 965.81	6 501.19	5 583.52	5 689.62	5 772.79	5 579.88	5 304.57	5 114.48	4 937.26
PFCs	171.47	176.86	168.68	149.21	18.66	17.72	16.84	16.00	15.20	14.44	13.71	13.03	12.38	11.76	11.17	10.61	10.08
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF ₆	27.62	34.22	32.12	33.88	38.76	36.45	40.22	43.21	49.00	54.41	79.39	80.78	84.97	110.67	93.54	92.29	92.60
NF ₃	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
TOTAL (with LULUCF)	353 255.10	373 896.79	380 078.27	373 755.00	355 737.29	374 842.53	367 971.02	359 642.90	353 384.03	348 084.17	354 798.06	358 464.02	372 154.70	372 746.17	368 576.14	352 937.10	379 842.88
TOTAL (without LULUCF)	401 273.62	416 003.24	415 314.43	408 587.86	390 486.81	407 804.83	406 388.18	398 442.34	394 345.19	381 565.30	383 941.52	394 859.78	409 543.49	409 494.44	386 870.64	371 894.95	399 937.61

Table 2.6. National emissions of greenhouse gases for 1988–2021 by source categories [kt CO₂ eq.]

IPCC sector	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1. Energy	479 481.46	458 968.42	385 148.74	383 017.81	375 133.35	376 603.71	369 480.85	370 528.99	386 532.38	375 143.55	346 579.14	337 945.90	324 336.88	325 632.23	318 365.13	329 719.38	333 975.19
2. Industrial Processes and Product Use	29 865.86	28 937.48	21 971.96	19 265.17	18 546.07	18 531.93	20 750.83	22 146.46	21 305.53	22 207.52	20 613.30	19 633.11	22 224.44	20 799.45	19 460.17	22 281.43	23 939.20
3. Agriculture	50 057.03	52 757.76	49 291.34	42 514.51	38 641.17	37 212.72	36 922.29	36 724.76	35 755.94	36 562.43	36 457.19	34 988.94	33 205.86	32 615.28	31 664.66	31 190.86	31 251.47
4. Land-Use, Land-Use Change and Forestry	-17 589.66	-22 067.52	-28 493.66	-21 428.21	-205.56	-7 919.91	-7 474.40	-17 716.93	-35 127.83	-35 018.03	-40 732.98	-37 939.44	-34 569.11	-26 805.85	-35 488.41	-37 470.10	-48 687.85
5. Waste	18 260.61	18 481.28	18 142.28	18 382.55	18 536.05	18 588.99	17 673.56	17 331.66	16 789.69	16 098.84	15 740.14	14 963.85	14 225.54	13 476.00	12 811.86	12 346.91	11 633.57
INDIRECT CO ₂ EMISSIONS	622.92	580.34	283.93	322.21	349.45	385.38	423.26	397.88	415.67	418.09	419.07	419.92	481.86	479.50	507.66	499.56	577.85
TOTAL (with LULUCF)	560 698.22	537 657.76	446 344.59	442 074.05	451 000.53	443 402.81	437 776.39	429 412.83	425 671.38	415 412.39	379 075.86	370 012.27	359 905.48	366 196.62	347 321.06	358 568.03	352 689.43
TOTAL (without LULUCF)	578 287.88	559 725.27	474 838.25	463 502.25	451 206.08	451 322.72	445 250.79	447 129.76	460 799.21	450 430.42	419 808.84	407 951.71	394 474.58	393 002.47	382 809.47	396 038.14	401 377.28

Table 2.6. (cont.) National emissions of greenhouse gases for 1988–2021 by source categories [kt CO₂ eq.]

IPCC sector	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1. Energy	334 317.08	346 972.09	343 730.09	338 729.65	327 237.60	344 423.02	340 815.26	334 726.44	331 295.54	317 593.86	321 729.78	332 453.13	345 196.89	344 374.23	323 527.89	307 991.99	336 170.52
2. Industrial Processes and Product Use	23 732.01	26 006.52	28 400.56	27 118.76	21 733.19	22 878.65	25 634.54	24 631.25	23 623.32	25 102.81	24 351.84	24 551.53	25 068.73	25 563.41	25 081.19	24 516.29	24 557.99
3. Agriculture	31 659.42	32 148.73	32 843.79	32 939.52	32 256.88	31 659.66	31 989.59	31 826.63	32 464.68	32 364.07	31 705.48	32 067.10	33 359.59	33 688.37	32 595.16	34 051.67	34 035.26
4. Land-Use, Land-Use Change and Forestry	-48 018.52	-42 106.45	-35 236.16	-34 832.86	-34 749.52	-32 962.30	-38 417.15	-38 799.44	-40 961.15	-33 481.13	-29 143.46	-36 395.76	-37 388.80	-36 748.27	-18 294.50	-18 957.85	-20 094.72
5. Waste	11 000.17	10 213.96	9 678.38	9 069.25	8 599.15	8 275.63	7 359.36	6 716.42	6 498.00	6 003.98	5 608.23	5 243.51	5 377.97	5 377.94	5 182.12	4 752.48	4 674.72
INDIRECT CO ₂ EMISSIONS	564.93	661.95	661.60	730.68	660.00	567.87	589.42	541.61	463.65	500.58	546.19	544.52	540.32	490.49	484.28	582.52	499.12
TOTAL (with LULUCF)	353 255.10	373 896.79	380 078.27	373 755.00	355 737.29	374 842.53	367 971.02	359 642.90	353 384.03	348 084.17	354 798.06	358 464.02	372 154.70	372 746.17	368 576.14	352 937.10	379 842.88
TOTAL (without LULUCF)	401 273.62	416 003.24	415 314.43	408 587.86	390 486.81	407 804.83	406 388.18	398 442.34	394 345.19	381 565.30	383 941.52	394 859.78	409 543.49	409 494.44	386 870.64	371 894.95	399 937.61

2.2. Description and interpretation of emission trends by gas

Carbon dioxide (CO₂)

In 2021, the CO₂ emissions (without LULUCF) were estimated to be 331.58 million tonnes, while - when sector 4. *LULUCF* is included - the figure reaches 309.73 million tonnes (table 2.1). CO₂ share in total GHG emissions in 2021 amounted to 82.9%. The main CO₂ emission source is *Fuel Combustion* (1.A) subcategory. This sector contributed to the total CO₂ emission (without LULUCF) with 92.4% share in 2021 (fig. 2.2). The shares of the main subcategories in 1.A were as follows: *Energy industries* - 48.1%, *Manufacturing Industries and Construction* – 9.0%, *Transport* – 20.4% and *Other Sectors* – 14.9%. Sector 2. *Industrial Processes* contributed to the total CO₂ emission with 5.7% share in 2021. *Mineral industry* (especially *Cement Production*) is the main emission source in this sector. The CO₂ emission/removal in LULUCF sector in 2021, was calculated to be approximately – 21.8 million tonnes what means that removals prevail emissions significantly in this sector.

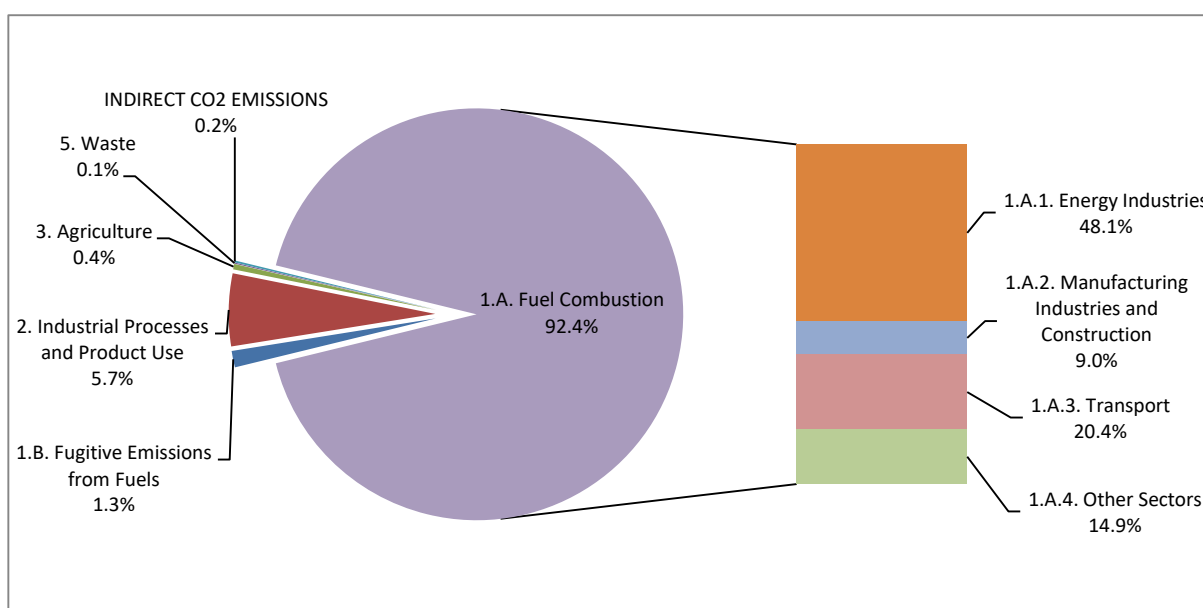


Figure 2.2. Carbon dioxide emission (excluding category 4) in 2021 by sector

Methane (CH₄)

The CH₄ emission (excluding category 4) amounted to 1 525.17 kt in 2021 i.e. 42.70 million tonnes of CO₂ equivalents (table 2.1). CH₄ share in total GHG emissions in 2021 amounted to 10.7%. Three of main CH₄ emission sources include the following categories: *Fugitive Emissions from Fuels*, *Agriculture* and *Fuel Combustion*. They contributed with 44.0%, 37.5% and 10.0% shares to the national methane emission in 2021, respectively (fig. 2.3). The emission from the first mentioned sector was covered by emission from coal and lignite mines (app. 37.1% of total CH₄ emission) and *Oil and Natural Gas* system (about 6.9% of total emission). The emission from *Enteric Fermentation* dominated in *Agriculture* and amounted to app. 34.2% of total methane emission in 2021. *Waste* sector contributed to 8.4% of the methane emission.

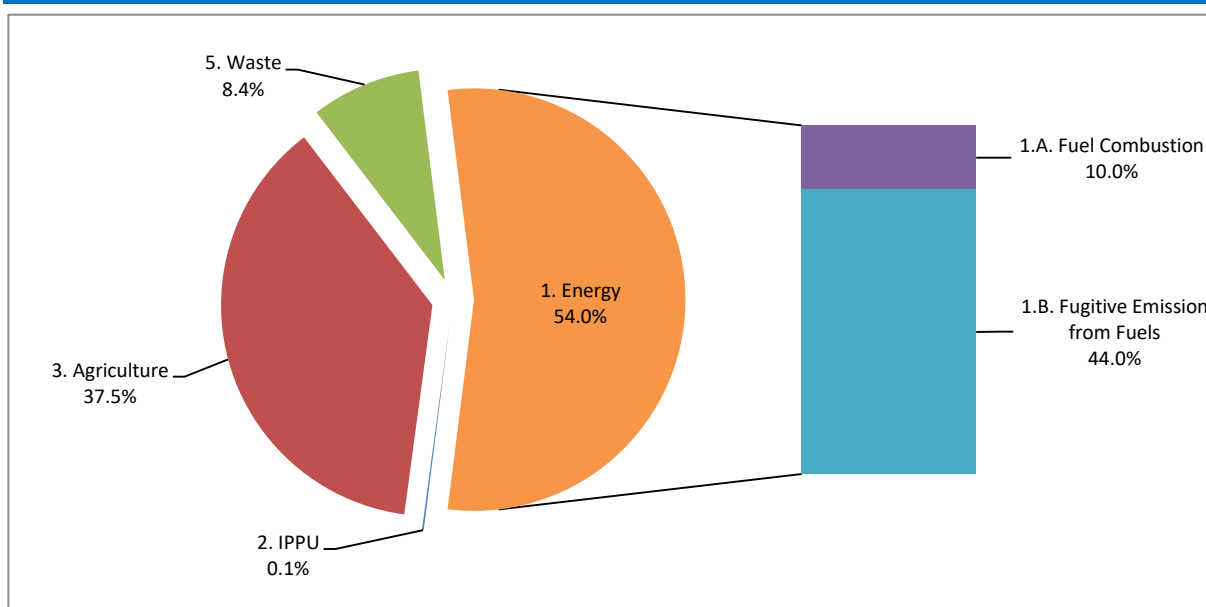


Figure 2.3. Methane emission (excluding category 4) in 2021 by sector

Nitrous oxide (N_2O)

The nitrous oxide emissions (excluding category 4) in 2021 were 77.80kt i.e. 20.62 million tonnes of CO_2 equivalents (table 2.2). N_2O share in total GHG emissions in 2021 amounted to 5.2%. The main N_2O emission sources and their shares in total N_2O emission in 2021 are: *Agricultural Soils* – 68.0%, *Manure Management* – 12.5%, *Fuel Combustion* – 12.6% and *Domestic wastewater treatment* – 3.3% and *Chemical Industry* – 2.2% (fig. 2.4).

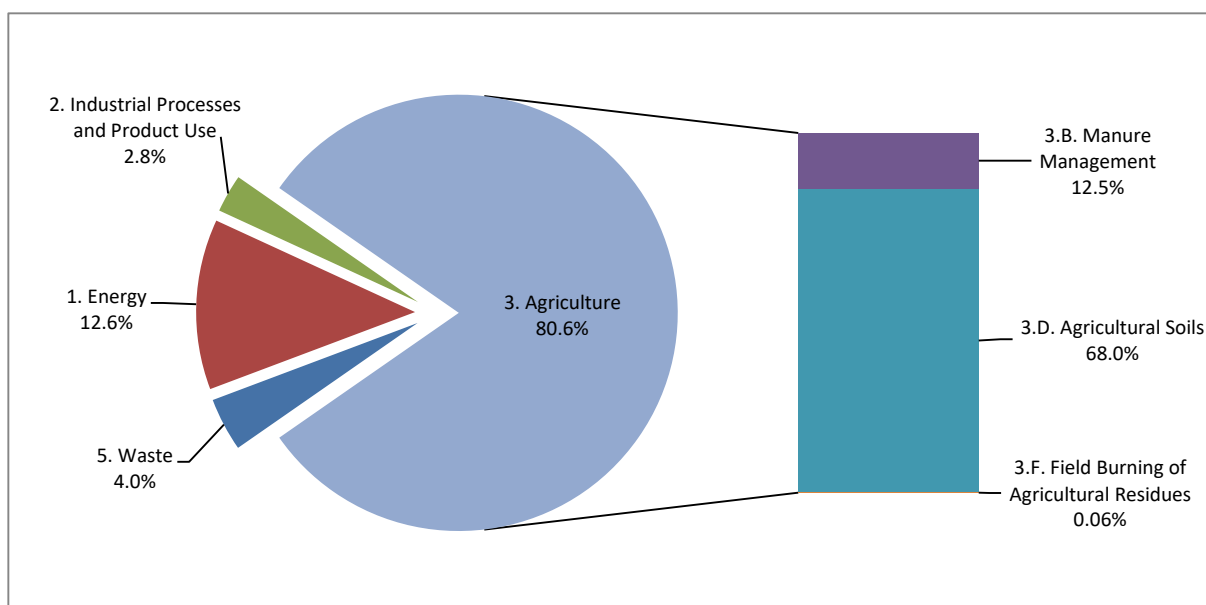


Figure 2.4. Nitrous oxide emission (excluding category 4) in 2021 by sector

Fluorinated gases

The total emission of industrial gases (HFCs, PFCs SF_6 and NF_3) in 2021 was 5039,94 kt CO_2 equivalent what accounts for 1.3% of total GHG emissions share in 2021. Industrial gases emissions were by 3709.1% higher comparing to the base year. This significant growth in HFCs emission is mainly due to the increase in emission from refrigeration and air conditioning equipment. Shares of HFCs, PFCs and SF_6 in total 2021 GHG emissions was respectively as follows: 1.23%, 0.003% and 0.02%. NF_3 emissions did not occur.

The total emissions in 2021 according to groups of industrial gases are as follows: HFCs – 4.94 million tonnes of CO₂ equivalents, PFCs – 0.01 million tonnes of CO₂ equivalents and SF₆ – 0.09 million tonnes of CO₂ equivalents.

2.3. Comparison of GHG emissions to the base year

Percentage share of individual GHGs to national total in the base year (1988/1995) is presented in figure 2.5. Compared to the base year, the percentage share of CO₂ (excluding category 4) in 2021 increased from 81.6% to 82.9%.

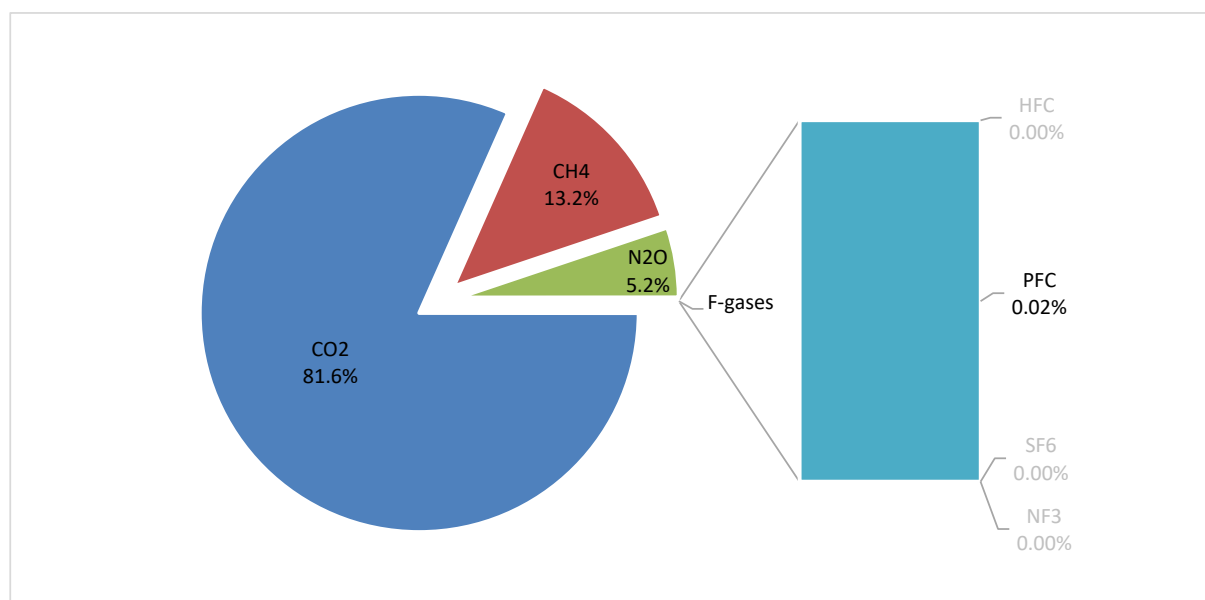


Figure 2.5. Percentage share of national greenhouse gas emissions in 1988 excluding emission from category 4

Table 2.7. Greenhouse gas emissions in 2021 including indirect emission with respect to base year (1988)

GHG	Emission in CO ₂ eq. [kt]		(2021-1988)/1988 [%]
	1988	2021	
CO ₂ (with LULUCF)	452 685.79	309 731.76	-31.58
CO ₂ (without LULUCF)	472 037.75	331 576.28	-29.76
CH ₄ (with LULUCF)	76 371.79	42 712.42	-44.07
CH ₄ (without LULUCF)	76 316.70	42 704.71	-44.04
N ₂ O (with LULUCF)	31 508.33	22 358.76	-29.04
N ₂ O (without LULUCF)	29 801.12	20 616.67	-30.82
HFCs	NO,NA	4 937.26	100.00
PFCs	132.31	10.08	-92.38
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF ₆	NA,NO	92.60	100.00
NF ₃	NA,NO	NA,NO	NA,NO
TOTAL net emission (with LULUCF)	560 698.22	379 842.88	-32.26
TOTAL without LULUCF	578 287.88	399 937.61	-30.84

Comparison of GHG emissions in 2021 and the base year given in table 2.7 indicates significant drop in all gases, except HFCs and SF₆, in case of CO₂, methane and nitrous oxides emissions, where decrease reached ca. 29.8%, 44.0% and 30.8% respectively in 1988-2021 (excluding LULUCF). This was mainly caused by significant changes in fuel mix as well as serious drop in coal mining and livestock population.

Carbon dioxide

CO₂ emission (excluding category 4) decreased by app. 29.8% from the base year (1988) to 2021. The following changes took place in the structure of fuel use within this period:

- share of solid fuels decreased from 78.9% in the base year to 43.0% in 2021,
- share of liquid fuels increased from 12.0% in the base year to 28.9 % in 2021,
- share of gaseous fuels increased from 7.4% in the base year to 17.2% in 2021.

Methane

CH₄ emission (excluding category 4) decreased by app. 44.0% from the base year (1988) to 2021 triggered by the following biggest sectoral emission changes:

- the decrease in emission from *Waste* sector by 79.1%,
- the decrease in emission from *Enteric Fermentation* by 35.1%,
- the decrease in *Fugitive Emission* by 33.1%.

Nitrous oxide

The nitrous oxide emissions (excluding category 4) in 2021 were app. 30.8% lower than the respective figure for the base year (1988) what was caused mostly by diminishing agricultural and chemical production where: N₂O emissions from *Manure Management* decreased by 29.6%, from *Agricultural Soils* by 25.3% and from *Chemical Industry* decreased by 89.2% in 1988-2021.

Industrial gases: HFCs, PFCs, NF₃ and SF₆

HFCs emissions in 2021 were 2864% higher than in base year for f-gases (1995). This significant growth in HFCs emission is mainly due to the increase in emission from refrigeration and air conditioning equipment. PFCs emissions in 2021 were by 93% lower than in base year (1995). The PFCs emission changes between 2021 and the preceding years depend on the aluminium production levels (main PFC source) and the use of C₄F₁₀ in fire extinguishers.

SF₆ emissions in 2021 were higher by about 208% than in base year (1995). Leakage from electrical equipment during its use and production is the main SF₆ emission. Large percentage increase of industrial gases emissions, compared to the base year (1995), does not influence significantly the national total GHG emission trend, because all the fluorinated industrial gases together contributed merely with app. 1.3% to the national total in 2021. NF₃ emissions did not occur.

2.4. Description and interpretation of emission trends by category

Table 2.8 includes emissions of greenhouse gases from all categories for the base year and for year 2021 by main categories. In 2021 total GHG emissions accounted for 399.94 million tonnes CO₂ eq. excluding sector 4. *LULUCF*. Comparing to the base year emissions in 2021 decreased by 30.8%.

Table 2.8. GHG emissions by main sector in the base year and in 2021

	Total [kt eq. CO ₂]		(2021-1988)/1988 [%]
	1988	2021	
TOTAL with LULUCF	560 698.22	379 842.88	-32.26
TOTAL without LULUCF	578 287.88	399 937.61	-30.84
1. Energy	479 481.46	336 170.52	-29.89
2. Industrial Processes and Product Use	29 865.86	24 557.99	-17.77
3. Agriculture	50 057.03	34 035.26	-32.01
4. Land-Use, Land-Use Change and Forestry	-17 589.66	-20 094.72	14.24
5. Waste	18 260.61	4 674.72	-74.40
INDIRECT CO ₂ EMISSIONS	622.92	499.12	-19.87

2.4.1. Energy

The emission of GHGs from *Energy* sector in 2021 was 336.2 million tonnes of CO₂ equivalent. CO₂ emission share amounted to 92.4% of the total GHG emissions within 1. *Energy* category (table 2.9). The most emission intensive category was 1.A.1. *Energy industries* with the share 47.5% in emission from 1. *Energy* category.

Table 2.9. GHG emissions from sub-sectors in category 1. *Energy* in 2021

GHG emission categories	GHG emission [kt CO ₂ eq.]	% share in the total emission from sector 1. <i>Energy</i>	% share in total 1. <i>Energy</i> emission per GHG		
			CO ₂	CH ₄	N ₂ O
1. TOTAL ENERGY	336 170.52	100.0	92.4	6.9	0.8
A. Fuel Combustion	313 101.04	93.1	91.1	1.3	0.8
1. Energy Industries	160 223.08	47.7	47.5	0.0	0.2
2. Manufacturing Industries and Construction	30 106.35	9.0	8.9	0.0	0.0
3. Transport	68 350.91	20.3	20.1	0.0	0.2
4. Other Sectors	54 420.70	16.2	14.7	1.2	0.3
5. Other	0.00	0.0	0.0	0.0	0.0
B. Fugitive Emissions from Fuels	23 069.48	6.9	1.3	5.6	0.0
1. Solid Fuels	18 290.42	5.4	0.7	4.7	0.0
2. Oil and Natural Gas and other emissions from energy production	4 779.05	1.4	0.5	0.9	0.0

2.4.2. Industrial Processes and Product Use

Table 2.10 shows detailed information on emissions of CO₂, CH₄, N₂O as well as HFCs, PFCs, SF₆ in 2. *Industrial Processes and Product Use* sector in 2021. CO₂ is dominating among GHGs – its contribution reaches 76.9%. The main GHG emission sources in this category were: production processes of cement, nitric acid and ammonia.

Table 2.10. The emissions of CO₂, CH₄ and N₂O from *Industrial Processes and Product Use* in 2021

GHG emission categories	GHG emission [kt CO ₂ eq.]	% share in the total emission from sector 2. <i>IPPU</i>	% share in total 2. <i>IPPU</i> emission per GHG			
			CO ₂	CH ₄	N ₂ O	HFC, PFC and SF ₆
2. TOTAL INDUSTRIAL PROCESSES AND PRODUCT USE	24 557.99	100.0	76.9	0.2	2.4	20.5
A. Mineral Industry	11 914.85	48.5	48.5	0.0	0.0	0.0
B. Chemical Industry	5 057.59	20.6	18.5	0.2	1.9	0.0
C. Metal Industry	2 084.65	8.5	8.4	0.0	0.0	0.0
D. Non-energy products from fuels and solvent use	341.02	1.4	1.4	0.0	0.0	0.0
F. Product uses as substitutes for ODS	4947.35	20.1	0.0	0.0	0.0	20.1
G. Other product manufacture and use	212.54	0.9	0.0	0.0	0.5	0.4

2.4.3. Agriculture

The main sources of GHG in category 3. *Agriculture* were: 3.A *Enteric Fermentation*, 3.D *Agricultural Soils* and 3.B *Manure Management* (table 2.11). N₂O emission share was the largest in total GHG emission from 3. *Agriculture* in 2021 and came from both – direct (mineral and organic fertilization) and indirect (volatilization, leaching and runoff from applied synthetic fertilizer and animal manure) N₂O emissions from soils.

Table 2.11. GHG emissions from *Agriculture* in 2021

GHG emission categories	GHG emission [kt CO ₂ eq.]	% share in the total emission from sector 3. <i>Agriculture</i>	% share in total 3. <i>Agriculture</i> emission per GHG		
			CO ₂	CH ₄	N ₂ O
3. TOTAL AGRICULTURE	34 035.26	100.0	4.1	47.0	48.8
A. Enteric Fermentation	14 586.57	42.9	0.0	42.9	0.0
B. Manure Management	3 964.74	11.6	0.0	4.1	7.6
D. Agricultural Soils	14 028.53	41.2	0.0	0.0	41.2
F. Field Burning of Agricultural Residues	43.31	0.1	0.0	0.1	0.0
G. Liming	871.08	2.6	2.6	0.0	0.0
H. Urea application	399.14	1.2	1.2	0.0	0.0
I. Other carbon-containing fertilizers	141.90	0.4	0.4	0.0	0.0

2.4.4. Waste

As it can be seen in table 2.12, the emission of CH₄ dominated in *Waste* sector in 2021 (with 76.7% share). The main part of GHG emissions came from 5.D *Wastewater Treatment and Discharge*.

Table 2.12. GHG emissions from *Waste* in 2021

GHG emission categories	GHG emission [kt CO ₂ eq.]	% share in the total emission from sector 5. <i>Waste</i>	% share in total 5. <i>Waste</i> emission per GHG		
			CO ₂	CH ₄	N ₂ O
5. TOTAL WASTE	4 674.72	100	5.9	76.7	17.4
A. Solid Waste Disposal	1 303.29	27.9	0.0	27.9	0.0
B. Biological Treatment of Solid Waste	331.28	7.1	0.0	4.5	2.6
C. Incineration and Open Burning of Waste	279.97	6.0	5.9	0.0	0.1
D. Wastewater Treatment and Discharge	2 760.19	59.0	0.0	44.3	14.8

2.4.5. EU Climate and energy package (ETS and ESD emissions)

To achieve the greenhouse gas emission reduction target for 2030 the EU adopted the next climate and energy package (hereinafter referred to as the 2030 CEP) which has been divided between the three main areas of the economies of the EU and its Member States in the following way:

- the target for the EU ETS area (including domestic and international aviation): a 40% reduction of the greenhouse gas emissions compared with 2005 levels;
- the target for the area not covered by the EU ETS (the so-called non-ETS, i.e. the sectors subject to the ESR Regulation): a 30% reduction of the GHG emissions compared with 2005 levels. The EU target was divided among all the EU Member States. As part of this division, Poland's target is to reduce its GHG emissions by 7% compared with 2005 levels by 2030;
- the LULUCF area: the Member States were expected to ensure that their emissions would not exceed their removals in this area.

The 2030 CEP included the following main legal acts concerning the reform of the EU ETS system and the non-ETS area, representing to a large extent amendments to the regulations setting out the targets and manner of their implementation, i.e.:

- Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013 (the so-called ESR Regulation) (OJ L 156, 19.6.2018, p. 26);
- Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (the so-called LULUCFR Regulation – LULUCFR) (OJ L 156, 19.6.2018, p. 1).

The 2021 year is the first one within EU ETS and non-ETS covered with new climate and energy package established for 2021–2030 and is presented with GWP from AR5.

The emissions from sources included in EU ETS (electricity and heat production, heavy industry) are reported directly by installations. The sum of all the reported emissions by installations in Poland constitutes the emission of the Polish part of EU ETS. Those reports cover mostly CO₂ emissions, but also some N₂O emissions are included. Total emissions in EU ETS in Poland amounted to 191.5 Mt of CO₂ eq. in 2021. The total ESR emissions in 2021 in Poland amounted to 208.5 Mt CO₂ eq. and comparing to the target established for Poland for this year, an overachievement is expected amounting to 6.5 Mt CO₂ eq.

3. ENERGY (CRF SECTOR 1)

3.1. Overview of sector

Following subcategories from sector 1 have been identified as key source (excluding LULUCF):

IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)		
		Level	Trend	Qualitative
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO ₂	L	T	
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO ₂	L	T	
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO ₂	L	T	
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO ₂	L	T	
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO ₂	L	T	
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO ₂	L	T	
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO ₂	L	T	
1.A.3.b Road Transportation	CO ₂	L	T	
1.A.3.c Railways	CO ₂	L	T	
1.A.4 Other Sectors - Biomass	CH ₄	L	T	
1.A.4 Other Sectors - Gaseous Fuels	CO ₂	L	T	
1.A.4 Other Sectors - Liquid Fuels	CO ₂	L	T	
1.A.4 Other Sectors - Solid Fuels	CO ₂	L	T	
1.A.4 Other Sectors - Solid Fuels	CH ₄	L	T	
1.B.1 Fugitive emissions from Solid Fuels	CH ₄	L	T	
1.B.1 Fugitive emissions from Solid Fuels	CO ₂	L		
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH ₄		T	
1.B.2.d Fugitive Emissions from Fuels - Other	CO ₂	L	T	

Share of these subcategories in total Poland's GHG emissions amounts ca. 82%.

Figure 3.1.1 shows emission trend in *Energy* sector while figure 3.1.2 shows emission trend according to subcategories 1.A *Fuel combustion* and 1.B *Fugitive emission*. Emission from entire 1. *Energy* sector is the largest contributor to national GHG emissions – in 2021 ca. 82%.

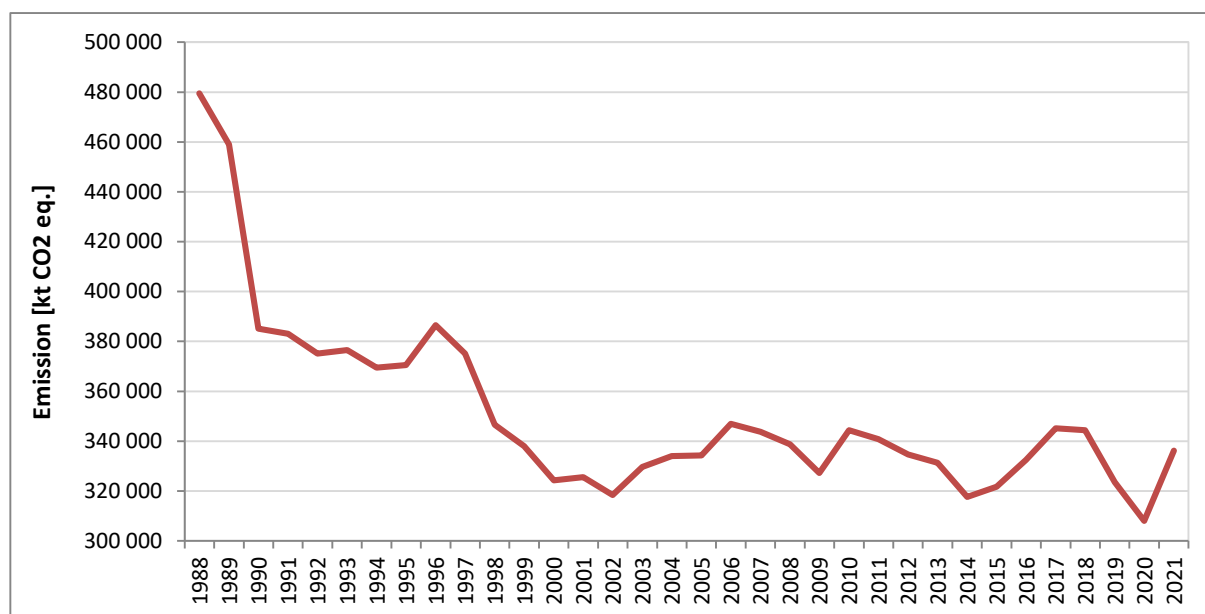


Figure 3.1.1. GHG emission trend in period 1988-2021 in sector *Energy*

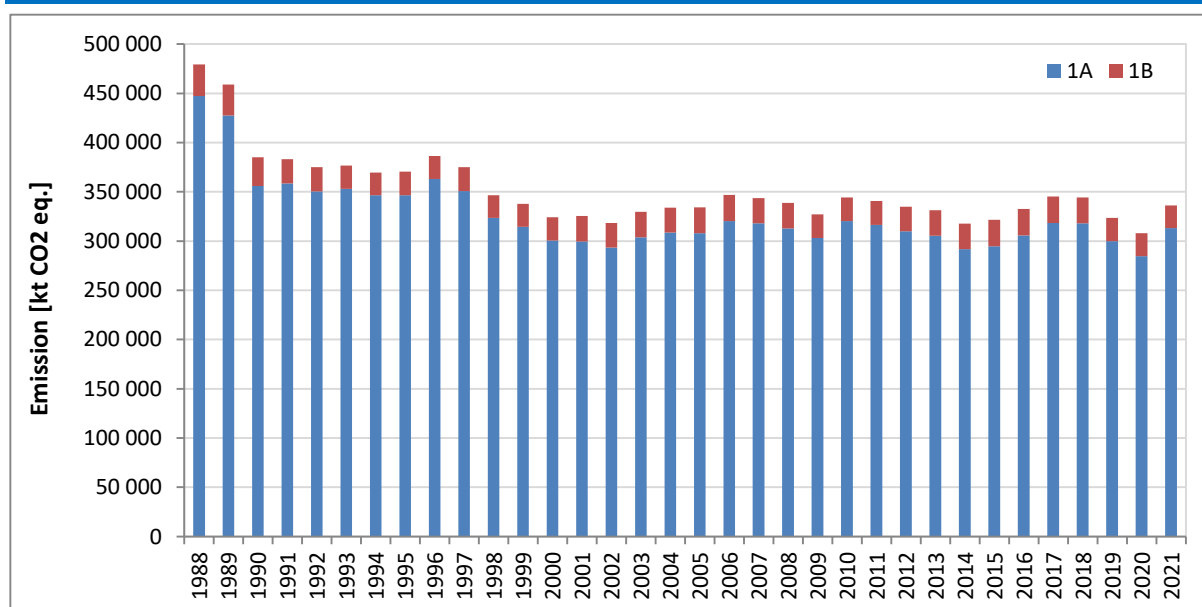


Figure 3.1.2. GHG emission trend in period 1988-2021 in subsectors 1.A and 1.B

3.1.1. Fuel combustion (CRF sector 1.A)

Combustion as a source of GHG emission occurs in the following category groups:

- 1.A.1. *Energy industries*
- 1.A.2. *Manufacturing industries and construction*
- 1.A.3. *Transport*
- 1.A.4. *Other sectors:*
 - a. *Commercial/institutional*
 - b. *Residential*
 - c. *Agriculture/forestry/fishing*

Share of sector in total GHG emission in 2021 is 78.4%. Subsector 1.A.1 *Energy Industries* is by far the largest contributor to emissions from fuel combustion (see figure 3.1.3).

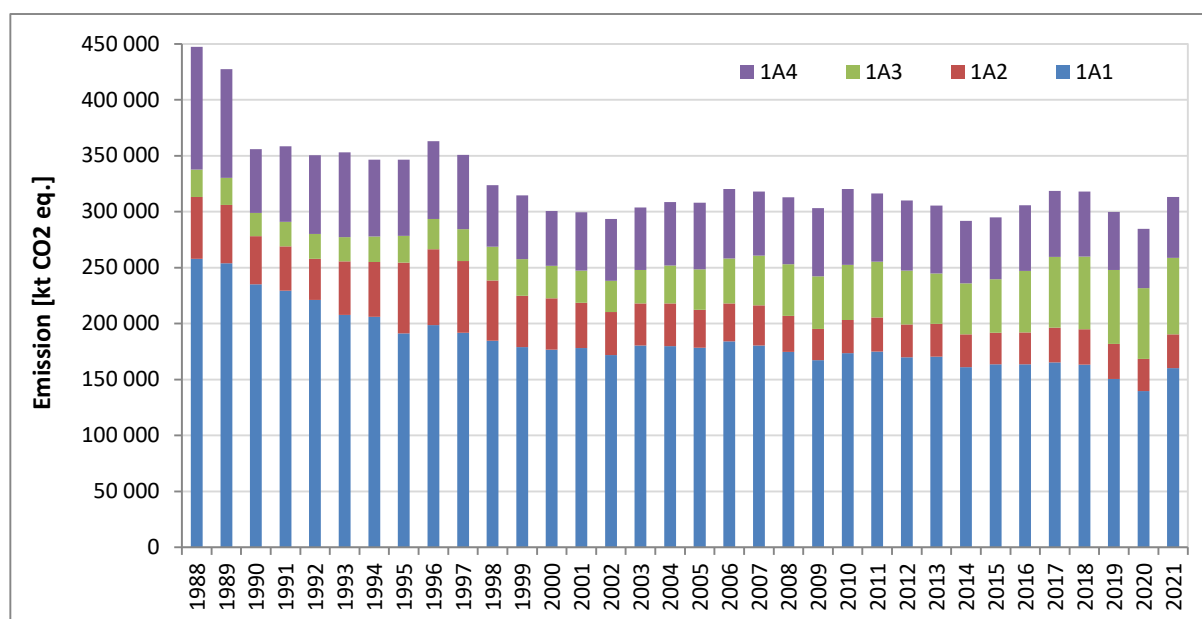


Figure 3.1.3. GHG emissions from fuel combustion in 1988-2021 according to subcategories

Emissions in 1.A.1 *Energy industries* category are estimated for each detailed sub-categories as follows:

- a) 1.A.1.a *Public electricity and heat production*

- *Electricity generation* - 1.A.1.a.i
- *Combined heat and power generation* - 1.A.1.a.ii
- *Heat plants* - 1.A.1.a.iii
- b) 1.A.1.b *Petroleum refining*
- c) 1.A.1.c *Manufacture of solid fuels and other energy industries*
 - *Manufacture of solid fuels* - 1.A.1.c.i (coke-oven plants, gas-works plants, mines, patent fuel/briquetting plants)
 - *Oil and gas extraction* - 1.A.1.c.ii
 - *Other energy industries* - 1.A.1.c.iii (own use in electricity, CHP and heat plants)

Emissions in 1.A.2 *Manufacturing industries and construction* category are estimated for each fuel in detailed sub-categories as follows:

- a) *Iron and steel* - 1.A.2.a
- b) *Non-ferrous metals* - 1.A.2.b
- c) *Chemicals* - 1.A.2.c
- d) *Pulp, paper and print* - 1.A.2.d
- e) *Food processing, beverages and tobacco* - 1.A.2.e
- f) *Non-metallic minerals* - 1.A.2.f
- g) *Other* - 1.A.2.g:
 - *Manufacturing of machinery* - 1.A.2.g.i
 - *Manufacturing of transport equipment* - 1.A.2.g.ii
 - *Mining (excluding fuels) and quarrying* - 1.A.2.g.iii
 - *Wood and wood products* - 1.A.2.g.iv
 - *Construction* - 1.A.2.g.v
 - *Textile and leather* - 1.A.2.g.vi
 - *Other* - 1.A.2.g.vii - other industry branches not included elsewhere

Estimation of emissions in 1.A.3 *Transport* are carried out for each fuel in sub-categories listed below:

- a) *Civil Aviation* (1.A.3.a)
- b) *Road Transportation* (1.A.3.b)
- c) *Railways* (1.A.3.c)
- d) *Navigation* (1.A.3.d)
- e) *Other Transportation* (1.A.3.e)

Emissions in 1.A.4 *Other sectors* are estimated for each fuel in detailed sub-categories given below:

- a) *Commercial/institutional* (1.A.4.a)
- b) *Residential* (1.A.4.b)
- c) *Agriculture/forestry/fishing* (1.A.4.c)
 - *Stationary* - 1.A.4.c.i
 - *Off-road vehicles and other machinery* - 1.A.4.c.ii
 - *Fishing* - 1.A.4.c.iii.

The amount of CO₂ emissions from fuel combustion in stationary sources were estimated on the level determined as IPCC *Tier 2 or Tier 1 depending on EF type (country specific or default)*. In this case the calculation was based on the following equation:

$$E = \sum (EF_{ab} * A_{ab})$$

where: E - emission

EF - emission factor

A - fuel consumption

a - fuel type, b - sector

The amount of combusted fuel was accepted according to data included in the energy balance submitted by GUS to Eurostat [EUROSTAT].

List of combusted fuels for which GHG emissions were estimated based upon selected or calculated emission factors is as follows:

- liquid fuels: fuel oil, diesel oil, liquid petroleum gas (LPG), crude oil, motor gasoline, jet kerosene, refinery gas, feedstocks, other petroleum products and petroleum coke
- gaseous fuels: natural gas
- solid fuels: hard coal, lignite, coke, hard coal briquettes, lignite briquettes, coke oven gas, blast furnace gas, gas works gas,
- other fuels: industrial wastes, municipal waste (non-biogenic fraction)
- biomass: fuel wood and wood waste, biogas, municipal waste – biogenic fraction.

Country specific emission factors for estimation of CO₂ emission from fuel combustion in stationary sources have been developed for hard coal, lignite, natural gas and fuel oil. For the other fuels default CO₂ emission factors derived from 2006 IPCC GLs have been applied.

CO₂ country specific emission factors for hard coal and lignite are based on empirical functions, that link the amount of carbon in fuel with the corresponding net calorific value. That empirical functions are the following:

- for hard coal:

$$C_{hc} = 10(2.4898 * NCV + 3.3132)/NCV$$

where:

C_{hc} - emission factor/carbon content for hard coal [kg C/GJ],
 NCV - net calorific value of hard coal [MJ/kg] in the given sub-category calculated based upon hard coal combusted expressed in both physical and energy units,

- for lignite:

$$C_{bc} = 10(1.9272 * NCV + 9.3856)/NCV$$

where:

C_{bc} - emission factor for lignite [kg C/GJ],
 NCV - net calorific value of lignite [MJ/kg] in the given sub-category calculated based upon lignite combusted expressed in both physical and energy units

The function describing the dependence of carbon content on NCV was developed on the basis of domestic measurements of over 100 hard coal samples, in a wide range of NCV values for this fuel. The measurement results and the calculation file with the function development are presented in Annex 2.1. The function used in the inventory was developed in the same way as in the article [Fott 1999].

An empirical function describing the dependence of carbon content on NCV for lignite was developed analogously. Equation is based on data collected from all Polish lignite mines. Aggregated data is presented in the Annex 2.1.

CS EFs for natural gas are elaborated on the basis of plant specific data on the values of CO₂ emissions and the amounts of fuel consumed reported to KOBiZE by installations covered by the ETS [KOBiZE 2022]. EFs for high-methane natural gas, nitrified natural gas and colliery gas were estimated for particular years in the period 2005-2021. For the years before 2005, i.e. for years preceding the functioning of the ETS, the average EF values for individual gas types were calculated based on the CS EF values obtained for the years 2005-2016. These calculations for particular types of natural gas were used to estimate the CO₂ emission factors for the period 1988-2021 generally for natural gas combusted in the energy and industry sectors (1.A.1 and 1.A.2), and in the category: other sectors (1.A.4). The share estimation of individual natural gas types in the total natural gas consumption in a given sub-category was based on the national study [Waśniewska et al. 2016].

CO₂ country specific emission factors for fuel oil were based on the plant specific data from installations covered by the emissions trading system in which fuel oil was combusted (data specified in ETS reports as level 3 relating to EF was used [KOBiZE 2022]). Due to the fact that for 2005 representative

measurement data on fuel oil combustion was not available, the data from ETS reports was applied starting from 2006, and for earlier years the average value was adopted from the indicators specified for 2006-2018.

Values of country specific CO₂ EFs for hard coal, lignite, natural gas and fuel oil applied in GHG emission inventory were presented in the table in Annex 2.2.

Default emission factors [IPCC 2006] for the following fuels were applied: coke, hard coal briquettes, lignite briquettes, coke oven gas, blast furnace gas, diesel oil, LPG, crude oil, motor gasoline, jet kerosene, refinery gas, feedstock, other petroleum products, petroleum coke, biomass (fuel wood and wood waste, biogas), waste (industrial and municipal waste) and gas works gas.

It should be mentioned here, in response to the ERT recommendation that CO₂ EF for gasoline applied in road transportation sector in previous submissions was not implemented for combustion processes in stationary sources. The reason is that since 2017 Submission new methodology for 1.A.3 category applying the COPERT model with its emission factors has been used, which is not relevant for stationary combustion as CS one.

Generally, share of CO₂ emission from liquid fuels in total emission from combustion in stationary sources is not significant. This is especially visible when the analysis focuses on the share of individual liquid fuels and not as entire group, which covers several items. The table 3.1.1. provides an example of mentioned analysis for 1.A.1 category for 2021. Fuels classified as liquid fuels are marked in bold in the table. The share of individual fuels from this group in combustion in category 1.A.1 amounts only 0-1.6% in 2021.

Table 3.1.1. Percentage of emissions from individual fuels in total emissions in 1.A.1 category for 2021

Individual fuels	Share in CO ₂ emission in 1.A.1 category
Hard coal	56.8
Lignite	29.9
Hard coal briquettes (patent fuels)	0.0
Brown coal briquettes	0.0
Crude oil	0.0
Natural gas	6.5
Fuel wood and wood waste	-
Biogas	-
Industrial wastes	0.2
Municipal waste - non-biogenic fraction	0.4
Municipal waste – biogenic fraction	-
Other petroleum products	0.1
Petroleum coke	0.0
Coke	0.0
Liquid petroleum gas (LPG)	0.0
Motor gasoline	0.0
Aviation gasoline	0.0
Jet kerosene	0.0
Diesel oil	0.2
Fuel oil	1.6
Feedstocks	0.0
Refinery gas	0.6
Coke oven gas	1.7
Blast furnace gas	1.9
Gas works gas	0.0
Fuel groups	
Liquid fuels	2.5
Gaseous fuels	6.5
Solid fuels	90.4
Other fuels	0.6
Biomass	-
Total	100.0

The data in the table 3.1.1. shows that the adoption of emission factors from category 1.A.3 for fuels such as diesel oil, motor gasoline, LPG will not affect the inventory result, because the share of these fuels in emissions from stationary combustion is insignificant.

The above analysis shows that almost 95% of CO₂ emissions in category 1.A.1 are estimated based on country specific EFs.

The share of CO₂ emissions estimated based on national indicators in total emissions from the combustion of fuels in stationary sources in 2021 was over 90%. In the entire reporting period, this share ranged between 86% and 92%.

For coal and lignite, where the CS EFs were used, the oxidation factor was assumed as 0.980. In other cases oxidation factor assumed to be 1, in accordance with 2006 IPCC GLs.

CH₄ emission estimation from fuel combustion in stationary sources is based on the fuel consumption submitted by GUS to Eurostat (Eurostat database). In case of 1.A.1 IPCC subcategory for coal, lignite and biomass the country specific EFs of CH₄ were developed (following the recommendation E4 of the FCCC/ARR/2020/POL). Those EFs were established based on country study: *Development of methane country specific emission factors from the combustion of hard coal, lignite and biomass, ENERGOPOMIAR, Warsaw 2022*. The mentioned study was elaborated on the basis of data from national measurements and includes CH₄ emission factors for various types of boilers used in the Polish energy industry. It was necessary then to elaborate data set on corresponding boiler type share in Poland. Such analysis of the structure of boilers in large combustion plants was made using information contained in National Emission Database managed since 2010 by the KOBIZE. All these information allowed to establish the CH₄ emission factors based on the cited above study. Based on the analysis for selected years from 2011-2021, the following emission factors were applied for the entire reporting period: 0.11 kg CH₄/TJ for hard coal, 0.335 kg CH₄/TJ for lignite and 0.6 kg CH₄/TJ for biomass. Other CH₄ emission factors used to estimate emissions from fuel combustion in stationary sources are default ones [IPCC 2006].

Estimation of N₂O emission from fuel combustion in stationary sources is based on fuel consumption submitted by GUS to Eurostat (Eurostat database) and the recommended default emission factors [IPCC 2006].

All emission factors used in the GHG emission inventory for stationary combustion in 1.A IPCC category are presented in the tables in Annex 2.2 (tab. 14-29).

Trend of fuel use and methodology over the years 1988-2021

Estimation of CO₂ emission from fuel combustion in stationary sources for the years 1988-2021 is based on the way corresponding to the methodology presented above. Fuel consumptions from the Eurostat database were used. The Eurostat database does not cover fuel use data for Poland for the years before 1990. Therefore, fuel use data for the period: 1988-1989 were taken from IEA database [IEA]. The use of a different source of data on fuel consumption for the years 1988-1989 than for the period after 1990 does not affect data consistency in time-series. Evidence of data compliance between two AD sources is given by the consistency of fuel consumption since 1990 in the IEA database and Eurostat. Comparison of data from both sources for selected fuels is presented in the Annex 10 (the tables in the annex present comparison of the main fuel balance items for 7 significant fuels in selected years). Analysis of data source consistency proved full compliance of fuel consumption data for entire reported series and in the detail subsectors of individual categories of activity.

Fuel consumption in individual subsectors: 1.A.1, 1.A.2 and 1.A.4 was presented in the tables 1-13 (Annex 2.2). The country specific EFs of CO₂ for hard coal, lignite, natural gas and fuel oil for the years 1988-2021 are compiled in Annex 2.2 – table 14-26. CO₂ emission factors for other fuels are the IPCC default ones [IPCC 2006] and are included in Annex 2.2 – tab. 27. Applied CH₄ EFs are presented in table 28 while the default EFs of N₂O for particular fuel are given in the table 29 of this annex.

The time series of consumption for particular fuel groups and GHG emissions for the main subsectors of 1.A IPCC category are presented in the following chapters.

3.1.2. Fugitive emissions (CRF sector 1.B)

The GHG emission sources in fugitive emissions sector cover: fugitive emission from solid fuels (CO_2 and CH_4) and fugitive emission from oil and gas (CO_2 , CH_4 and N_2O).

Total emission of GHGs as carbon dioxide equivalent in 1.B subcategory amounted to 21 371 kt in 2021 and decreased since 1988 by 28%. Figure 3.1.4 shows emissions from 1.B.1 and 1.B.2 subcategories in period 1988-2021.

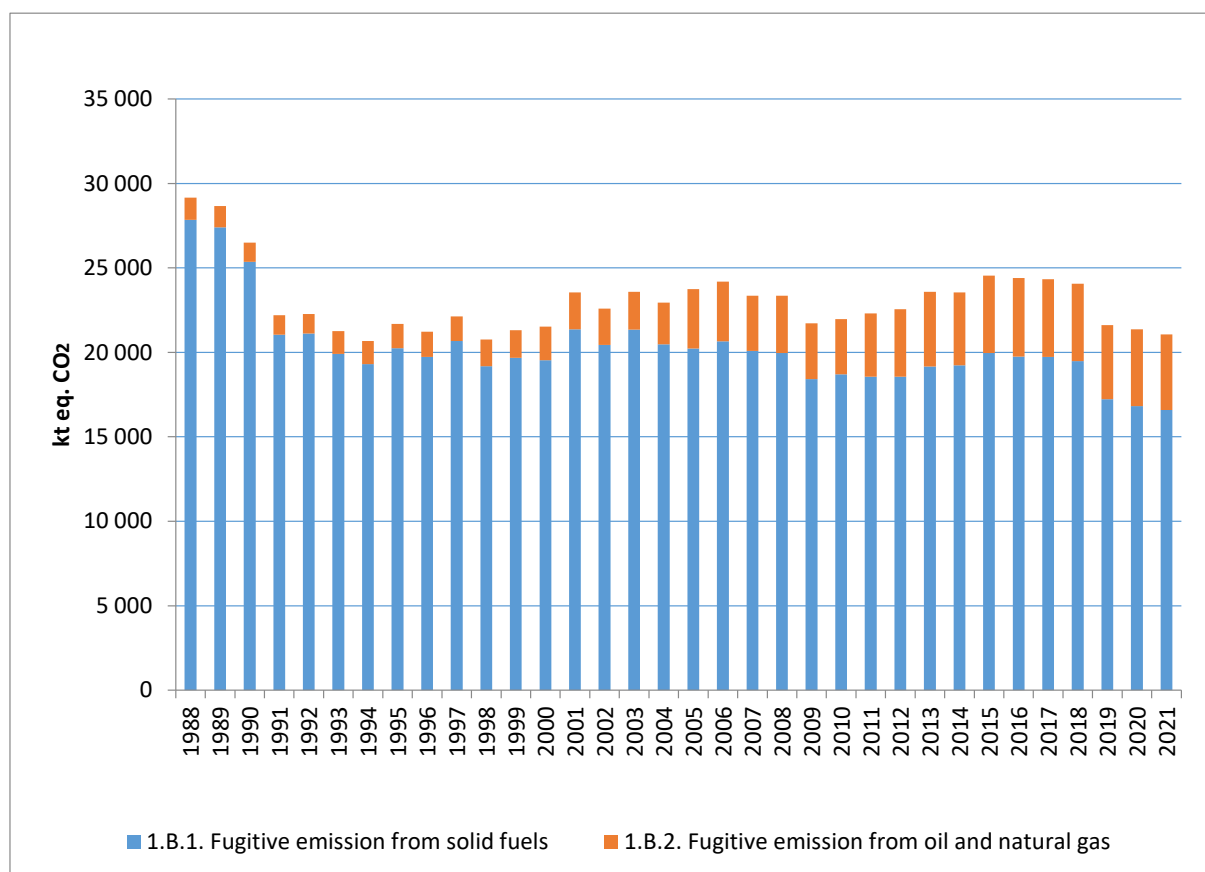


Figure 3.1.4. GHG emissions from 1.B.1 and 1.B.2 subcategories in 1988-2021

3.2. Fuel combustion (CRF 1.A)

3.2.1. Comparison of the sectoral approach with the reference approach

The Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO₂ from combustion of mainly fossil fuels. Comparability between the sectoral and reference approaches continues to allow a country to produce a second independent estimate of CO₂ emissions from fuel combustion. It allows to compare the results of these two independent estimates and indicate possible problems with the activity data, net calorific values, carbon content, carbon stored calculation, etc.

The Reference Approach is designed to calculate the emissions of CO₂ from fuel combustion, starting from high level energy supply data. The Reference Approach does not distinguish between different source categories within the energy sector and only estimates total CO₂ emissions from source category 1.A *Fuel Combustion*. The IPCC Reference Approach is based on determining carbon dioxide emissions from domestic consumption of fuels and its secondary products.

CO₂ emissions from fuel combustion were estimated based on recommended IPCC methodology [IPCC 2006, equation 6.1]:

$$CO_2 \text{ Emissions} = \sum_i [(AP_i \times CF_i \times CC_i)10^{-3} - EC_i]COF_i \times 44/12]$$

where:

i – fuel type

AP – apparent consumption of fuel, TJ or kt

CF – conversion factor for the fuel to energy unit, TJ/kt

CC – carbon content, t C/TJ

EC – excluded carbon, kt C

COF – carbon oxidation factor

44/12 – mass ratio of CO₂/C

CO₂ emissions were estimated based on adjusted fuel consumption data and default oxidation factors. National carbon emission factors were assumed for hard coal and lignite (based on empirical functions described in chapter 3.2.1). For fuels used in transport (gasoline, jet kerosene, diesel oil, LPG) average emission factors were applied from subcategories of 1.A. For other fuels default carbon emission factors were applied.

Apparent consumption of fuels was calculated as below:

$$\text{Apparent Consumption} = \text{Production} + \text{Imports} - \text{Exports} - \text{International Bunkers} - \text{Stock Change}$$

Data about production, imports, exports, international bunkers and stock change are based on Eurostat database. For calculations only data in energy unit (TJ) were used, therefore conversion factors for all fuels is equal 1 TJ/kt (CRF table 1.A(b)).

Total apparent consumption was corrected by subtracting the amount of carbon (excluded carbon) which does not lead to fuel combustion emission (carbon which is emitted in another sector of the inventory or is stored in a product manufactured from the fuel). The main sources of such carbon are those used as non-energy products and feedstocks. The quantity of carbon to be excluded is calculated according to following equation:

$$\text{Excluded carbon} = \text{activity data} \times CC \times 10^{-3}$$

where:

activity data – non energy use of fuel and feedstock, TJ

CC – carbon content, t C/TJ

As the use of energy products for non-energy purposes can lead to emissions Poland has calculated these emission and report them under category 2.D *Non-energy products from fuels and solvent use* (chapter 4.5).

In 2021 the difference between reference and sectoral approaches in CO₂ emissions is equal 1.16%. Comparison of both methods is given in table 3.2.1.

Table 3.2.1. Differences between CO₂ emissions in sectoral and reference approach

Year	Reference approach [kt]	Sectoral approach [kt]	Difference [%]
2021	309 765	306 225	1.16
2020	281 485	277 753	1.34
2019	295 090	292 920	0.74
2018	314 935	310 408	1.46
2017	312 118	311 960	0.05
2016	300 064	299 310	0.25
2015	285 790	288 749	-1.02
2014	286 134	285 703	0.15
2013	303 351	298 989	1.46
2012	298 220	303 353	-1.69
2011	317 117	309 817	2.36
2010	317 133	313 363	1.20
2009	296 595	296 992	-0.13
2008	311 089	306 711	1.43
2007	312 000	311 910	0.03
2006	317 496	313 882	1.15
2005	303 427	301 905	0.50
2004	301 226	302 634	-0.47
2003	303 518	297 932	1.87
2002	296 664	287 238	3.28
2001	299 706	293 435	2.14
2000	298 376	294 665	1.26
1999	317 012	307 785	3.00
1998	324 911	317 126	2.45
1997	354 287	343 398	3.17
1996	361 550	355 298	1.76
1995	349 227	339 229	2.95
1994	340 249	339 251	0.29
1993	360 296	345 401	4.31
1992	361 620	344 189	5.06
1991	370 683	352 345	5.20
1990	374 335	350 636	6.76
1989	451 822	419 770	7.64
1988	482 016	438 906	9.82

The Reference Approach and the Sectoral Approach often have different results which may be caused by:

- statistical differences - is the difference between energy available for final consumption covering the energy placed at the disposal of final users and final energy consumption covering energy supplied to the final consumer's door for all energy uses;
- distribution losses - losses due to transport or distribution of natural gas;
- differences in NCVs used in reference and sectoral approaches, especially for hard and brown coal, where NCV affects emission factors;
- part of emission from solid fuel use was included in sector Industrial processes (2.C.1: production of sinter, pig iron and steel).

The example of the differences between RA and SA related to the Statistical differences and Distribution losses in energy balance are shown in Annex 2.3. For example, for the years 1990-1993 there were significant Statistical differences in the balance of solid fuels, which is reflected in a greater difference between RS and SA for solid fuels in these years.

3.2.2. International bunker fuels

3.2.2.1. International aviation

This category include emissions from flights that depart in one country and arrive in a different country.

For the years 1990-2021 data related to jet kerosene are those of the Eurostat database, while for the base year and 1989 – those of the IEA database.

Jet kerosene given in Polish statistic is reported as International aviation although include whole amount of jet kerosene used for domestic and international purposes. To split jet kerosene Eurocontrol data were used. Each year, under contract with the European Commission's Directorate-General for Climate Action, EUROCONTROL calculates the mass of fuel burnt by civil aviation flights starting from and/or finishing at airports in the Member States of the European Union (EU). This work is done in support of both the European Environment Agency (EEA) and the Member States of the EU. The calculation are made with the split on domestic and international aviation. The total amount of jet kerosene used by Poland – calculated by Eurocontrol is similar to this reported by Poland to Eurostat. To stay in line with Eurostat database (and Polish statistic) only the share of domestic and international fuel use were used based on Eurocontrol data. Below in table are given Eurocontrol data of jet kerosene used in Poland for international and domestic purposes, the share of domestic and international use and for comparison Eurostat data.

Table 3.2.2. Eurocontrol and Eurostat data of jet kerosene used in Poland and the share of domestic and international use

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Eurocontrol														
Domestic	kt	21.86	24.78	26.94	26.16	24.30	28.61	31.43	45.75	34.21	38.84	34.36	34.21	36.89
International	kt	303.44	383.80	455.51	516.92	456.41	481.94	483.51	499.64	526.34	559.45	596.54	679.55	1266.92
Total	kt	325.30	408.58	482.44	543.08	480.71	510.55	514.93	545.39	560.55	598.28	630.90	713.76	1303.81
Eurostat	kt	311	415	432	519	470	495	485	537	524	590	646	685	852
Share														
Domestic	%	6.72	6.07	5.58	4.82	5.05	5.60	6.10	8.39	6.10	6.49	5.45	4.79	2.83
International	%	93.28	93.93	94.42	95.18	94.95	94.40	93.90	91.61	93.90	93.51	94.55	95.21	97.17
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
		2018	2019	2020	2021									
Eurocontrol														
Domestic	kt	36.89	35.78	35.34	17.65									
International	kt	1266.92	1457.94	1529.36	603.11									
Total	kt	1303.81	1493.72	1564.71	620.76									
Eurostat	kt	852	1 008	1 077	459									
Share														
Domestic	%	2.40	2.26	2.84	2.36									
International	%	97.60	97.74	97.16	97.64									
Total	%	100.00	100.00	100.00	100.00									

Due to the lack of Eurocontrol data for the years before 2005, the share for years 1988-2004 was assumed as a 5-years average from Eurocontrol data for years 2005-2009. The 5-years average, taken from the nearest years to data lack period, was evaluated as the most representative in consultations with experts in the area of transport and energy. The share 94.35% was then accepted for the whole period before 2005. Such assumption seems to be reliable and not affecting accuracy of the inventory.

For the estimation of GHG emissions from aviation bunker fuels, the same IPCC 2006 default emission factors for jet fuel were assumed as those used for emission estimation for domestic aviation: for CO₂ – 71.50 kg/GJ, for CH₄ - 0.0005 kg/GJ and for N₂O - 0.002 kg/GJ.

The fuel use data and the corresponding emission estimates of CO₂, CH₄ and N₂O for international aviation bunker for the 1988-2021 period are presented in table 3.2.2. Between 1988 and early 1990-

ties dramatic decrease in fuel consumption and heavy industry production occurred triggered by significant economic changes related to political transformation from centralized to market economy. These changes affected all energy sectors and this is the main reason why Poland choose 1988 as a base year (as being more representative in trend than 1990 with collapsing industry).

Table 3.2.3. Fuel consumption and GHG emissions in international aviation in 1988-2021

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Jet Kerosene	PJ	14.16	19.47	8.95	9.24	10.03	9.99	10.11	10.90	12.82	11.48
CO ₂ emission	kt	1 012	1 392	640	660	717	714	723	779	916	821
CH ₄ emission	kt	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
N ₂ O emission	kt	0.03	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Jet Kerosene	PJ	11.69	10.44	11.11	10.94	10.74	11.61	11.40	12.79	17.19	17.99
CO ₂ emission	kt	836	747	794	782	768	830	815	915	1 229	1 286
CH ₄ emission	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N ₂ O emission	kt	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.04
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Jet Kerosene	PJ	21.79	19.19	20.09	19.58	21.15	21.16	23.72	26.27	28.04	35.58
CO ₂ emission	kt	1 558	1 372	1 437	1 400	1 513	1 513	1 696	1 878	2 005	2 544
CH ₄ emission	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
N ₂ O emission	kt	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.07
		2018	2019	2020	2021						
Jet Kerosene	PJ	42.29	45.25	19.18	24.28						
CO ₂ emission	kt	3024.07	3235.20	1371.58	1760.07						
CH ₄ emission	kt	0.02	0.02	0.01	24.29						
N ₂ O emission	kt	0.08	0.09	0.04	0.05						

3.2.2.2. International navigation

This category include emissions from journeys that depart in one country and arrive in a different country. Includes emissions from fuels used by vessels of all flags that engaged in international water-borne navigation. Exclude consumption by fishing vessels.

1990-2021 fuel use data for fuels classified to the international marine bunker were taken directly from the Eurostat database. For the years 1988-1989, the respective data were taken from the database of the International Energy Agency (IEA).

For the estimation of GHG emissions from bunker fuels, the same IPCC 2006 default emission factors were assumed as those used for maritime navigation: for CO₂ and diesel oil 74.10 kg/GJ, for fuel oil 77.40 kg/GJ. The emission factors for CH₄ and N₂O for the two fuels are: 0.007 kg/GJ and 0.002 kg/GJ, respectively. The fuel use data and the corresponding emission estimates of CO₂, CH₄ and N₂O for international marine bunker for the 1988-2021 period are presented in table 3.2.4.

Table 3.2.4. Fuel consumption and GHG emissions in international navigation in 1988-2021

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Diesel oil	PJ	14.23	11.16	6.02	2.71	3.18	2.45	1.29	1.20	1.76	2.54
Fuel oil	PJ	9.00	9.37	10.58	3.80	6.83	3.19	4.28	4.65	5.13	6.34
CO ₂ emission	kt	1 751	1 552	1 265	495	764	429	427	449	528	679
CH ₄ emission	kt	0.163	0.144	0.116	0.046	0.070	0.039	0.039	0.041	0.048	0.062
N ₂ O emission	kt	0.046	0.041	0.033	0.013	0.020	0.011	0.011	0.012	0.014	0.018
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Diesel oil	PJ	2.88	4.43	1.89	0.95	1.85	1.98	1.68	4.99	3.74	2.15
Fuel oil	PJ	8.16	10.91	10.02	9.90	9.41	9.90	8.89	8.56	8.65	8.24
CO ₂ emission	kt	845	1172	916	836	866	913	812	1033	946	797
CH ₄ emission	kt	0.077	0.107	0.083	0.076	0.079	0.083	0.074	0.095	0.087	0.073
N ₂ O emission	kt	0.022	0.031	0.024	0.022	0.023	0.024	0.021	0.027	0.025	0.021

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Diesel oil	PJ	2.11	2.77	2.34	2.90	2.86	3.29	3.25	6.19	5.55	9.07
Fuel oil	PJ	9.41	7.60	6.68	4.24	3.20	2.60	2.92	1.88	2.12	2.12
CO ₂ emission	kt	885	794	690	543	459	445	467	604	575	836
CH ₄ emission	kt	0.081	0.073	0.063	0.050	0.042	0.041	0.043	0.057	0.054	0.078
N ₂ O emission	kt	0.023	0.021	0.018	0.014	0.012	0.012	0.012	0.016	0.015	0.022
		2018	2019	2020	2021						
Diesel oil	PJ	8.14	8.25	9.10	12.05						
Fuel oil	PJ	3.17	3.30	3.53	2.57						
CO ₂ emission	kt	848.11	866.78	946.96	1091.89						
CH ₄ emission	kt	0.08	0.08	0.09	0.10						
N ₂ O emission	kt	0.02	0.02	0.03	0.03						

Figure 3.2.1 shows emissions of greenhouse gases from international navigation and aviation bunker in period 1988-2021.

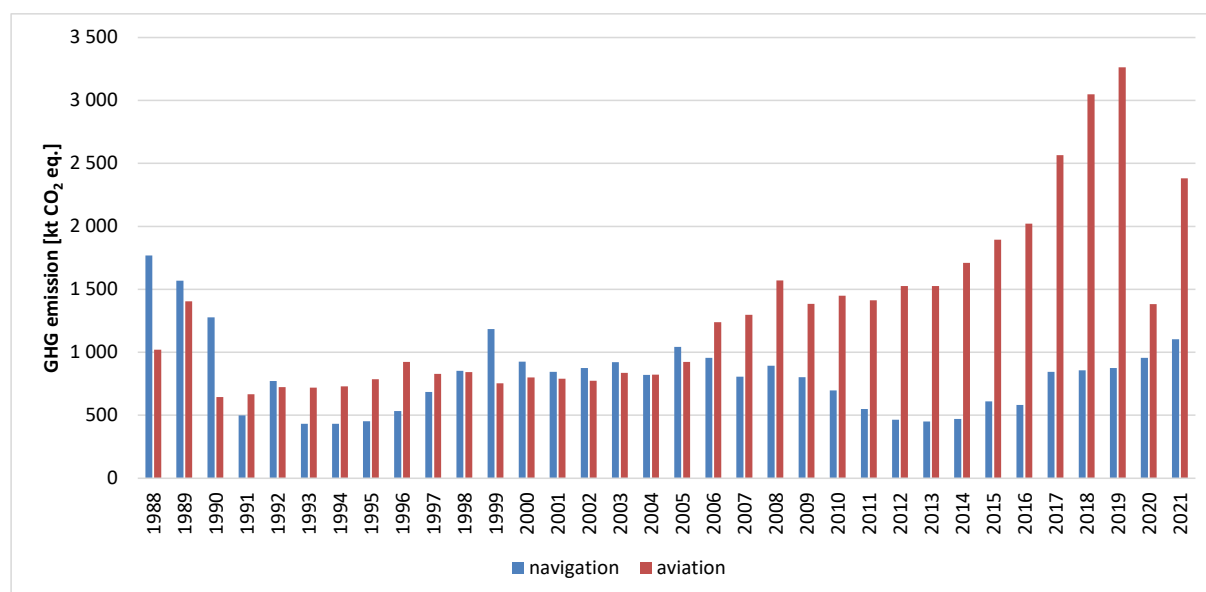


Figure 3.2.1. GHG emissions from international navigation and aviation bunker in period 1988-2021

3.2.3. Feedstocks and non-energy use of fuels

As the use of energy products for non-energy purposes can lead to emissions, Poland has calculated emissions from lubricant and paraffin waxes use and report them under category 2.D *Non-energy products from fuels and solvent use*. For more description see chapter 4.5.

3.2.4. CO₂ capture from flue gases and subsequent CO₂ storage

Not applicable in Poland.

3.2.5. Country-specific issues

Information on country specific fuel structure, important for national emission level and CO₂ emission factors for hard coal, lignite and natural gas (main fuels in Polish economy), is presented in chapters 3.1.1, 3.2.6 - 3.2.9 and in Annex 2.2.

3.2.6. Energy Industries (CRF sector 1.A.1)

3.2.6.1. Source category description

Emissions in 1.A.1 *Energy Industries* category are estimated for each detailed sub-categories as follows:

a) 1.A.1.a *Public electricity and heat production*

- 1.A.1.a.i *Electricity generation*
- 1.A.1.a.ii *Combined heat and power generation*
- 1.A.1.a.iii *Heat plants*

b) 1.A.1.b *Petroleum refining*

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

- 1.A.1.c.i *Manufacture of solid fuels* (coke-oven plants, gas-works plants, mines, patent fuel/briquetting plants)
- 1.A.1.c.ii *Oil and gas extraction*
- 1.A.1.c.iii *Other energy industries* (own use in Electricity, CHP and heat plants)

Subsector 1.A.1.a *Public Electricity and Heat Production* is by far the largest contributor to emissions from this category (see figure 3.2.6.1) – over 95.0% in 2021.

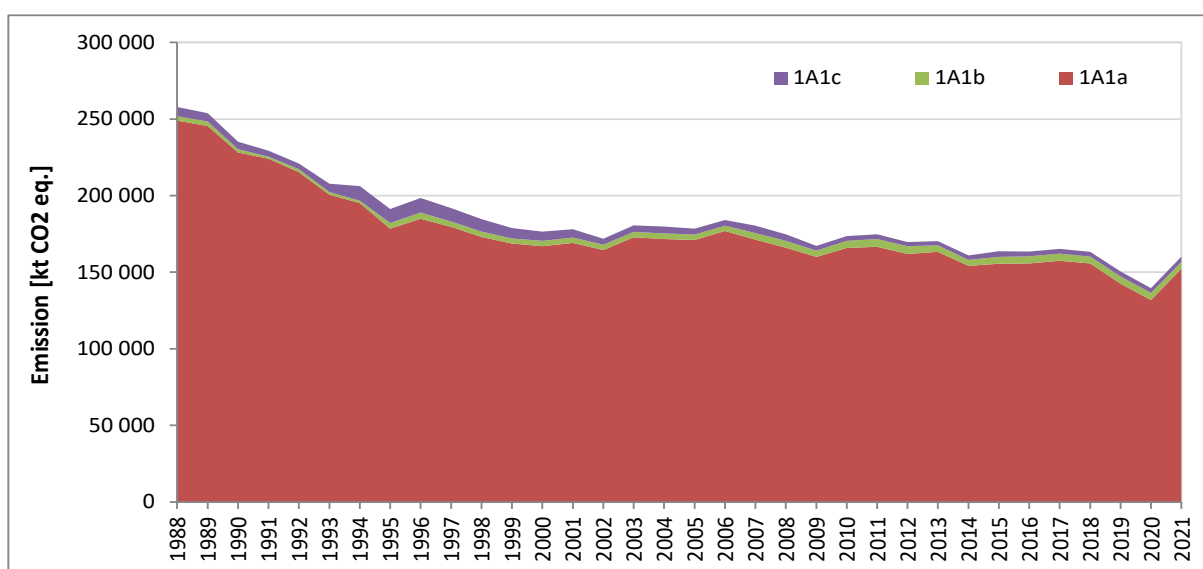


Figure 3.2.6.1. GHG emissions from *Energy Industries* in years 1988-2021 according to subcategories

3.2.6.2. Methodological issues

Methodology of emission estimation in 1.A.1 subcategory corresponds with methodology described for fuel combustion in stationary sources. Detailed information on fuel consumption and applied emission factors for subcategories mentioned below are presented in Annex 2.2.

3.2.6.2.1. Public electricity and heat production (CRF sector 1.A.1.a)

Table 3.2.6.1 presents the structure and amounts of fuel used in the sub-category 1.A.1.a *Public electricity and heat production* for the years 1988-2021.

Table 3.2.6.1. Fuel consumption for the years 1988-2021 in 1.A.1.a subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	75.134	72.672	67.606	63.237	58.167	56.902	57.781	26.492
Gaseous Fuels	21.274	21.900	21.641	16.329	9.562	3.106	4.095	4.738
Solid Fuels	2374.674	2346.290	2189.015	2165.482	2092.877	1945.459	1884.409	1758.969
Other Fuels	3.741	3.873	5.265	8.914	7.354	6.658	6.876	3.878
Biomass	16.699	15.129	14.585	14.387	17.289	13.783	14.057	1.447
TOTAL	2491.522	2459.864	2298.112	2268.349	2185.248	2025.908	1967.218	1795.524

	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	29.158	29.277	27.432	28.292	24.618	29.650	28.582	29.195
Gaseous Fuels	7.157	7.950	10.769	16.210	21.626	28.242	38.700	45.495
Solid Fuels	1828.531	1774.067	1713.596	1667.926	1645.950	1660.843	1607.298	1687.883
Other Fuels	3.393	3.267	0.550	0.575	0.883	1.031	1.520	0.372
Biomass	2.793	3.381	3.877	3.747	3.904	5.449	5.424	6.642
TOTAL	1871.032	1817.942	1756.223	1716.750	1696.981	1725.215	1681.524	1769.587
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	27.431	25.820	27.082	25.136	24.611	23.604	25.124	19.596
Gaseous Fuels	53.627	57.099	52.877	49.691	51.163	51.653	52.287	57.962
Solid Fuels	1666.839	1667.789	1725.837	1680.076	1617.899	1558.535	1613.359	1609.737
Other Fuels	0.459	0.541	0.477	0.440	0.593	0.682	0.809	0.861
Biomass	9.439	17.789	21.527	26.269	40.001	57.022	67.892	81.917
TOTAL	1757.795	1769.038	1827.800	1781.611	1734.266	1691.497	1759.471	1770.072
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	18.070	15.704	13.756	17.603	18.983	17.617	16.670	15.538
Gaseous Fuels	61.963	53.395	52.017	60.426	70.592	83.467	101.008	114.019
Solid Fuels	1555.795	1573.823	1475.713	1482.039	1479.913	1485.793	1456.596	1322.226
Other Fuels	0.791	0.718	0.813	1.552	4.378	6.159	8.501	10.243
Biomass	109.804	92.581	102.737	101.980	81.635	66.065	68.628	81.898
TOTAL	1746.423	1736.221	1645.037	1663.600	1655.500	1659.101	1651.403	1543.925
	2020	2021						
Liquid Fuels	16.691	19.043						
Gaseous Fuels	131.248	128.891						
Solid Fuels	1208.003	1418.522						
Other Fuels	9.956	9.456						
Biomass	92.074	89.219						
TOTAL	1457.972	1665.130						

The data in table 3.2.6.1 shows that the use of solid fuels is dominant in 1.A.1.a – mainly hard coal and lignite. In 2021, the use of hard coal was above 951 PJ i.e. almost 57% of the entire energy of all fuels used in that sub-sector. Lignite made approximately 26% of the energy, accordingly. Detailed data concerning individual fuel consumptions in 1.A.1.a subcategory for the entire period 1988-2021 was presented in Annex 2.2 (tab. 1).

Figure 3.2.6.2 shows CO₂ emission changes over the period 1988-2021. A significant emission decrease took place over the years 1988-1996 followed by a period of emission stabilization.

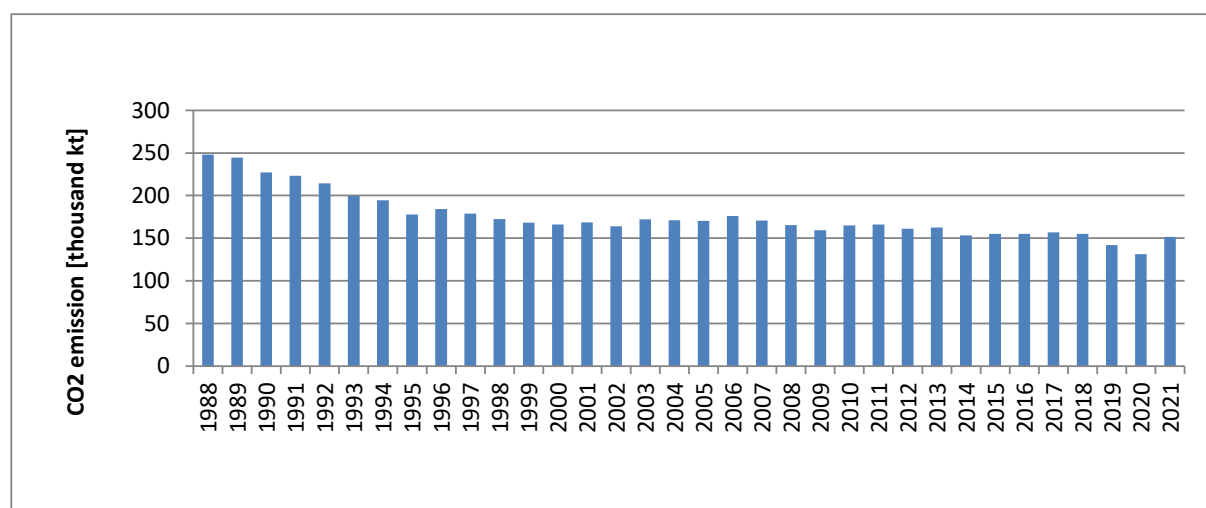


Figure 3.2.6.2. CO₂ emission for 1.A.1.a category in 1988-2021

Figure 3.2.6.3 shows emission trends for CH₄ and N₂O between the base year and 2021. Similarly to CO₂ a significant emission decrease for these gases happened in the period 1988-1995. Compared to the previous submission, the CH₄ emission from the 1.A.1.a category significantly decreased due to the introduction of country specific EFs for coal, lignite and solid biomass, which are much lower than the default ones (see chapter 3.1.1 and the table 28 in Annex 2.2).

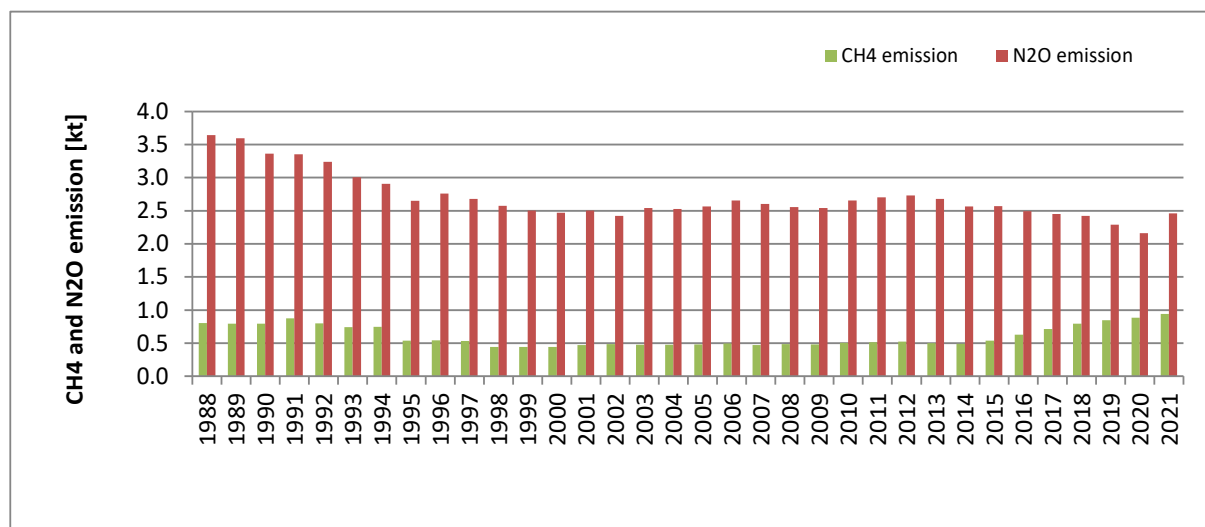


Figure 3.2.6.3. CH₄ and N₂O emissions for 1.A.1.a category in 1988-2021

3.2.6.2.2. Petroleum refining (CRF sector 1.A.1.b)

Table 3.2.6.2 shows fuel consumption data in sub-category 1.A.1.b *Petroleum refining* for the years 1988-2021. Detailed data on fuel consumptions in 1.A.1.b subcategory for the entire period 1988-2021 was presented in Annex 2.2 (table 2).

Table 3.2.6.2. Fuel consumption in 1988-2021 in 1.A.1.b subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	23.660	23.106	19.072	18.332	24.432	22.271	22.610	44.925
Gaseous Fuels	2.395	2.396	1.671	1.539	1.508	1.608	1.591	1.562
Solid Fuels	0.142	0.140	0.045	0.118	0.070	0.248	0.067	1.296
Other Fuels	7.724	7.487	5.222	0.272	0.682	0.002	0.259	1.919
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	33.921	33.129	26.010	20.261	26.691	24.129	24.527	49.701
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	50.579	44.067	39.930	34.331	38.739	41.005	41.243	39.700
Gaseous Fuels	1.749	2.529	8.244	10.832	12.110	11.354	10.124	12.770
Solid Fuels	1.509	1.315	0.701	0.610	0.269	0.135	0.022	0.000
Other Fuels	0.350	0.163	0.000	0.310	0.219	0.095	0.253	0.176
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	54.187	48.073	48.875	46.082	51.337	52.589	51.642	52.646
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	40.590	37.929	38.479	44.626	46.202	44.637	53.171	50.181
Gaseous Fuels	15.535	14.482	14.900	20.816	18.816	17.511	19.363	27.468
Solid Fuels	0.000	0.000	0.000	0.000	0.000	0.130	0.134	0.171
Other Fuels	0.221	0.285	0.224	0.000	0.000	0.000	0.000	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	56.346	52.696	53.603	65.442	65.018	62.278	72.668	77.820
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	50.212	35.081	29.978	42.429	44.013	30.737	33.491	31.653
Gaseous Fuels	30.638	34.779	35.103	25.957	25.802	43.842	36.056	42.920
Solid Fuels	0.122	0.178	0.198	1.045	0.935	0.890	0.778	0.695
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	80.972	70.038	65.279	69.431	70.750	75.468	70.325	75.268

	2020	2021
Liquid Fuels	33.079	36.523
Gaseous Fuels	41.086	33.795
Solid Fuels	0.539	0.602
Other Fuels	0.000	0.000
Biomass	0.000	0.000
TOTAL	74.704	70.920

Figure 3.2.6.4 shows CO₂ emission changes in 1988-2021 in sub-category 1.A.1.b.

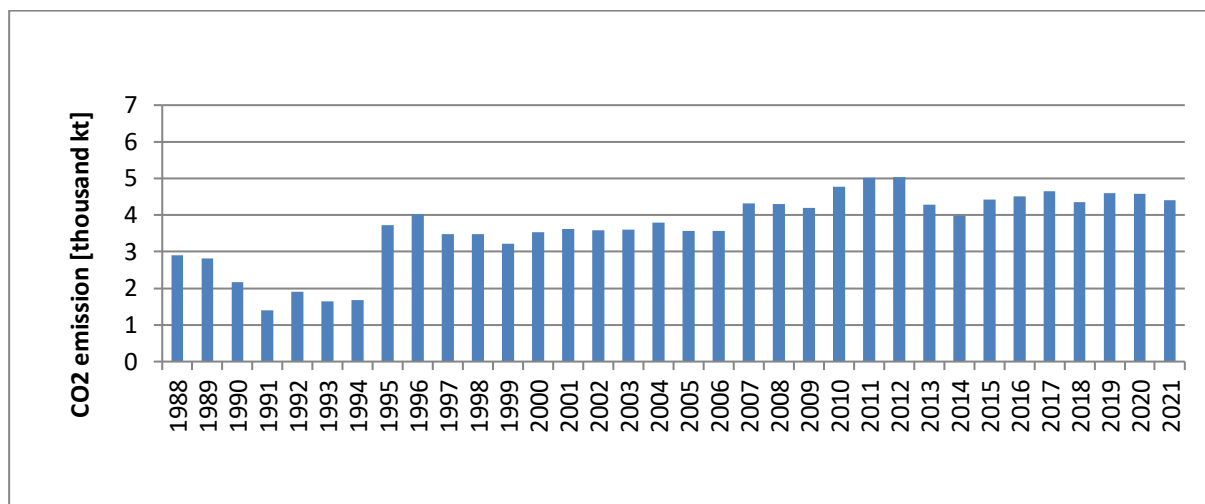


Figure 3.2.6.4. CO₂ emission for 1.A.1.b category in 1988-2021

Figure 3.2.6.5 shows the corresponding CH₄ and N₂O emission in that source sub-category between the base year and 2021.

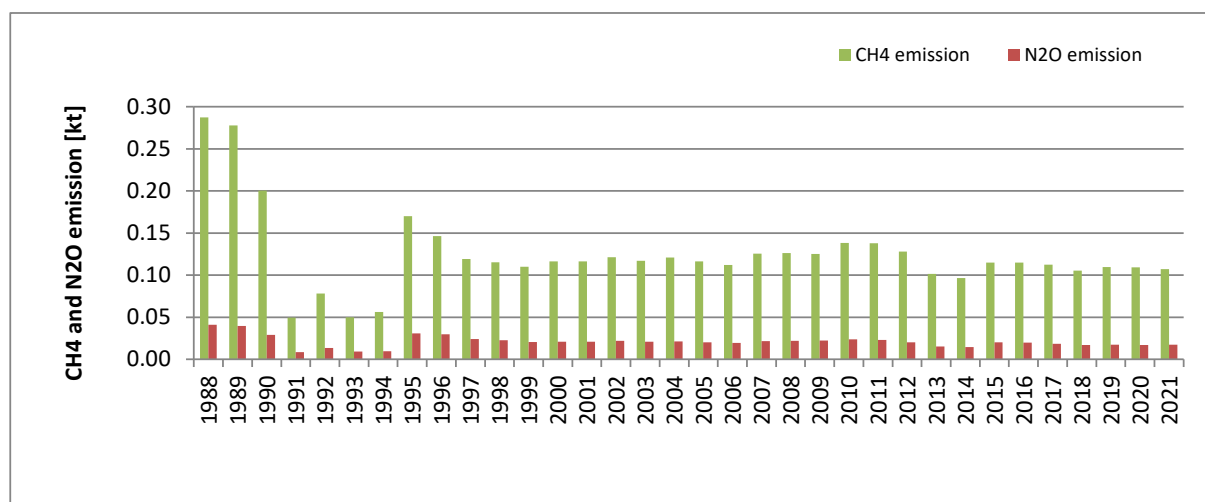


Figure 3.2.6.5. CH₄ and N₂O emissions for 1.A.1.b category in 1988-2021

3.2.6.2.3. Manufacture of solid fuels and other energy industries (CRF sector 1.A.1.c)

Table 3.2.6.3 shows the fuel use data in the sub-category 1.A.1.c over the period: 1988-2021. Particular fuel consumptions in 1.A.1.c subcategory for the entire period 1988-2021 were tabulated in Annex 2.2 (table 3).

Table 3.2.6.3. Fuel consumption in 1988-2021 in 1.A.1.c subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	2.550	2.180	2.073	2.374	2.543	5.017	4.209	4.259
Gaseous Fuels	13.736	15.364	12.371	12.432	14.666	12.353	17.401	14.851
Solid Fuels	70.465	66.330	58.471	49.165	47.205	61.441	101.445	98.892
Other Fuels	0.046	0.001	0.000	0.000	0.000	0.311	0.235	0.184

	1988	1989	1990	1991	1992	1993	1994	1995
Biomass	0.018	0.001	0.006	0.000	0.004	0.008	0.011	0.004
TOTAL	86.815	83.875	72.921	63.970	64.417	79.130	123.301	118.190
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	3.731	3.173	2.978	2.225	2.216	1.716	1.738	1.657
Gaseous Fuels	23.270	21.155	17.779	19.458	19.490	12.987	12.515	9.741
Solid Fuels	100.110	94.190	88.470	74.141	67.310	64.088	48.914	55.888
Other Fuels	0.158	0.138	0.000	0.000	0.014	0.008	0.005	0.013
Biomass	0.014	0.031	0.026	0.027	0.037	0.052	0.047	0.026
TOTAL	127.283	118.686	109.252	95.850	89.067	78.851	63.218	67.325
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	1.447	1.696	1.418	1.496	1.448	1.631	1.755	2.178
Gaseous Fuels	11.190	10.106	10.363	9.680	9.239	8.858	10.321	9.805
Solid Fuels	60.786	51.647	53.458	66.074	63.469	44.062	47.350	47.519
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.010
Biomass	0.020	0.014	0.026	0.085	0.037	0.137	0.349	0.162
TOTAL	73.443	63.464	65.265	77.335	74.193	54.687	59.777	59.674
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	1.574	1.891	1.429	1.892	1.376	1.413	1.441	1.835
Gaseous Fuels	11.205	12.013	12.788	24.089	17.804	15.999	15.014	18.586
Solid Fuels	41.801	42.683	43.085	45.386	44.217	43.478	44.972	44.272
Other Fuels	0.001	0.002	0.002	0.002	0.005	0.006	0.012	0.001
Biomass	0.160	0.122	0.039	0.000	0.032	0.023	0.036	0.029
TOTAL	54.742	56.711	57.343	71.369	63.434	60.919	61.475	64.723
	2020	2021						
Liquid Fuels	1.297	1.179						
Gaseous Fuels	22.482	24.293						
Solid Fuels	38.071	44.620						
Other Fuels	0.001	0.001						
Biomass	0.035	0.019						
TOTAL	61.886	70.111						

The emission trends of CO₂, CH₄ and N₂O in the 1988-2021 period are shown in figures 3.2.6.6 and 3.2.6.7.

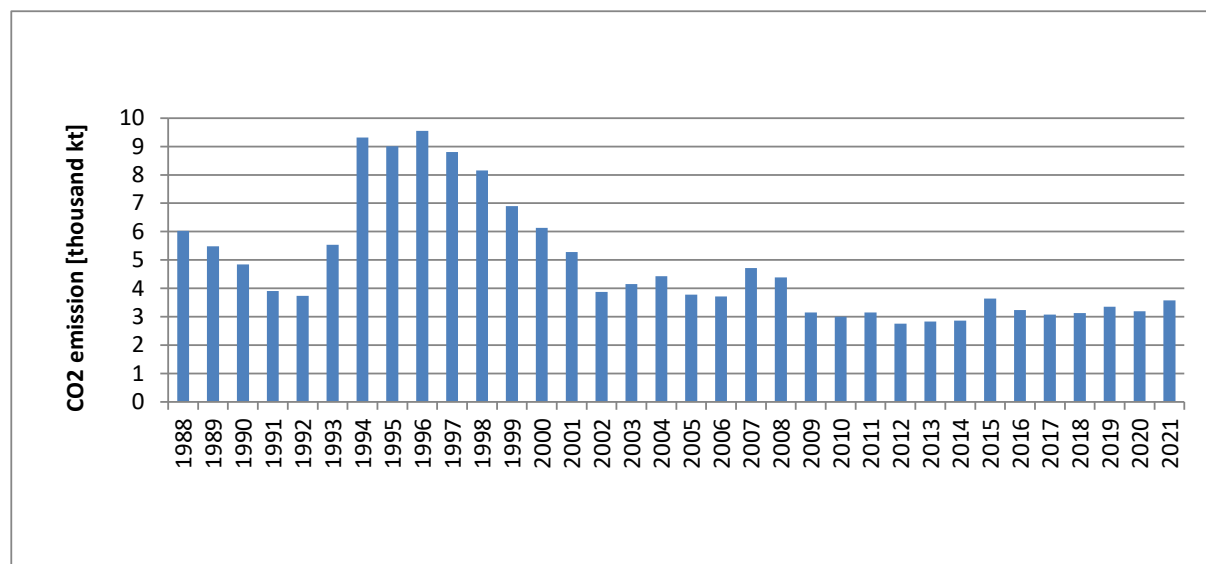
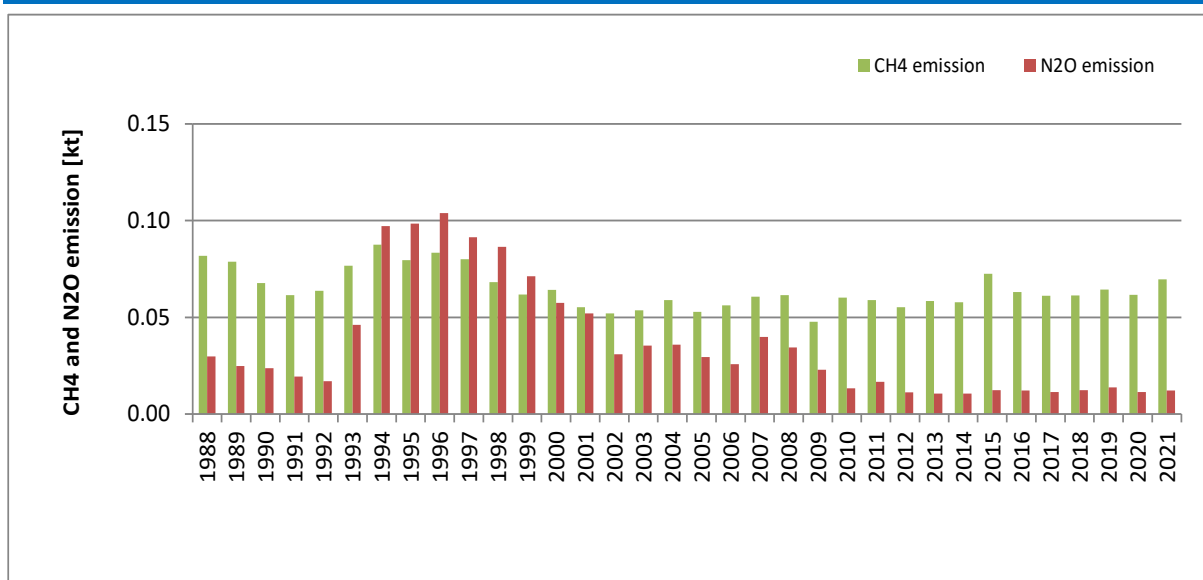


Figure 3.2.6.6. CO₂ emission for 1.A.1.c category in 1988-2021

Figure 3.2.6.7. CH₄ and N₂O emissions for 1.A.1.c category in 1988-2021

3.2.6.3. Uncertainties and time-series consistency

Uncertainty analysis for the year 2021 for IPCC sector 1. *Energy* was estimated with use of approach 1 described in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Simplified approach was based on the assumptions that every value is independent and probability distribution is symmetric. Results of the sectoral uncertainty analysis are given below. More details on uncertainty assessment of whole inventory are given in annex 8.

Recalculation of data for years 1988-2020 ensured consistency for whole time-series.

2021	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ Emission uncertainty [%]	CH ₄ Emission uncertainty [%]	N ₂ O Emission uncertainty [%]
1. Energy	310 508.39	823.51	9.83	1.9%	31.7%	11.6%
A. Fuel combustion	306 225.28	152.59	9.82	2.0%	13.9%	11.6%
1. Energy industries	159 531.72	1.12	2.49	2.6%	9.3%	29.9%
2. Manufacturing industries and construction	29 829.41	4.31	0.59	2.3%	12.3%	25.6%
3. Transport	67 559.43	3.69	2.60	5.8%	9.7%	19.1%
4. Other sectors	49 304.71	143.47	4.15	3.9%	14.7%	16.6%
5. Other						
B. Fugitive emissions from fuels	4 283.11	670.92	0.00	9.6%	38.8%	74.9%
1. Solid fuels	2 449.08	565.76		15.0%	45.8%	
2. Oil and natural gas and other from energy production	1 834.03	105.16	0.00	9.9%	20.1%	74.9%

3.2.6.4. Source-specific QA/QC and verification

Activity data used in the GHG inventory concerning energy sector come from Eurostat Database which is fed by the Statistics Poland (GUS). As this database covers period since 1990, IEA database before 1990 is used for years 1988 and 1989. It should be underlined that data in both databases are fully consistent and based on the same questionnaires sent by Polish national statistics. Evidence of data compliance between two AD sources is given by the consistency of fuel consumption since 1990 in the IEA database and Eurostat. Comparison of data from both sources for selected fuels is presented in the Annex 10.

GUS is responsible for QA/QC of collected and published data. Activity data applied in GHG inventory are regularly checked and updated if necessary according to adjustments made in Eurostat Database.

The source of data on the consumption of fuels and energy for national statistics are based on reports, which enterprises are obliged to report to the Statistics Poland (GUS). This is done through the reporting portal. The forms for all statistical reports are available on GUS website: <http://form.stat.gov.pl/formularze/2021/index.htm>

The main energy forms are G-03 and G-02. Among enterprises obligated to this reporting there are also entities participating in the ETS system. Based on the data collected via the reporting portal, a database is created from which information for national energy balances elaboration and filling out questionnaires reporting Polish energy data to international statistical institutions (Eurostat, IEA, OECD) are taken. This ensures data consistency. Data from individual reports are subject to cross-check procedures. There are also algorithms comparing the data from the reporting year with the previous submission. Questionnaires with data on fuel and energy consumption reported to Eurostat, IEA and OECD are also subject to verification by these institutions. The questions regarding data from the entire long-term time series are directed to GUS. Doubts are clarified and, if necessary, the data is corrected (the entire adjusted trend is submitted in the questionnaire to the above-mentioned statistical organizations). Therefore the data in the mentioned databases can be treated as consistent, coherent and verified.

In the context of the information given above the drop in fuels consumption between 1989 and 1990 is not the result of source data change. Main driver of the significant decline in AD and emissions in the energy sector between these years is political system change and transformation of the economy in Poland where sudden drop in production in many energy-intensive industries occurred followed by energy efficiency measures.

One of the quality control elements of activity data check in national GHG inventories is preparation of fuel balances (see Chapter 1.4, tab. 1.1). For the main fuels (i.e. coal, lignite) calorific values are analysed for avoiding significant errors. Close cooperation is developed between inventory experts and institutions responsible for energy data. Any doubtful fuel consumption values are systematically verified - it is often required to obtain additional confirmation of data by installations/entities submitting the energy questionnaire. In case of any doubts energy data are also validated based on Statistics Poland's Energy Statistics published annually.

Additional verification of data in energy sector covers comparison of sectoral and reference approaches within the GHG inventory.

Information from reports on emissions from installations covered by the ETS, reported to KOBiZE on an annual basis, is also taken into account for preparation the national greenhouse gas inventory. Country specific EFs are used in GHG inventory in category 1A - *Fuel combustion* for natural gas and fuel oil which were developed on the basis of data on CO₂ emissions and fuel consumption contained in reports prepared by companies under ETS. CO₂ emission factors for hard coal and lignite from ETS reports for public power plants are also analysed for comparison with the CS EFs applied in inventory. The results of the national GHG inventory in comparison with relevant ETS data according to the main IPCC subcategories are reported to the EU in the form of *MMR Annex V table (Article 10-Reporting on consistency of reported emissions with data from the emissions trading system)*. High convergence between both kind of data is noted although in some cases methodological differences influence reported emissions under inventory and ETS. The example of such different approaches covers fuel consumption published by energy statistic used in the GHG inventory and data on fuel use given in ETS reports. National statistics include data in which the division of fuels into the production of commercial and non-commercial heat is distinguished for Autoproducers (Autoproducer CHP Plants and Autoproducer Heat Plants), which is not differentiated in ETS reports. Fuel consumptions connected with the production of commercial heat at Autoproducers are aggregated and added in inventory to category 1.A.1.a, due to unavailability in statistical data of detail division of input for commercial heat production into individual industry sectors. Fuels used for the production of non-commercial heat at Autoproducers are qualified in statistics as final energy consumption in a given industry sector, and are reported in inventory in given sub-category 1.A.2. Additional problem in comparison of fuel

consumption between ETS and energy statistics/GHG inventory AD can be the results of differences in NCVs. There are cases where different NCVs are used for calculations in ETS and in statistics applied in the GHG inventory. It should be mentioned here that the amounts of fuel expressed in energy units (TJ) are used in the inventory.

Calculations in energy sector were examined with focus on formulas, units and trends consistency. Generally QC procedures follow QA/QC plan presented in Annex 7.

3.2.6.5. Source-specific recalculations

Significant correction for the years 1988-2020 in CH₄ emission is the result of application of the country specific EFs for methane in combustion of coal, lignite and solid biomass in 1.A.1 subcategory (development of new CS EFs was described in the Chapter 3.1.1 and values of CH₄ EFs are presented in table 28 in Annex 2.2).

Additional changes for 2020 are connected with the slight adjustments in fuel consumption introduced as a data update from EUROSTAT database.

Table 3.2.6.4. Changes of GHG emission values in 1.A.1 subcategory as a result of recalculations

Changes	1988	1989	1990	1991	1992	1993	1994	1995
CO₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH₄								
kt	-2.441	-2.368	-2.223	-2.202	-2.223	-2.011	-1.991	-1.516
%	-67.55	-67.27	-67.67	-69.09	-70.31	-69.84	-69.06	-65.86
N₂O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Changes	1996	1997	1998	1999	2000	2001	2002	2003
CO₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH₄								
kt	-1.622	-1.584	-1.539	-1.484	-1.460	-1.512	-1.454	-1.550
%	-67.80	-68.41	-71.11	-70.71	-70.13	-70.13	-68.87	-70.59
N₂O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Changes	2004	2005	2006	2007	2008	2009	2010	2011
CO₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH₄								
kt	-1.626	-1.866	-2.010	-2.118	-2.427	-2.879	-3.226	-3.608
%	-71.28	-74.10	-75.21	-76.29	-78.24	-81.53	-82.13	-83.56
N₂O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Changes	2012	2013	2014	2015	2016	2017	2018	2019
CO₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH₄								
kt	-4.349	-3.832	-4.020	-3.983	-3.354	-2.839	-2.881	-3.154
%	-86.03	-85.28	-86.19	-84.60	-80.65	-76.18	-75.02	-75.54
N₂O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Changes	2020
CO₂	
kt	-2.61
%	0.00
CH₄	
kt	-3.288
%	-75.69
N₂O	
kt	0.000
%	0.00

3.2.6.6. Source-specific planned improvements

No improvements are planned at the moment.

3.2.7. Manufacturing Industries and Construction (CRF sector 1.A.2)

3.2.7.1. Source category description

Emissions in 1.A.2 *Manufacturing industries and construction* category are estimated for each fuel in detailed sub-categories as follows:

- a) *Iron and steel* - 1.A.2.a
- b) *Non-ferrous metals* - 1.A.2.b
- c) *Chemicals* - 1.A.2.c
- d) *Pulp, paper and print* - 1.A.2.d
- e) *Food processing, beverages and tobacco* - 1.A.2.e
- f) *Non-metallic minerals* - 1.A.2.f
- g) *Other* - 1.A.2.g:
 - *Manufacturing of machinery* - 1.A.2.g.i
 - *Manufacturing of transport equipment* - 1.A.2.g.ii
 - *Mining (excluding fuels) and quarrying* - 1.A.2.g.iii
 - *Wood and wood products* - 1.A.2.g.iv
 - *Construction* - 1.A.2.g.v
 - *Textile and leather* - 1.A.2.g.vi
 - *Other* (other industry branches not included elsewhere) - 1.A.2.g.vii

Subsector 1.A.2.f *Non-metallic minerals*, 1.A.2.c *Chemicals* and 1.A.2.a *Iron and Steel* are the largest contributors to emissions from this category (see figure 3.2.7.1) – respectively 30.8%, 22.9% and 13.6% in 2021.

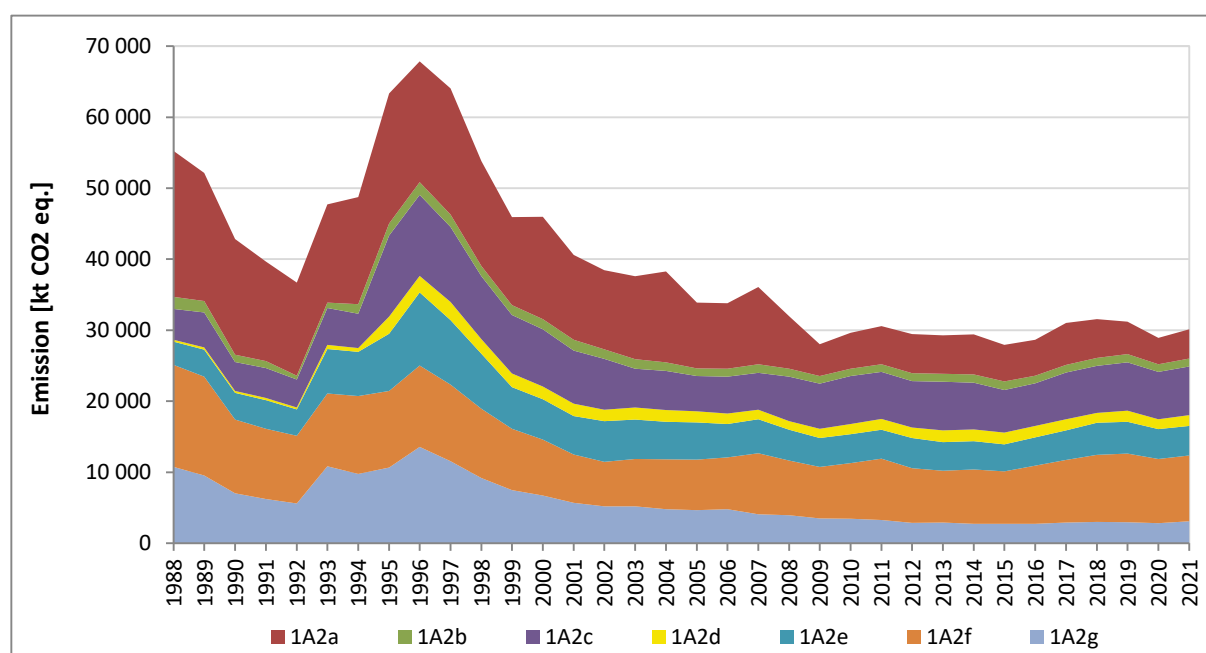


Figure 3.2.7.1. Emissions from *Manufacturing Industries and Construction* category in years 1988-2021 according to subcategories

3.2.7.2. Methodological issues

Methodology of emission estimation in 1.A.2 subcategory corresponds with methodology described for fuel combustion in stationary sources. Detailed information on fuel consumption and applied emission factors for subcategories listed below are presented in Annex 2.2.

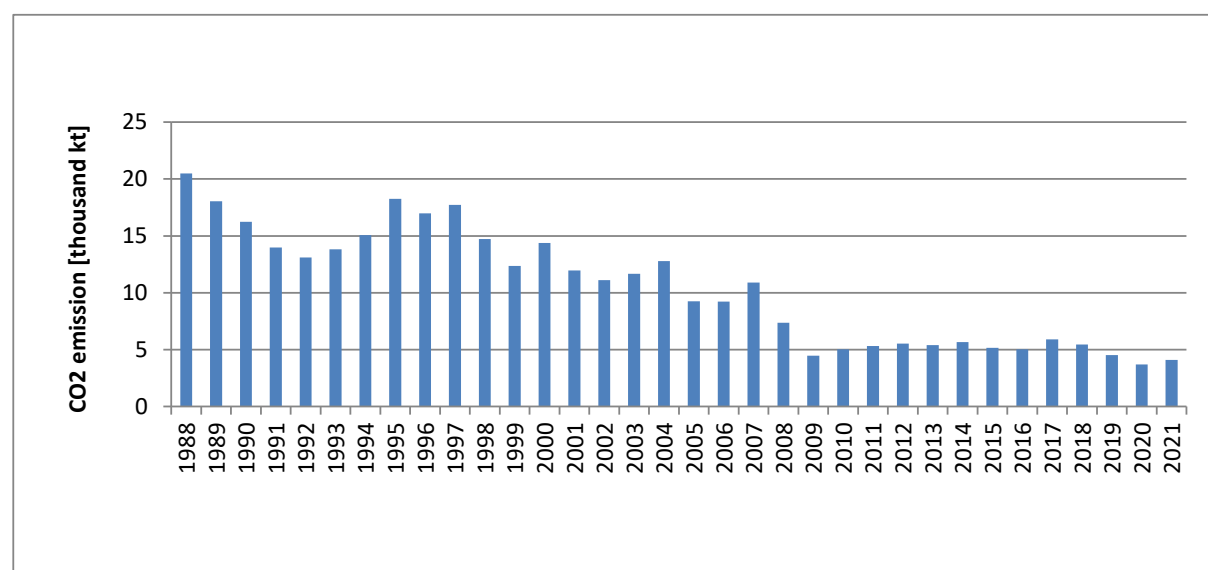
3.2.7.2.1. Iron and steel (CRF sector 1.A.2.a)

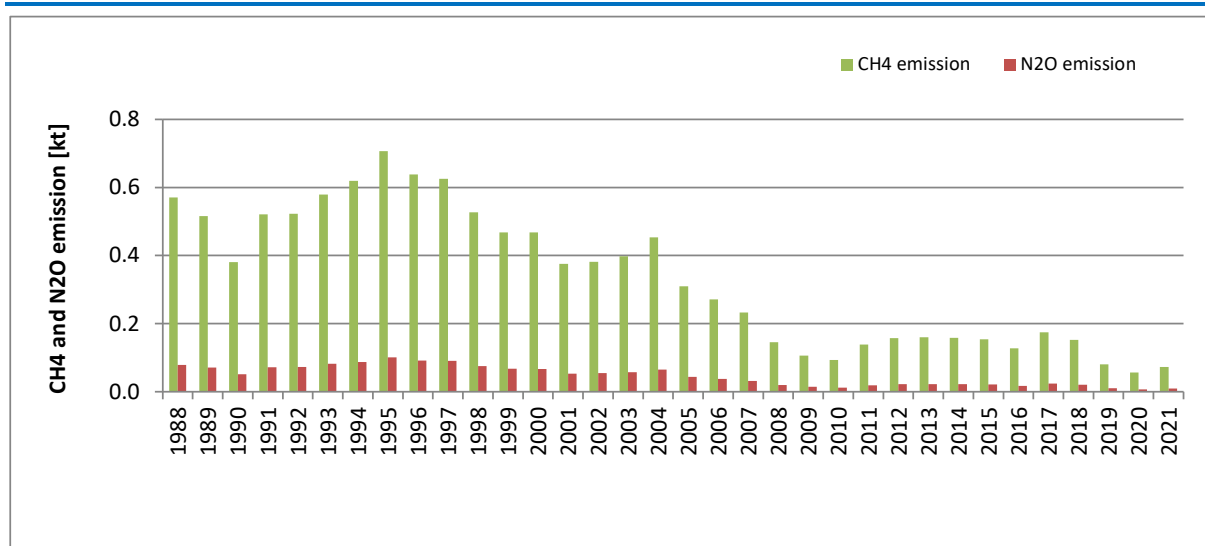
Table 3.2.7.1 shows the fuel use data in the sub-category 1.A.2.a *Iron and steel* for the period: 1988-2021. Detailed data on fuel consumptions in 1.A.2.a subcategory for the entire period 1988-2021 was presented in Annex 2.2 (table 4).

Table 3.2.7.1. Fuel consumption in 1988-2021 in 1.A.2.a subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	18.248	15.528	11.282	8.007	5.505	4.667	3.549	2.834
Gaseous Fuels	73.507	63.332	52.851	33.974	26.568	25.562	25.487	24.239
Solid Fuels	95.323	82.955	75.403	72.311	72.764	84.180	95.514	117.353
Other Fuels	3.158	3.344	4.079	6.756	6.497	4.272	3.757	2.941
Biomass	0.000	0.000	0.000	0.000	0.000	0.016	0.014	0.005
TOTAL	190.236	165.159	143.615	121.048	111.334	118.697	128.320	147.372
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	1.873	5.374	1.917	2.209	1.756	1.008	0.366	0.318
Gaseous Fuels	25.898	28.278	23.993	21.440	22.024	18.329	15.463	14.827
Solid Fuels	111.979	112.482	98.551	79.891	88.616	75.051	72.276	76.592
Other Fuels	0.498	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.006	0.004	0.006	0.004	0.003	0.006	0.003	0.004
TOTAL	140.253	146.138	124.467	103.544	112.398	94.393	88.108	91.741
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	0.271	0.086	0.129	0.086	0.133	0.133	0.133	0.165
Gaseous Fuels	19.964	20.455	20.998	22.716	20.397	16.595	16.916	17.209
Solid Fuels	82.612	58.075	55.649	59.989	38.709	23.012	26.182	29.987
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.004	0.002	0.001	0.001	0.001	0.001	0.000	0.000
TOTAL	102.851	78.619	76.777	82.792	59.240	39.740	43.230	47.360
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	0.199	0.185	0.197	0.196	0.196	0.238	0.232	0.230
Gaseous Fuels	16.905	16.242	16.097	16.701	19.458	23.715	25.022	21.212
Solid Fuels	31.663	31.706	33.044	28.527	24.703	30.124	26.884	19.660
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
TOTAL	48.767	48.134	49.338	45.425	44.358	54.078	52.139	41.103
	2020	2021						
Liquid Fuels	0.179	0.196						
Gaseous Fuels	21.382	23.123						
Solid Fuels	14.812	17.825						
Other Fuels	0.000	0.000						
Biomass	0.000	0.008						
TOTAL	36.373	41.152						

Figure 3.2.7.2 shows CO₂ emissions in the 1988-2021 period. Emissions of CH₄ and N₂O in the same time period are shown in figure 3.2.7.3. Emission trends for all three gases follow closely the trends in fuel use.

Figure 3.2.7.2. CO₂ emission for 1.A.2.a category in 1988-2021

Figure 3.2.7.3. CH₄ and N₂O emissions for 1.A.2.a category in 1988-2021

3.2.7.2.2. Non-ferrous metals (CRF sector 1.A.2.b)

The data on fuel type use in the sub-category 1.A.2.b *Non-ferrous metals* over the 1988-2021 period is presented in table 3.2.7.2. More detailed data concerning fuel consumptions was tabulated in Annex 2.2 (table 5).

Table 3.2.7.2. Fuel consumption in 1988-2021 in 1.A.2.b subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	0.683	0.803	0.811	0.851	0.937	0.854	0.937	0.899
Gaseous Fuels	5.638	5.470	4.599	4.633	1.213	1.745	5.321	5.447
Solid Fuels	12.001	10.832	6.601	5.703	3.186	4.618	7.831	10.099
Other Fuels	0.870	0.719	0.439	0.483	0.514	0.729	0.823	2.150
Biomass	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
TOTAL	19.191	17.823	12.449	11.670	5.850	7.947	14.913	18.595
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	0.949	0.861	0.783	0.738	0.871	0.792	0.623	0.500
Gaseous Fuels	5.108	5.424	5.639	5.660	5.814	5.700	5.589	5.868
Solid Fuels	10.609	10.156	11.478	11.106	11.426	12.452	11.431	10.590
Other Fuels	2.411	2.361	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.149	0.042	0.026	0.010	0.011	0.005	0.001	0.000
TOTAL	19.226	18.844	17.925	17.514	18.122	18.949	17.644	16.958
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	0.664	0.623	0.623	0.381	0.381	0.379	0.383	0.339
Gaseous Fuels	6.402	6.464	6.880	6.740	6.537	5.846	6.039	6.670
Solid Fuels	8.675	6.678	6.904	7.816	7.701	7.164	6.882	7.241
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	15.741	13.765	14.407	14.937	14.619	13.389	13.304	14.250
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	0.293	0.293	0.253	0.249	0.412	0.673	0.472	0.533
Gaseous Fuels	6.890	6.703	6.950	7.225	7.226	7.554	7.958	7.958
Solid Fuels	7.329	7.367	7.806	7.974	6.841	6.209	6.738	7.096
Other Fuels	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	14.512	14.364	15.009	15.448	14.480	14.437	15.168	15.587
	2020	2021						
Liquid Fuels	0.468	0.344						
Gaseous Fuels	7.663	7.982						
Solid Fuels	6.539	6.637						
Other Fuels	0.000	0.000						
Biomass	0.000	0.000						
TOTAL	14.670	14.963						

Emissions of the main greenhouse gases in 1.A.2.b between the base year and 2021 are shown in figures 3.2.7.4 and 3.2.7.5.

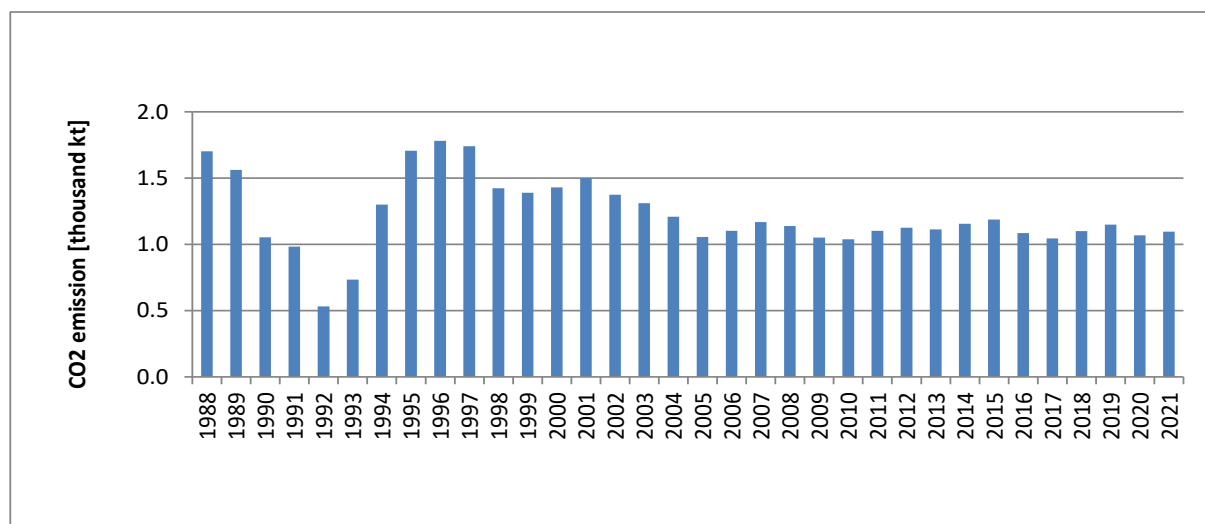


Figure 3.2.7.4. CO₂ emission for 1.A.2.b category in 1988-2021

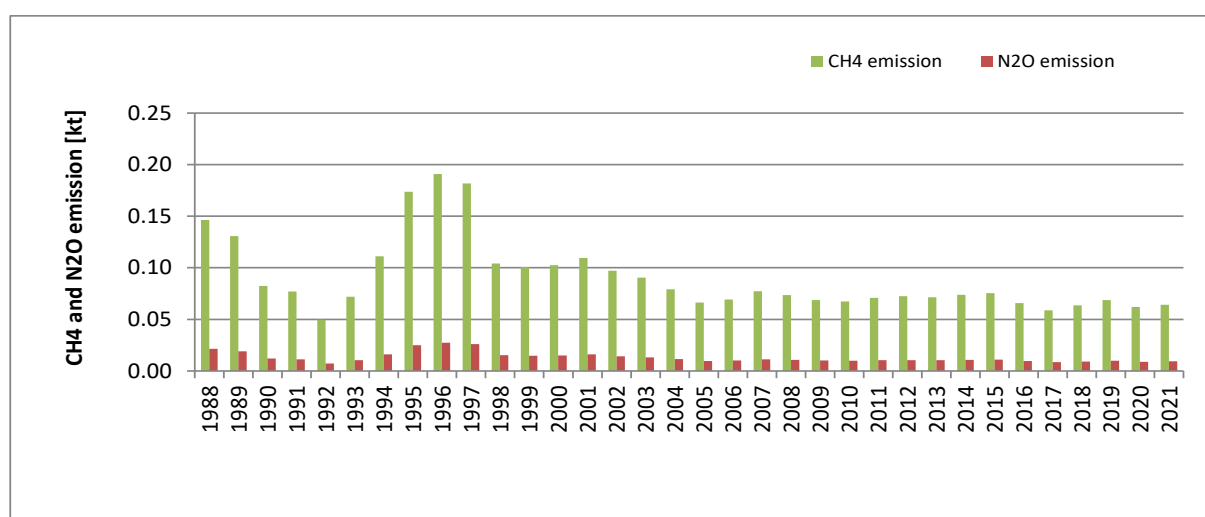


Figure 3.2.7.5. CH₄ and N₂O emissions for 1.A.2.b category in 1988-2021

3.2.7.2.3. Chemicals (CRF sector 1.A.2.c)

Detailed data on fuel consumptions in 1.A.2.c subcategory for the entire period 1988-2021 was presented in Annex 2.2 (table 6). The data on fuel type use in the sub-category 1.A.2.c *Chemicals* over the 1988-2021 period is presented in the table 3.2.7.3.

Table 3.2.7.3. Fuel consumption in 1988-2021 in 1.A.2.c subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	14.825	13.968	4.132	6.224	9.007	7.738	4.565	10.772
Gaseous Fuels	6.409	6.244	5.289	4.340	4.432	10.075	4.507	6.356
Solid Fuels	12.407	14.986	10.759	9.252	6.903	16.648	10.206	74.727
Other Fuels	12.255	14.915	16.712	18.586	17.039	18.003	22.591	21.546
Biomass	0.345	0.390	0.118	0.039	0.010	0.003	0.035	0.007
TOTAL	46.24061	50.503	37.011	38.440	37.390	52.467	41.905	113.408
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	19.685	23.076	41.125	39.304	38.484	33.232	32.995	33.565
Gaseous Fuels	6.191	11.024	9.408	9.041	9.464	8.481	7.199	6.457
Solid Fuels	75.325	65.835	57.054	52.352	51.675	50.217	47.431	30.119
Other Fuels	17.374	14.356	0.672	0.582	0.607	0.618	0.567	0.875
Biomass	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.153
TOTAL	118.575	114.290	108.260	101.280	100.230	92.547	88.194	71.168

	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	33.689	26.009	29.338	29.810	23.501	26.741	22.115	16.816
Gaseous Fuels	7.494	8.061	9.009	8.754	7.950	9.707	11.807	13.887
Solid Fuels	29.110	29.427	28.861	29.366	45.594	43.347	48.722	49.579
Other Fuels	1.070	0.570	0.671	0.707	0.509	0.584	0.770	0.732
Biomass	0.094	0.153	0.000	0.121	0.000	0.058	0.058	0.053
TOTAL	71.458	64.220	67.879	68.758	77.554	80.437	83.472	81.068
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	13.779	16.675	13.302	10.318	10.200	13.099	12.732	18.411
Gaseous Fuels	13.568	14.696	14.500	14.860	12.068	13.020	15.171	14.969
Solid Fuels	50.452	50.892	50.088	46.363	48.295	51.209	51.499	51.002
Other Fuels	0.581	1.092	1.082	0.936	0.652	1.494	0.744	0.393
Biomass	0.131	0.050	0.111	0.094	0.144	0.104	0.146	0.371
TOTAL	78.511	83.405	79.083	72.571	71.359	78.926	80.292	85.146
	2020	2021						
Liquid Fuels	19.634	20.584						
Gaseous Fuels	17.034	18.888						
Solid Fuels	46.825	48.552						
Other Fuels	0.330	0.028						
Biomass	0.353	0.255						
TOTAL	84.176	88.307						

Figure 3.2.7.6 shows CO₂ emissions in the sub-category 1.A.2.c in the 1988-2021 period. Emissions of CH₄ and N₂O, in turn, are shown in figure 3.2.7.7.

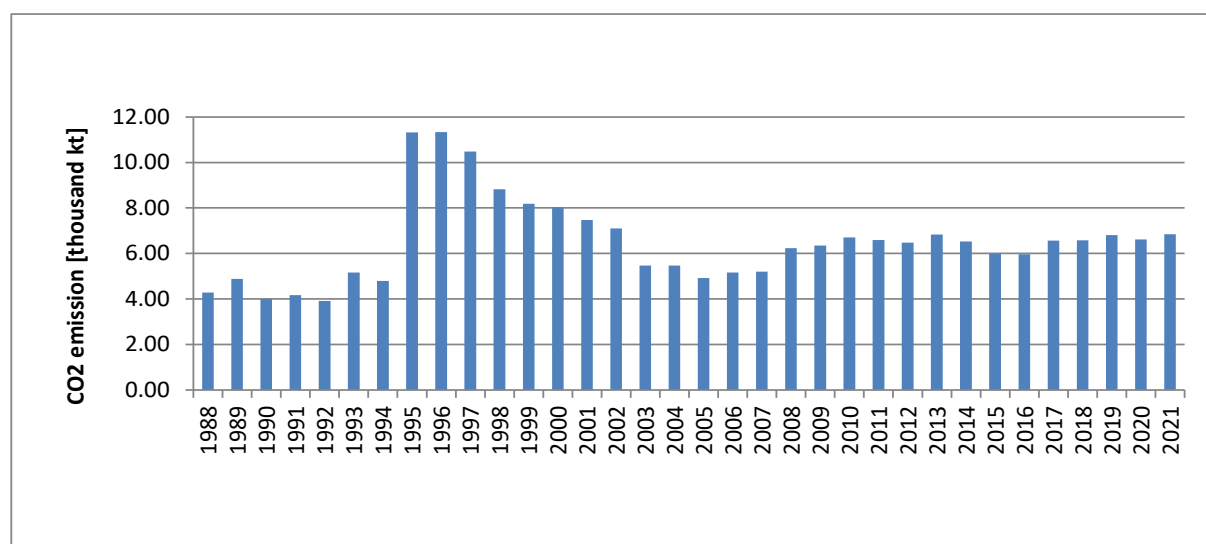


Figure 3.2.7.6. CO₂ emission for 1.A.2.c category in 1988-2021

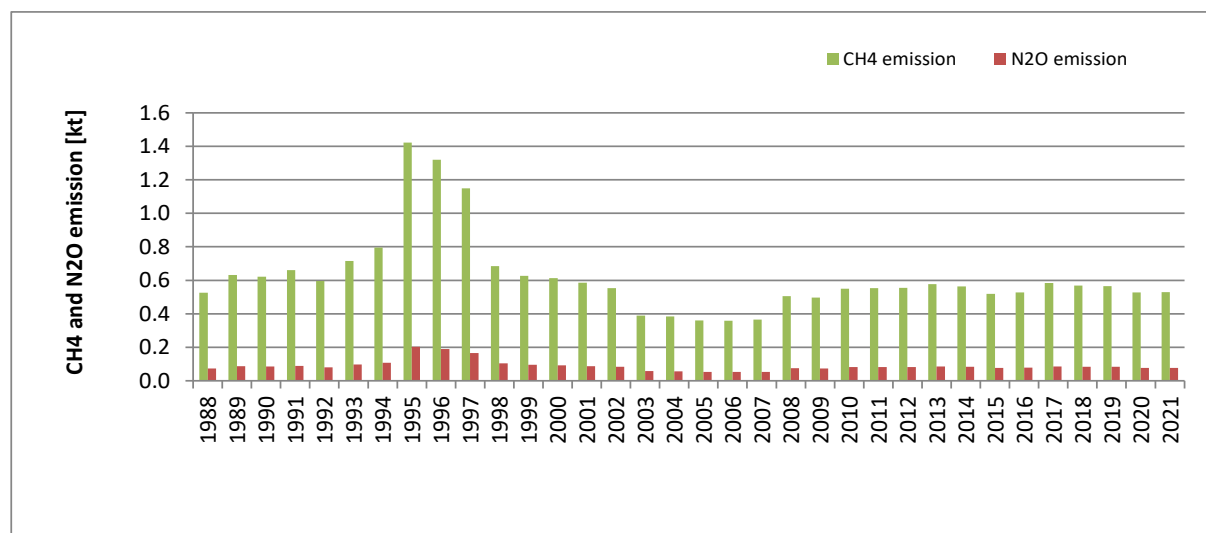


Figure 3.2.7.7. CH₄ and N₂O emissions for 1.A.2.c category in 1988-2021

Significant increase in fuel consumption between 1994 and 1995 in mentioned categories is the result of algorithm change in classification of fuel consumption for particular parts of national energy balance. For the years before 1995 all fuels consumed for energy and heat production in Autoproducer CHP Plants were included in *Transformation input in Autoproducer CHP Plants* and reported under 1.A.1.a subcategory. Starting from 1995 the fuel consumption for non-commercial heat production (heat not sold to third parties) was classified as part of final energy consumption in individual subsectors and reported in CRF in 1.A.2 category. This methodology change was described in *Energy Statistic of OECD Countries* (in Part I: *Methodology* as country notes for “Electricity and Heat”). Mentioned modification in national energy statistic is noticeable also in Eurostat database. In terms of GHG emission inventory analysed change resulted in reallocation of part of emission from 1.A.1.a into 1.A.2 IPCC category.

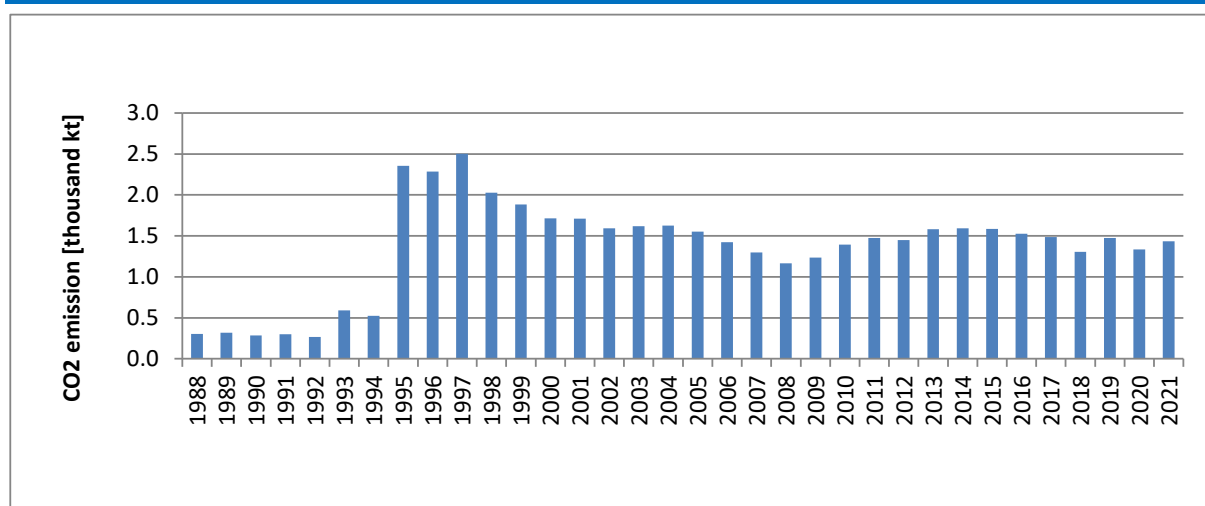
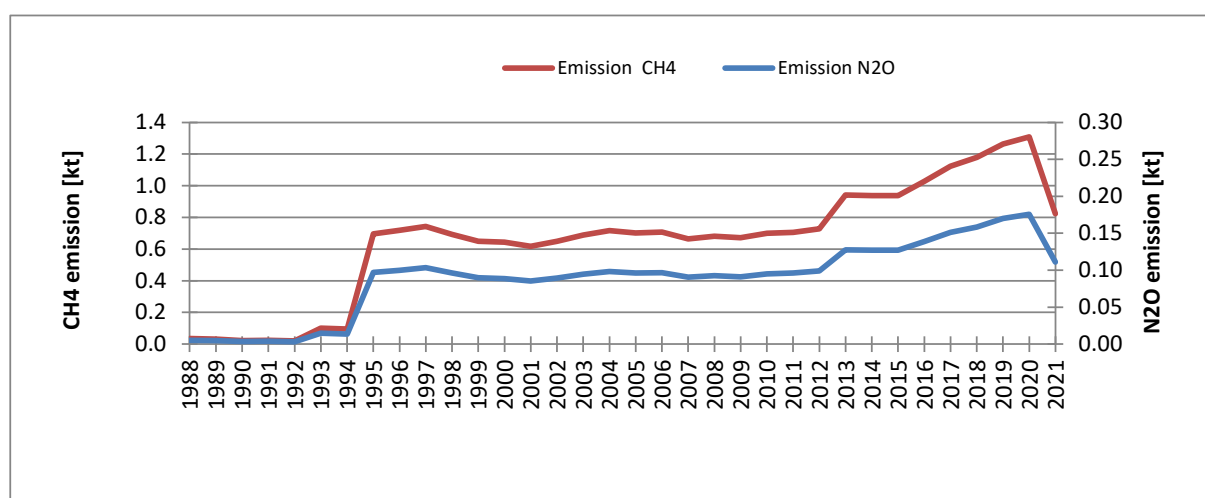
3.2.7.2.4. Pulp, paper and print (CRF sector 1.A.2.d)

The data on fuel type use in the sub-category 1.A.2.d *Pulp, paper and print* over the 1988-2021 period are presented in table 3.2.7.4. Characteristic for that sub-sector is relatively large share of biomass in the total fuel use. Detailed data on fuel consumptions in 1.A.2.d subcategory was presented in Annex 2.2 (table 7).

Table 3.2.7.4. Fuel consumption in 1988-2021 in 1.A.2.d subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	1.371	1.291	1.383	1.345	1.424	1.666	1.547	2.560
Gaseous Fuels	0.103	0.162	0.101	0.061	0.026	0.061	0.250	0.232
Solid Fuels	1.976	2.192	1.797	2.027	1.624	4.825	4.108	22.587
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.352	0.205	0.001	0.000	0.000	1.585	1.610	15.437
TOTAL	3.803	3.850	3.282	3.434	3.074	8.137	7.515	40.816
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	1.700	2.134	2.640	2.245	2.118	2.062	2.053	2.225
Gaseous Fuels	0.455	1.096	0.563	1.007	1.211	1.445	1.461	2.094
Solid Fuels	22.482	24.114	19.017	17.528	15.723	15.591	14.345	14.105
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	16.243	16.472	16.476	15.545	15.938	15.138	16.622	17.950
TOTAL	40.881	43.816	38.697	36.325	34.989	34.236	34.480	36.374
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	2.264	2.048	2.138	2.356	2.005	1.995	1.992	1.989
Gaseous Fuels	2.657	2.288	2.976	4.087	4.822	4.973	5.135	4.587
Solid Fuels	13.824	13.457	11.620	9.480	7.879	8.515	10.113	11.301
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	18.957	18.611	19.379	18.644	19.729	19.189	19.630	19.475
TOTAL	37.703	36.403	36.113	34.567	34.435	34.671	36.870	37.352
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	1.785	1.872	1.545	1.830	1.885	1.751	1.539	1.724
Gaseous Fuels	5.535	6.271	6.994	7.166	7.991	8.709	8.513	9.935
Solid Fuels	10.643	11.460	11.291	10.922	9.628	8.744	7.024	7.751
Other Fuels	0.000	0.037	0.125	0.108	0.190	0.295	0.360	0.427
Biomass	20.441	27.243	27.092	27.156	30.526	33.881	36.234	38.730
TOTAL	38.404	46.883	47.047	47.182	50.220	53.380	53.671	58.568
	2020	2021						
Liquid Fuels	1.514	1.998						
Gaseous Fuels	9.314	9.855						
Solid Fuels	6.637	7.194						
Other Fuels	0.531	0.406						
Biomass	40.512	24.300						
TOTAL	58.508	43.753						

Figures 3.2.7.8 and 3.2.7.9 show emissions of CO₂, CH₄ and N₂O, respectively in the sub-category 1.A.2.d in the period: 1988-2021.

Figure 3.2.7.8. CO₂ emission for 1.A.2.d category in 1988-2021Figure 3.2.7.9. CH₄ and N₂O emissions for 1.A.2.d category in 1988-2021

In 2021 noticeable decrease of CH₄ and N₂O emission is observed, which is connected with a drop of biomass consumption. That emission decrease is the result of relatively high value of default EFs for CH₄ and N₂O in case of solid biomass.

Considerable increase of fuel consumption and GHG emission between 1994 and 1995 results from the methodology change concerning fuel classification in energy balance, which is described in subchapter above (3.2.7.2.3. Chemicals).

3.2.7.2.5. Food processing, beverages and tobacco (CRF sector 1.A.2.e)

The data on fuel type use in the sub-category 1.A.2.e *Food Processing, Beverages and Tobacco* over the 1988-2021 period are presented in table 3.2.7.5. Detailed data on fuel consumption was tabulated in Annex 2.2 (table 8).

Table 3.2.7.5. Fuel consumption in 1988-2021 in 1.A.2.e subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	4.413	3.484	3.084	2.663	2.416	4.741	5.262	7.403
Gaseous Fuels	1.965	1.910	1.970	1.985	2.339	3.171	7.180	3.839
Solid Fuels	29.280	35.542	35.298	38.886	35.366	59.370	56.721	75.762
Other Fuels	0.003	0.002	0.000	0.000	0.031	0.003	0.003	0.000
Biomass	0.114	0.105	0.091	0.094	0.072	0.151	0.056	0.082
TOTAL	35.775	41.043	40.443	43.627	40.224	67.436	69.222	87.087
Liquid Fuels	8.655	7.941	9.956	10.302	10.741	10.957	11.425	11.458

	1996	1997	1998	1999	2000	2001	2002	2003
Gaseous Fuels	15.051	12.927	10.694	9.255	10.494	11.363	12.490	15.075
Solid Fuels	92.241	81.162	66.942	48.201	45.134	41.444	43.486	40.497
Other Fuels	0.000	0.000	0.000	0.000	0.001	0.014	0.000	0.000
Biomass	0.094	0.075	0.104	0.089	0.112	0.104	0.097	0.386
TOTAL	116.041	102.104	87.696	67.847	66.481	63.883	67.498	67.416
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	11.113	10.120	8.738	7.863	7.620	5.612	5.014	4.524
Gaseous Fuels	16.164	17.456	18.623	20.614	20.725	20.950	21.610	22.128
Solid Fuels	37.409	36.898	31.779	32.072	27.427	26.446	26.503	26.123
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.447	0.282	0.311	0.248	0.459	0.301	0.542	0.679
TOTAL	65.133	64.756	59.451	60.796	56.231	53.309	53.669	53.453
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	4.994	3.900	3.482	2.856	3.326	3.405	3.333	2.920
Gaseous Fuels	23.704	24.475	25.094	26.008	27.590	29.943	36.319	35.407
Solid Fuels	26.478	25.085	24.877	22.635	23.201	23.701	23.936	23.864
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.635	0.866	1.097	1.479	1.790	1.494	1.618	1.326
TOTAL	55.811	54.325	54.549	52.978	55.907	58.543	65.207	63.518
	2020	2021						
Liquid Fuels	2.498	2.458						
Gaseous Fuels	34.270	35.687						
Solid Fuels	22.103	21.022						
Other Fuels	0.000	0.000						
Biomass	1.251	0.912						
TOTAL	60.122	60.079						

Figures 3.2.7.10 and 3.2.7.11 show emissions of CO₂, CH₄ and N₂O, respectively in the sub-category 1.A.2.e in the period: 1988-2021.

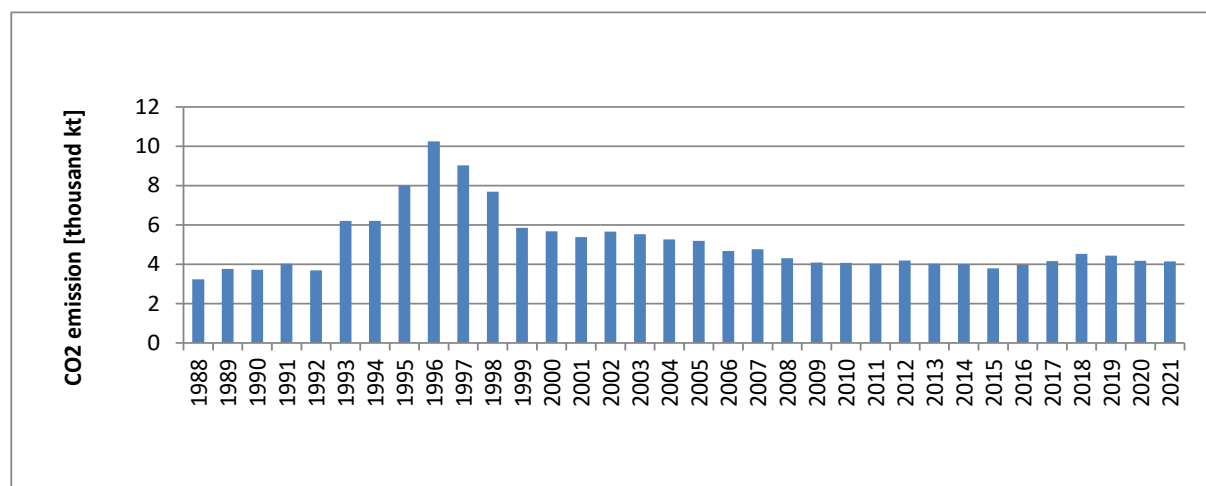
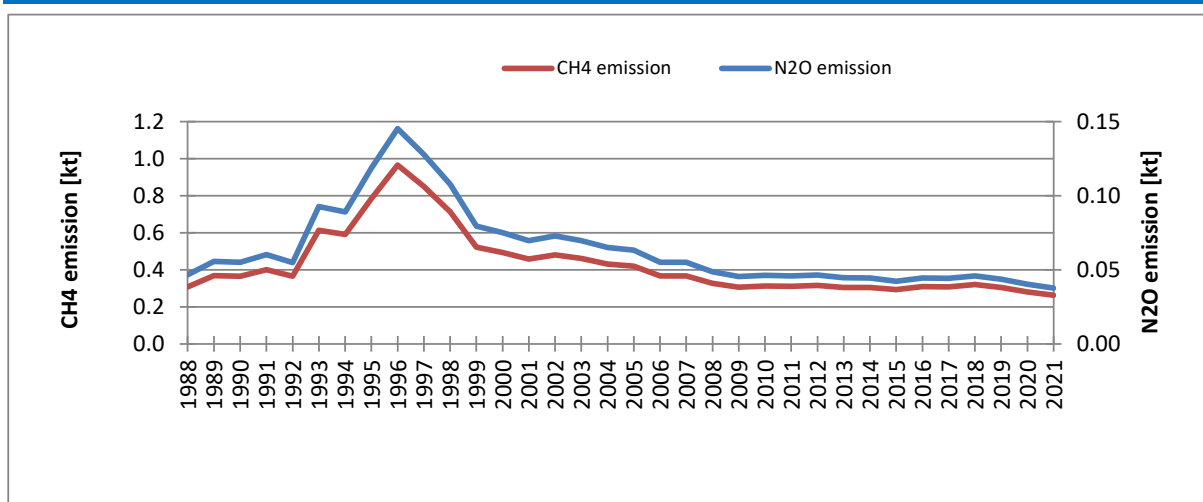


Figure 3.2.7.10. CO₂ emission for 1.A.2.e category in 1988-2021

Figure 3.2.7.11. CH₄ and N₂O emissions for 1.A.2.e category in 1988-2021

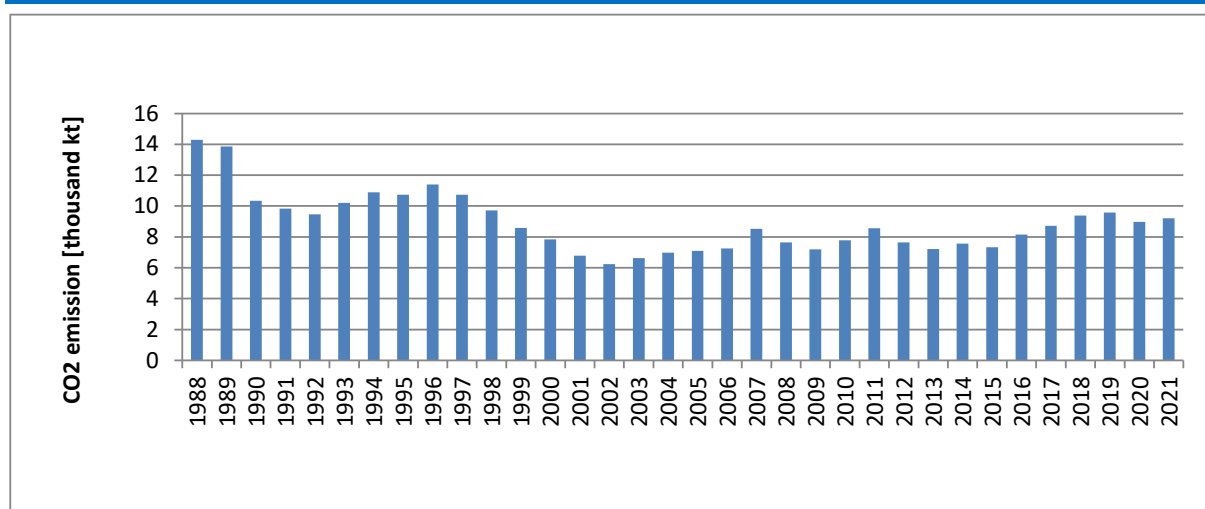
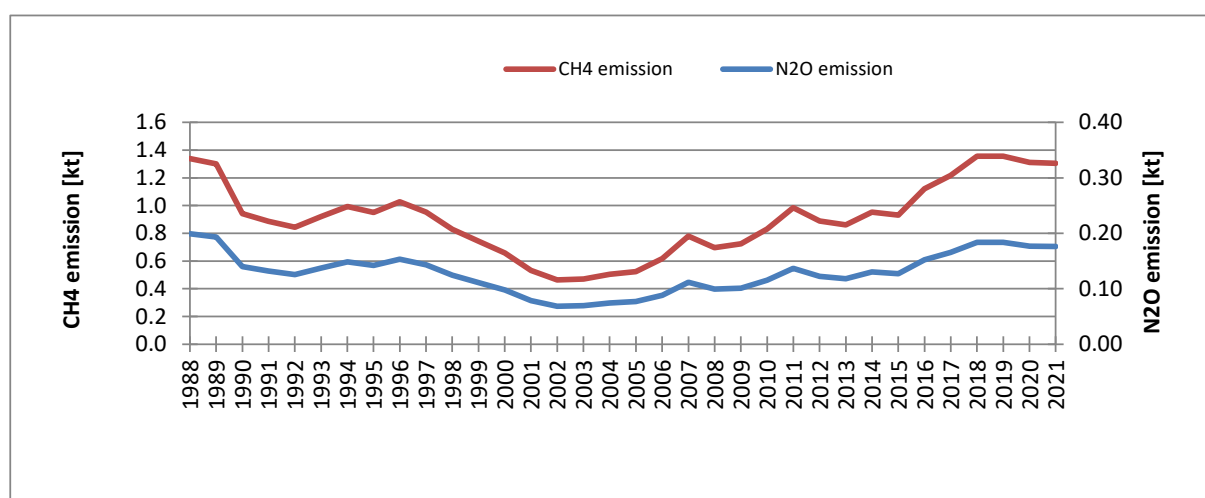
3.2.7.2.6. Non-metallic minerals (CRF sector 1.A.2.f)

The data on fuel type use in the sub-category 1.A.2.f *Non-metallic minerals* in the 1988-2021 period are presented in table 3.2.7.6. Detailed data concerning total fuel consumption in 1.A.2.f subcategory was tabulated in Annex 2.2 (table 9).

Table 3.2.7.6. Fuel consumption in 1988-2021 in 1.A.2.f subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	7.321	7.828	5.148	3.645	4.370	4.774	5.404	7.616
Gaseous Fuels	28.729	28.108	24.575	22.704	22.246	21.986	21.506	25.518
Solid Fuels	128.357	123.387	91.506	88.490	83.590	91.020	97.509	92.014
Other Fuels	0.382	0.446	0.068	0.023	0.267	0.250	0.145	0.197
Biomass	1.778	1.924	1.155	0.455	0.042	0.033	0.004	0.010
TOTAL	166.566	161.692	122.451	115.318	110.515	118.062	124.569	125.355
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	5.651	8.591	10.210	8.432	6.073	7.098	8.452	12.748
Gaseous Fuels	26.650	25.655	27.097	23.917	27.977	31.858	33.233	35.584
Solid Fuels	99.333	90.895	77.693	68.849	60.340	46.515	39.067	35.815
Other Fuels	0.144	0.047	0.207	0.529	0.472	0.524	0.508	1.474
Biomass	0.010	0.005	0.006	0.002	0.006	0.275	0.292	0.102
TOTAL	131.788	125.193	115.214	101.729	94.867	86.270	81.552	85.724
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	12.305	14.395	8.819	5.914	6.165	7.209	6.038	4.410
Gaseous Fuels	38.225	38.955	41.274	42.465	39.696	41.394	42.872	44.492
Solid Fuels	38.373	35.025	36.024	49.975	41.253	29.902	32.311	39.070
Other Fuels	1.831	3.418	6.663	7.737	7.778	12.134	14.966	16.746
Biomass	0.261	0.110	0.139	0.117	0.224	0.314	0.422	1.686
TOTAL	90.994	91.903	92.919	106.207	95.117	90.952	96.609	106.405
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	3.652	3.242	2.425	1.981	2.740	3.318	3.876	4.306
Gaseous Fuels	42.349	40.911	40.873	40.514	43.984	44.575	43.117	46.329
Solid Fuels	31.450	27.169	27.917	26.075	24.634	25.996	26.200	24.266
Other Fuels	16.083	16.515	19.231	19.079	25.428	28.126	32.375	33.271
Biomass	1.767	1.893	2.296	2.327	2.643	2.617	2.805	2.447
TOTAL	95.301	89.730	92.741	89.977	99.429	104.632	108.373	110.619
	2020	2021						
Liquid Fuels	2.833	2.923						
Gaseous Fuels	44.359	51.813						
Solid Fuels	21.635	22.513						
Other Fuels	32.509	30.478						
Biomass	2.716	4.087						
TOTAL	104.052	111.814						

Figures 3.2.7.12 and 3.2.7.13 show emissions of CO₂, CH₄ and N₂O, respectively, in the sub-category 1.A.2.f in the period: 1988-2021.

Figure 3.2.7.12. CO₂ emission from 1.A.2.f category in 1988-2021Figure 3.2.7.13. CH₄ and N₂O emissions from 1.A.2.f category in 1988-2021

3.2.7.2.7. Other (1.A.2.g)

The GHG emission was estimated for sub-categories as follows:

- *Manufacturing of machinery* - 1.A.2.g.i
- *Manufacturing of transport equipment* - 1.A.2.g.ii
- *Mining (excluding fuels) and quarrying* - 1.A.2.g.iii
- *Wood and wood products* - 1.A.2.g.iv
- *Construction* - 1.A.2.g.v
- *Textile and leather* - 1.A.2.g.vi
- *Other* - 1.A.2.g.vii

The data on fuel type use in stationary sources in the category 1.A.2.g *Other* over the 1988-2021 period are presented in table 3.2.7.7. Detailed data concerning total fuel consumption in 1.A.2.g subcategory was tabulated in Annex 2.2 (table 10).

Table 3.2.7.7. Fuel consumption in 1988-2021 in stationary sources of 1.A.2.g subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	19.848	18.040	13.880	12.053	10.715	12.118	11.612	14.456
Gaseous Fuels	24.039	22.347	15.645	11.756	13.811	17.922	17.337	15.177
Solid Fuels	82.038	72.062	53.343	48.237	41.225	91.821	79.959	86.995
Other Fuels	0.082	0.058	0.022	0.012	0.134	0.298	1.593	2.294
Biomass	8.335	7.545	5.826	5.518	5.035	4.995	3.410	4.970
TOTAL	134.342	120.051	88.715	77.575	70.920	127.154	113.910	123.892

	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	22.691	21.960	18.879	16.685	16.582	14.442	14.065	14.561
Gaseous Fuels	14.210	16.061	17.640	16.352	18.545	18.320	19.273	21.156
Solid Fuels	111.176	92.291	67.499	52.974	43.040	34.317	28.834	26.923
Other Fuels	2.675	1.133	2.080	1.482	2.075	1.802	2.078	2.503
Biomass	6.520	8.195	8.233	8.604	10.105	10.716	12.300	11.897
TOTAL	157.271	139.641	114.331	96.097	90.347	79.596	76.550	77.040
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	14.254	15.115	15.468	12.955	11.878	11.546	11.693	11.647
Gaseous Fuels	22.582	23.324	23.290	23.540	26.264	22.861	24.964	23.875
Solid Fuels	23.460	20.769	18.945	17.440	14.873	11.715	11.889	10.918
Other Fuels	1.661	1.700	3.789	0.938	1.154	1.392	0.070	0.052
Biomass	12.184	12.193	11.626	13.240	14.044	14.007	17.901	20.051
TOTAL	74.141	73.100	73.118	68.112	68.214	61.521	66.518	66.543
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	10.234	8.765	9.613	8.396	8.478	8.854	9.212	9.785
Gaseous Fuels	23.019	26.035	23.395	22.750	24.489	26.749	27.581	27.911
Solid Fuels	8.149	7.961	7.010	7.901	6.959	7.581	7.394	6.696
Other Fuels	0.069	0.098	0.064	0.045	0.037	0.105	0.107	0.050
Biomass	20.854	24.842	25.929	27.981	30.076	32.873	31.115	35.469
TOTAL	62.325	67.702	66.011	67.074	70.039	76.162	75.408	79.911
	2020	2021						
Liquid Fuels	8.799	9.437						
Gaseous Fuels	27.473	30.170						
Solid Fuels	5.850	6.649						
Other Fuels	0.043	0.117						
Biomass	39.353	37.724						
TOTAL	81.518	84.098						

Figures 3.2.7.14 and 3.2.7.15 show emissions of CO₂, CH₄ and N₂O, respectively in the 1.A.2.g category in the period: 1988-2021.

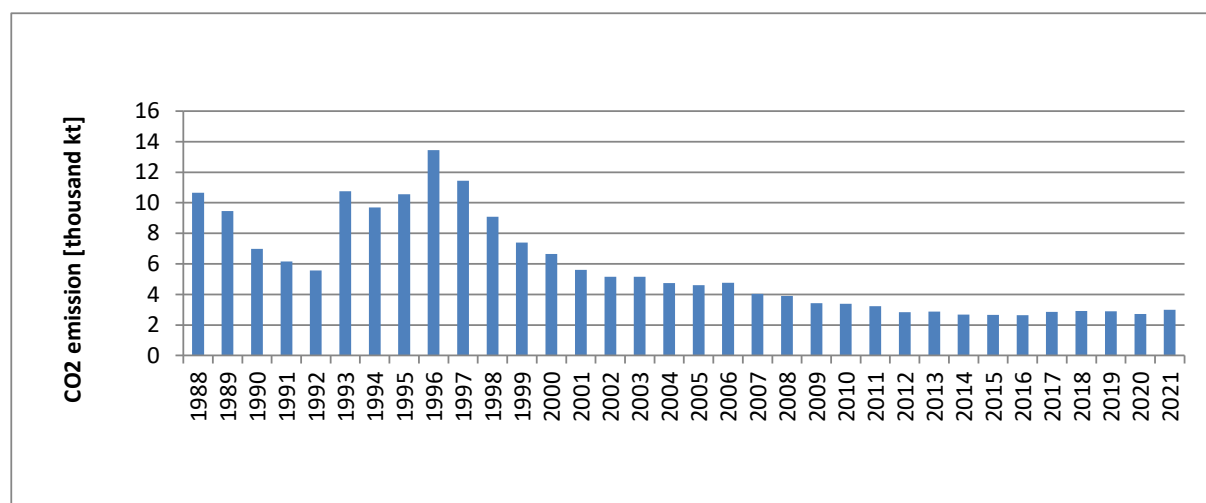
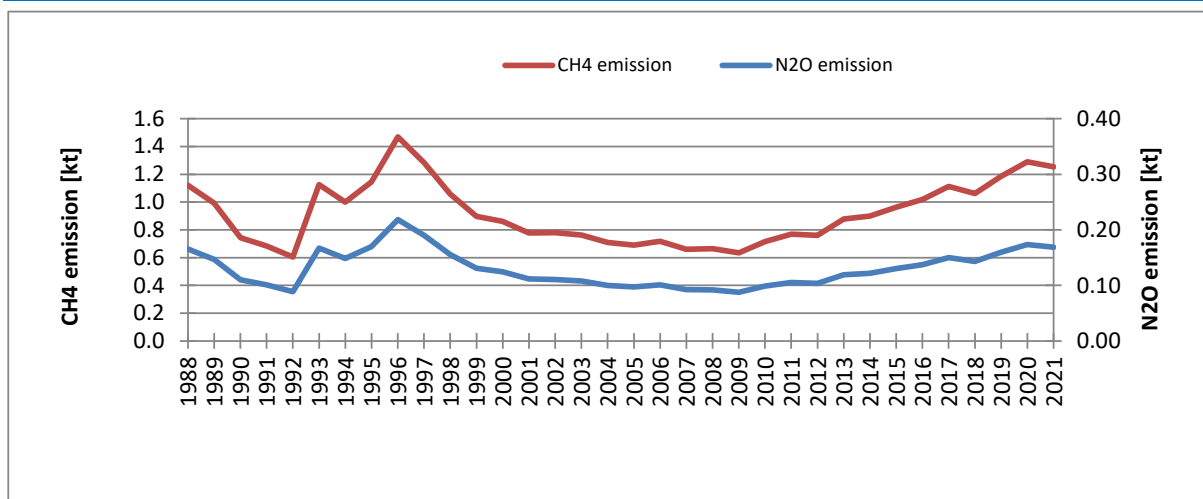


Figure 3.2.7.14. CO₂ emission from 1.A.2.g category in 1988-2021

Figure 3.2.7.15. CH₄ and N₂O emissions from 1.A.2.g category in 1988-2021

3.2.7.3. Uncertainties and time-series consistency

See chapter 3.2.6.3.

3.2.7.4. Source-specific QA/QC and verification

See chapter 3.2.6.4.

3.2.7.5. Source-specific recalculations

Recalculation for the years 2017-2019 is the result of decreasing in coke consumption in 1.A.2.b subcategory in updated energy balance.

Additionally adjustments in 2020 were placed, what is also connected with updated energy balance and slight corrections in fuels use in the subcategories included in 1.A.2 (mainly decrease of diesel oil consumption in 1.A.2.g and petroleum coke in 1.A.2.f).

Table 3.2.7.8. Changes of GHG emission values in 1.A.2 subcategory as a result of recalculations

Changes	1988	1989	1990	1991	1992	1993	1994	1995
CO₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH₄								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N₂O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Changes	1996	1997	1998	1999	2000	2001	2002	2003
CO₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH₄								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N₂O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Changes	2004	2005	2006	2007	2008	2009	2010	2011
CO ₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH ₄								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N ₂ O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Changes	2012	2013	2014	2015	2016	2017	2018	2019
CO ₂								
kt	0.00	0.00	0.00	0.00	0.00	-94.01	-153.75	-182.03
%	0.00	0.00	0.00	0.00	0.00	-0.31	-0.49	-0.59
CH ₄								
kt	0.000	0.000	0.000	0.000	0.000	-0.009	-0.015	-0.017
%	0.00	0.00	0.00	0.00	0.00	-0.19	-0.31	-0.36
N ₂ O								
kt	0.000	0.000	0.000	0.000	0.000	-0.001	-0.002	-0.003
%	0.00	0.00	0.00	0.00	0.00	-0.21	-0.34	-0.40
Changes	2020							
CO ₂								
kt	-281.19							
%	-0.98							
CH ₄								
kt	-0.010							
%	-0.21							
N ₂ O								
kt	-0.002							
%	-0.31							

3.2.7.6. Source-specific planned improvements

No improvements are planned at the moment.

3.2.8. Transport (CRF sector 1.A.3)

3.2.8.1. Source category description

Estimation of emissions in 1.A.3 *Transport* are carried out for each fuel in sub-categories listed below:

- a) *Civil Aviation* (1.A.3.a)
- b) *Road Transportation* (1.A.3.b)
- c) *Railways* (1.A.3.c)
- d) *Navigation* (1.A.3.d)
- e) *Other Transportation* (1.A.3.e)

The share of that sector in total GHG emission in 2021 amounts to 17.19%. Road transport is by far the largest contributor to transport emissions (see figure 3.2.8.1) – with the share of 98.34% in year 2021.

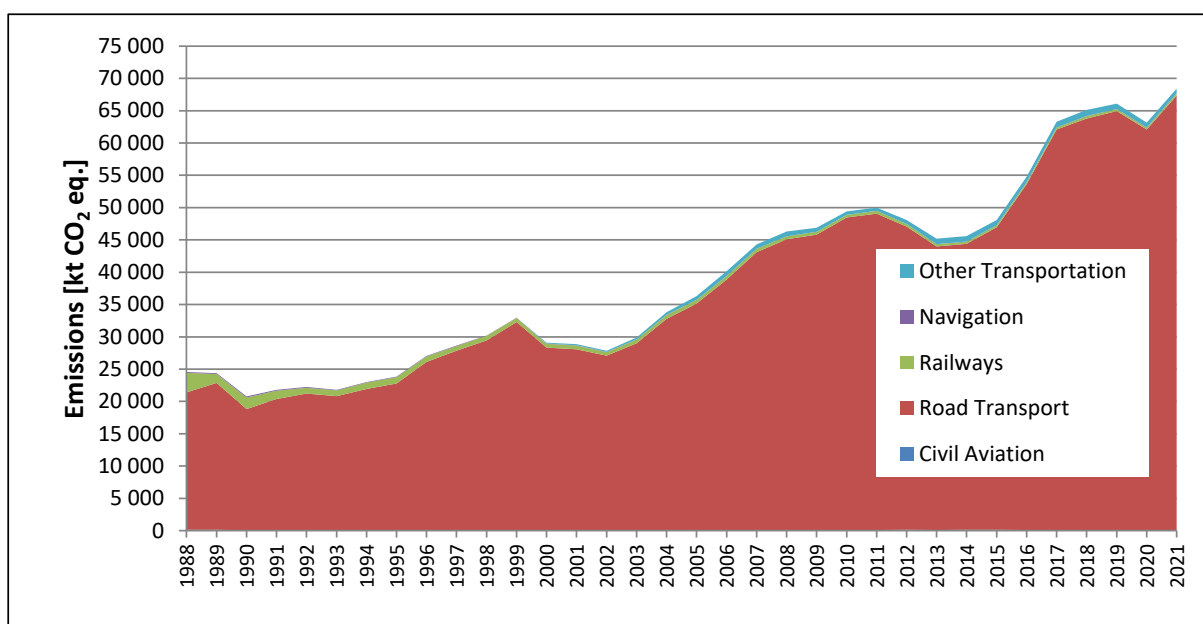


Figure 3.2.8.1. Emissions from transport in years 1988-2021

3.2.8.2. Methodological issues

The methodology used for estimation of GHG emissions in the national inventory for mobile non-road sources for the entire time series 1988-2021 is factor based – data on fuel used are multiplied by the corresponding emission factors. All emission factors for non-mobile sources were taken from IPCC 2006 guidelines and have constant values over the entire time series 1988-2021.

GHG emissions from sector 1.A.3.b *Road transport* have been calculated with the use of software COPERT 5. All emission factors are default values from COPERT 5.

3.2.8.2.1. Civil Domestic Aviation (CRF sector 1.A.3.a)

This category includes emissions from passenger and freight traffic that departs and arrives in the same country (commercial, private, agriculture, etc.) and excludes use of fuel at airports for ground transport, fuel for stationary combustion at airports.

All military activities based on fuel used are incorporated in country energy balance underlying the national inventory in energy sector. No specific individual data related to military share is available for confidential purposes.

For the years 1990-2021 data related to aviation gasoline and jet kerosene are those from the Eurostat database, while for the base year and 1989 – those of the IEA database.

Jet kerosene given in Polish statistics is reported as International aviation although it includes the whole amount of jet kerosene used for domestic and international purposes. To split jet kerosene, Eurocontrol data were used. Each year, under the contract with the European Commission's Directorate-General for Climate Action, EUROCONTROL calculates the mass of fuel burnt by civil aviation flights starting from and/or landing at airports in the Member States of the European Union (EU). This work is done in support of both the European Environment Agency (EEA) and the Member States of the EU. The calculation is made with the split on domestic and international aviation. The total amount of jet kerosene used in Poland – calculated by Eurocontrol is similar to this reported by Poland to Eurostat. To be consistent with Eurostat database (and Polish statistics) only the percentage ratio between domestic and international fuel use were used based on Eurocontrol data. Eurocontrol data of jet kerosene used in Poland and the share of domestic and international use are given in the table below.

Table 3.2.8.1. Eurocontrol data of jet kerosene used in Poland and the share of domestic and international use for years 2005-2021

Eurocontrol		2005	2006	2007	2008	2009	2010	2011
Domestic	kt	21.86	24.78	26.94	26.16	24.30	28.61	31.43
International	kt	303.44	383.80	455.51	516.92	456.41	481.94	483.51
Total	kt	325.30	408.58	482.44	543.08	480.71	510.55	514.93
<i>Eurostat</i>	kt	311	415	432	519	470	495	485
Share								
Domestic	%	6.72	6.07	5.58	4.82	5.05	5.60	6.10
International	%	93.28	93.93	94.42	95.18	94.95	94.40	93.90
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Eurocontrol		2012	2013	2014	2015	2016	2017	2018
Domestic	kt	45.75	34.21	38.84	34.36	34.21	36.89	35.78
International	kt	499.64	526.34	559.45	596.54	679.55	1266.92	1457.94
Total	kt	545.39	560.55	598.28	630.90	713.76	1303.81	1493.72
<i>Eurostat</i>	kt	537	524	590	646	685	852	1 008
Share								
Domestic	%	8.39	6.10	6.49	5.45	4.79	2.83	2.40
International	%	91.61	93.90	93.51	94.55	95.21	97.17	97.60
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Eurocontrol		2019	2020	2021				
Domestic	kt	35.34	17.65	18.98				
International	kt	1529.36	603.11	785.77				
Total	kt	1564.71	620.76	804.75				
<i>Eurostat</i>	kt	1 077	459	574				
Share								
Domestic	%	2.26	2.84	2.36				
International	%	97.74	97.16	97.64				
Total	%	100.00	100.00	100.00				

Due to the lack of Eurocontrol data for the years before 2005, the share of domestic use for years 1988-2004 was assumed as a 5-years average from Eurocontrol data for years 2005-2009. The 5-years average was evaluated as the most representative in consultations with experts in the area of transport and energy. The 5.65% share of domestic use was then accepted for the whole period before 2005. Such assumption seems to be reliable and not affecting accuracy of the inventory.

Emission factors for the estimation of GHG emissions from domestic aviation are default values from the IPCC 2006 guidelines (table 3.2.8.2)

Table 3.2.8.2. Emission factors for domestic aviation [kg/GJ]

EFs	CO₂	CH₄	N₂O
Aviation gasoline	70.00	0.0005	0.002
Jet kerosene	71.50	0.0005	0.002

Emissions from aviation come from the combustion of jet fuel and aviation gasoline. Data on fuel use in domestic aviation are shown in table 3.2.8.3 and figure 3.2.8.2. Figures 3.2.8.3 and 3.2.8.4 show emissions of CO₂, CH₄ and N₂O, respectively in the sub-category 1.A.3.a in the period 1988-2021.

Between 1988 and early 1990-ties dramatic decrease in fuel consumption and heavy industry production occurred triggered by significant economic changes related to political transformation from centralized to market economy. These changes affected all energy sectors and this is the main reason why Poland choose 1988 as a base year (as being more representative in trend than 1990 with collapsing industry).

Table 3.2.8.3. Fuel consumption and GHG emission in years 1988-2021

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Aviation gasoline	TJ	879.98	836.02	354.40	221.50	88.60	177.20	443.00	310.10	177.20	265.80
Jet kerosene	TJ	847.61	1 165.76	535.52	552.96	600.28	597.79	605.26	652.59	767.17	687.46
CO ₂ emission	kt	122.20	141.87	63.10	55.04	49.12	55.15	74.29	68.37	67.26	67.76
CH ₄ emission	kt	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
N ₂ O emission	kt	0.003	0.004	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Aviation gasoline	TJ	177.20	132.90	132.90	132.90	177.20	177.20	132.90	132.90	132.90	177.20
Jet kerosene	TJ	699.91	625.19	665.04	655.08	642.63	694.93	682.48	921.68	1 110.10	1 063.65
CO ₂ emission	kt	62.45	54.00	56.85	56.14	58.35	62.09	58.10	75.20	88.68	88.45
CH ₄ emission	kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
N ₂ O emission	kt	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Aviation gasoline	TJ	132.90	176.00	176.00	220.00	220.00	176.00	220.00	176.00	176.00	146.87
Jet kerosene	TJ	1 102.45	1 021.55	1 192.72	1 272.73	1 936.91	1 375.08	1 646.86	1 512.94	1 411.78	1 036.05
CO ₂ emission	kt	88.13	85.36	97.60	106.40	153.89	110.64	133.15	120.49	113.26	84.36
CH ₄ emission	kt	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N ₂ O emission	kt	0.002	0.002	0.003	0.003	0.004	0.003	0.004	0.003	0.003	0.002
		2018	2019	2020	2021						
Aviation gasoline	TJ	175.91	175.91	158.40	167.20						
Jet kerosene	TJ	1 037.91	1 045.71	561.53	586.47						
CO ₂ emission	kt	86.52	87.08	51.24	53.64						
CH ₄ emission	kt	0.001	0.001	0.000	0.000						
N ₂ O emission	kt	0.002	0.002	0.001	0.002						

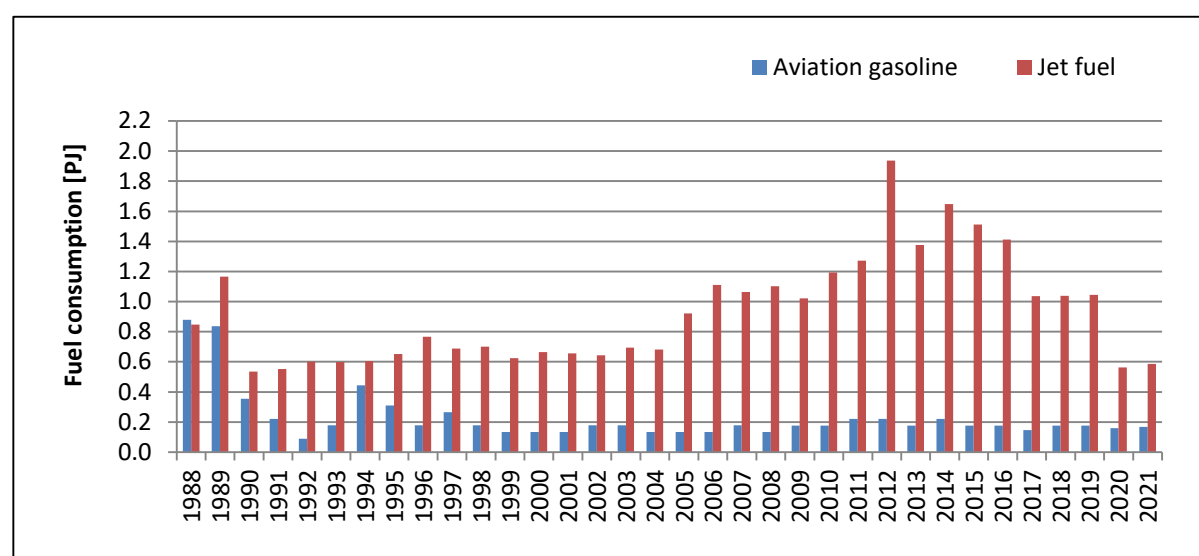
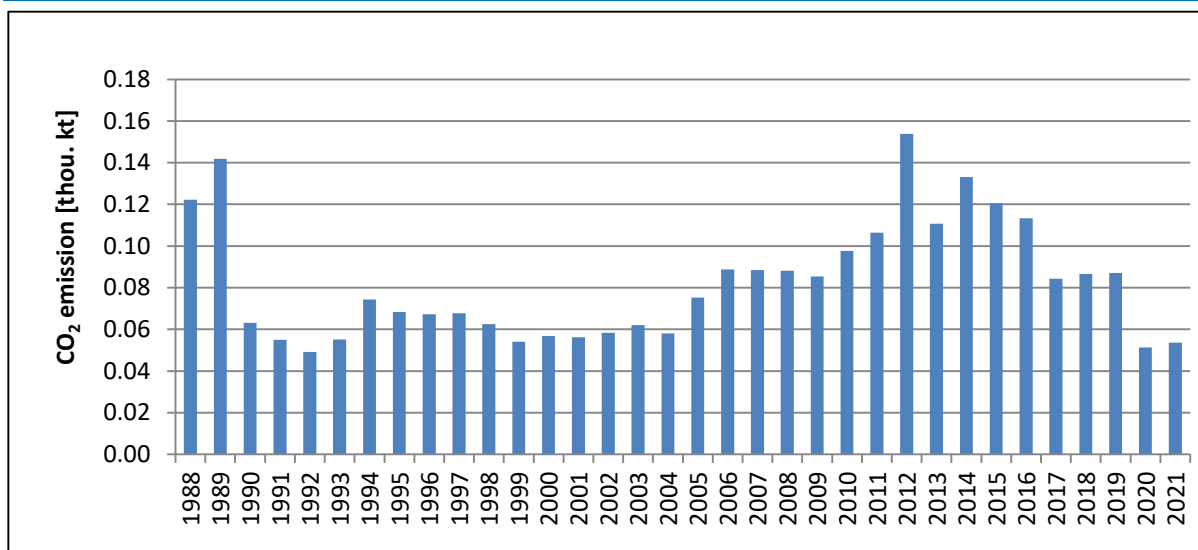
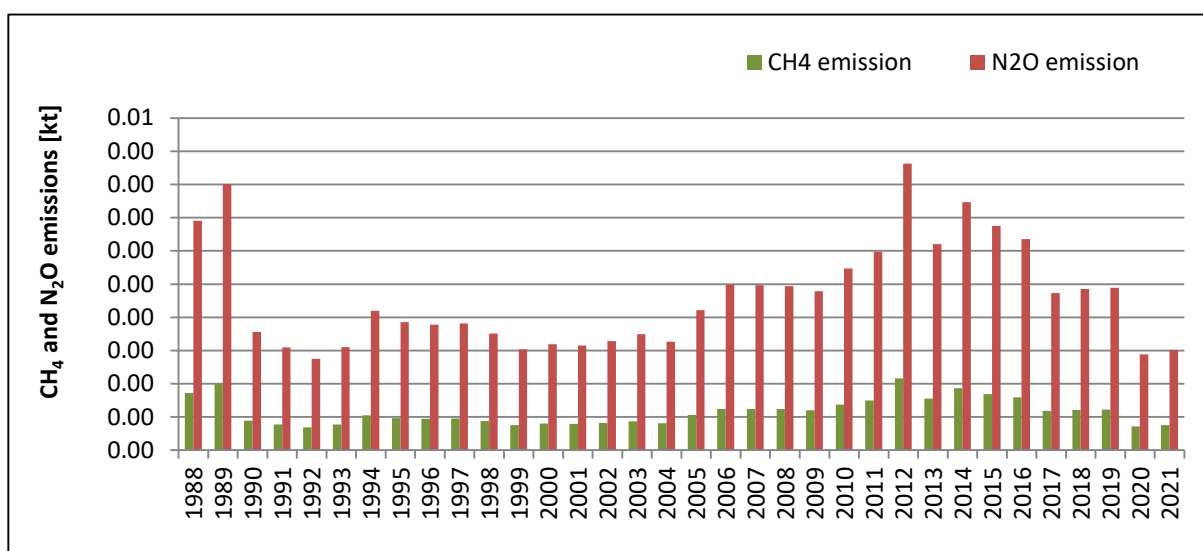


Figure 3.2.8.2. Fuel consumption in 1.A.3.a category for 1988-2021

Figure 3.2.8.3. CO₂ emission for 1.A.3.a category in 1988-2021Figure 3.2.8.4. CH₄ and N₂O emissions for 1.A.3.a category in 1988-2021

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

This category includes emissions from all types of motor vehicles such as: passenger cars, light and heavy duty vehicles, buses, motorcycles and mopeds. Poland applied COPERT software to the official reporting of national road transport emissions. COPERT 5 is a complex modelling software aiming at the calculation of air pollutant emissions from road transport and using the methodology of the EMEP/CORINAIR Emission Inventory Guidebook. Application of the COPERT model allows to estimate emissions in accordance with the requirements of international and EU legislation.

Calculations for the years 1988-2021 was made by model COPERT 5 version 5.6.1. All emission factors are default values from COPERT 5.

Emission estimates from this category are based on:

- fuel consumption,
- number of vehicles per vehicle category, engine size or vehicle weight and emission control technology,
- the mileage per vehicle class and,
- mileage share per road class (urban, rural and highways),
- the average speed per vehicle type and per road class,
- monthly temperature (min and max),
- fuel characteristics.

Data on fuel consumption for years 1990-2021 comes from Eurostat database, and for years 1988-1989 from IEA. Consumption of each type of fuel (used in road transport) in statistics is given without distinguishing on individual vehicle type. Therefore, for the purpose of this report fuel consumption was disaggregated based on COPERT 5 calculations – mass of statistical and calculated fuel consumption is equal. Table 3.2.8.4 shows fuel consumption, implied emission factors and GHG emissions in 2021 by main vehicle categories.

Table 3.2.8.4. Fuel consumption, emission factors and GHG emissions in 2021 by vehicle categories

Vehicle category by fuel type	Fuel consumption	Implied emission factors			Emissions		
		CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
	TJ	(t/TJ)	(kg/TJ)	(kg/TJ)	kt	kt	kt
Passenger cars	484339.59				32915.14	2.68	0.94
Gasoline	183347.80	72.23	8.42	0.80	13243.81	1.54	0.15
Diesel oil	191376.96	74.24	0.35	2.98	14206.94	0.07	0.57
Liquefied petroleum gases	83490.00	64.93	10.64	1.92	5421.22	0.89	0.16
Gaseous fuels (CNG)	34.80	57.15	27.49	0.47	1.99	0.00	0.00
Biomass	25550.14	70.87	6.88	2.27	1810.78	0.18	0.06
Other Fossil Fuels*	539.89	76.28	-	-	41.18	-	-
Light duty trucks	117842.66				8203.07	0.10	0.24
Gasoline	8974.43	72.32	7.04	2.07	649.03	0.06	0.02
Diesel oil	101463.96	74.24	0.28	1.99	7532.21	0.03	0.20
Biomass	7118.03	75.11	1.28	2.37	534.66	0.01	0.02
Other Fossil Fuels*	286.24	76.28	-	-	21.83	-	-
Heavy duty trucks and buses	359805.30	74.24	1.61	3.61	24965.52	0.54	1.21
Diesel oil	336302.22	57.15	53.97	NO	64.51	0.06	NO
Gaseous fuels (CNG)	1128.74	76.01	1.85	4.15	1628.53	0.04	0.09
Biomass	21425.60	76.28	1.85	4.16	72.37	0.00	0.00
Other Fossil Fuels*	948.74	74.24	1.61	3.61	24965.52	0.54	1.21
Motorcycles and mopeds	3612.33				239.89	0.24	0.00
Gasoline	3367.03	71.25	63.97	1.28	239.89	0.22	0.00
Biomass	245.30	65.28	97.23	1.94	16.01	0.02	0.00

* fossil part of biodiesel

Poland uses the COPERT model to estimate the N₂O emissions from 1.A.3.b. According to the 2006 IPCC Guidelines (vol. 2, table 3.2.2), default range of N₂O Emission Factor is 3.2–8.0 kg/TJ while the COPERT's N₂O EF goes below the lower default value. Therefore comparison of N₂O emissions calculated by the COPERT model and with the use of IEF from the guidelines (assumed value - 3.2 kg/TJ) is presented in table 3.2.8.5. The difference in N₂O emissions between two IEFs is insignificant. Based on consultations with EMISIA (creator of COPERT) in this regard one can explain that lower N₂O IEFs for later inventory years than in previous years as well as lower than the range of IPCC Guidelines is caused by the latest Euro Standards which have significantly lower N₂O emission factors, especially compared to Euro 1 and Euro 2. The most recent technologies dominate more and more in the vehicle fleet and as a result the N₂O emissions are gradually reduced. It could be assumed that the emission factors range presented in the 2006 IPCC GLs are based on older findings, not appropriate to correctly represent the situation of the current fleet.

Table 3.2.8.5. Comparison of N₂O emissions calculated with emission factors from COPERT and from 2006 IPCC GLs in 2015-2021 [kg/TJ]

IEF form COPERT							
	2015	2016	2017	2018	2019	2020	2021
i. Cars							
Gasoline	0.254	0.251	0.263	0.199	0.190	0.163	0.147
Diesel oil	0.420	0.510	0.613	0.663	0.669	0.657	0.570
LPG	0.209	0.208	0.209	0.176	0.174	0.146	0.161
Gaseous fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.040	0.041	0.052	0.065	0.069	0.070	0.058
ii. Light duty trucks							
Gasoline	0.070	0.074	0.077	0.042	0.038	0.029	0.019
Diesel oil	0.128	0.150	0.175	0.184	0.186	0.182	0.202
Biomass	0.012	0.012	0.015	0.017	0.018	0.018	0.017
iii. Heavy duty trucks and buses							
Diesel oil	0.442	0.560	0.714	0.795	0.836	0.848	1.215
Gaseous fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.025	0.015	0.029	0.055	0.061	0.067	0.089
iv. Motorcycles							
Gasoline	0.005	0.003	0.004	0.003	0.003	0.003	0.004
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	1.606	1.825	2.151	2.199	2.244	2.181	2.481
IEF 2006 IPCC Guidelines							
	2015	2016	2017	2018	2019	2020	2021
i. Cars							
Gasoline	0.405	0.429	0.472	0.531	0.553	0.519	0.587
Diesel oil	0.420	0.510	0.613	0.663	0.669	0.657	0.570
LPG	0.209	0.208	0.209	0.176	0.174	0.146	0.161
Gaseous fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.040	0.041	0.052	0.065	0.069	0.070	0.058
ii. Light duty trucks							
Gasoline	0.074	0.080	0.084	0.050	0.048	0.040	0.029
Diesel oil	0.128	0.150	0.175	0.184	0.186	0.182	0.202
Biomass	0.012	0.012	0.015	0.017	0.018	0.018	0.017
iii. Heavy duty trucks and buses							
Diesel oil	0.442	0.560	0.714	0.795	0.836	0.848	1.215
Gaseous fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.025	0.015	0.029	0.055	0.061	0.067	0.089
iv. Motorcycles							
Gasoline	0.011	0.008	0.009	0.007	0.007	0.007	0.011
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	1.766	2.014	2.373	2.543	2.621	2.553	2.937
Difference (COPERT – 2006 IPCC GLs)	-0.160	-0.189	-0.222	-0.345	-0.377	-0.372	-0.456

The number of vehicles per vehicle category, engine size or weigh and emission control technology comes from Polish Central Vehicle and Driver Register system (CEPiK) and Statistics Poland [GUS T]. The amount of vehicles according to categories and fuel type is shown in figure below.

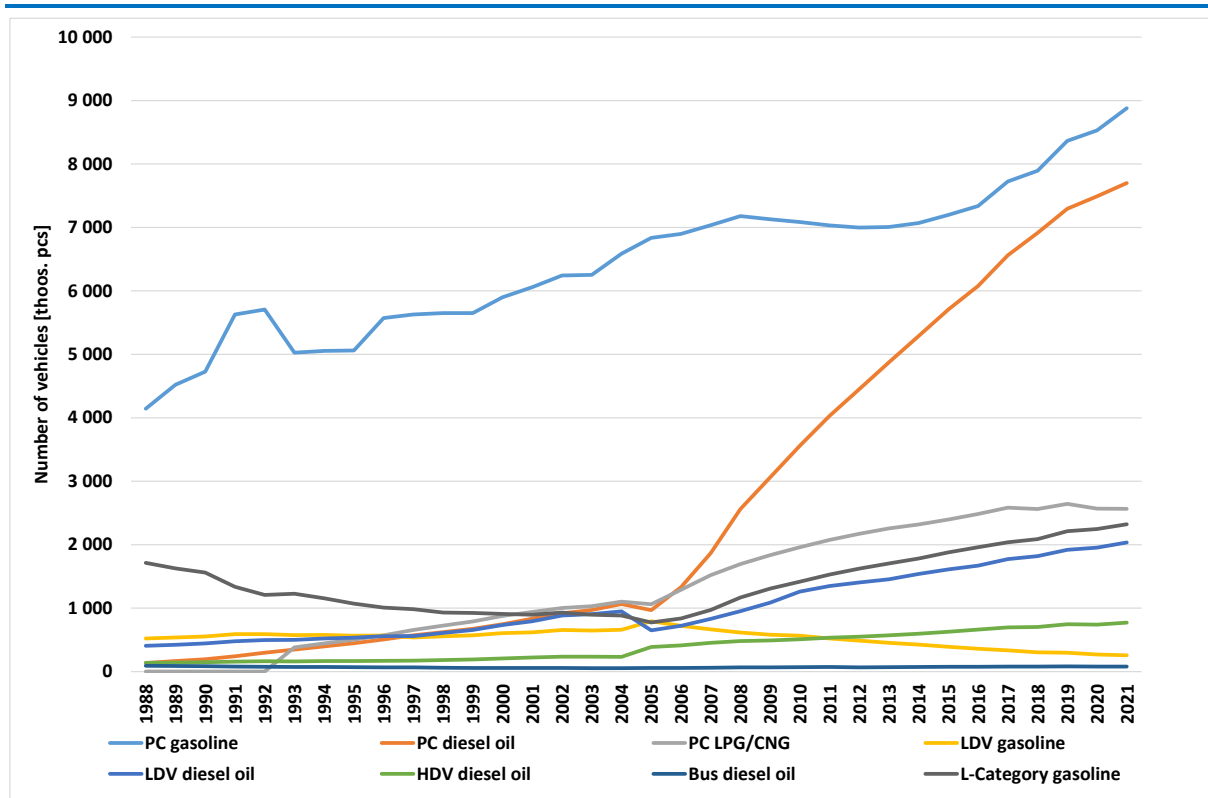


Figure 3.2.8.5. Number of vehicles in years 1988-2021

Average annual mileage for main vehicle categories in 2021 are presented in figure 3.2.8.6. Mileage share and speed per road class are shown in figures 3.2.8.7-8. The mileage comes from Polish Central Vehicle and Driver Register system (CEPiK).

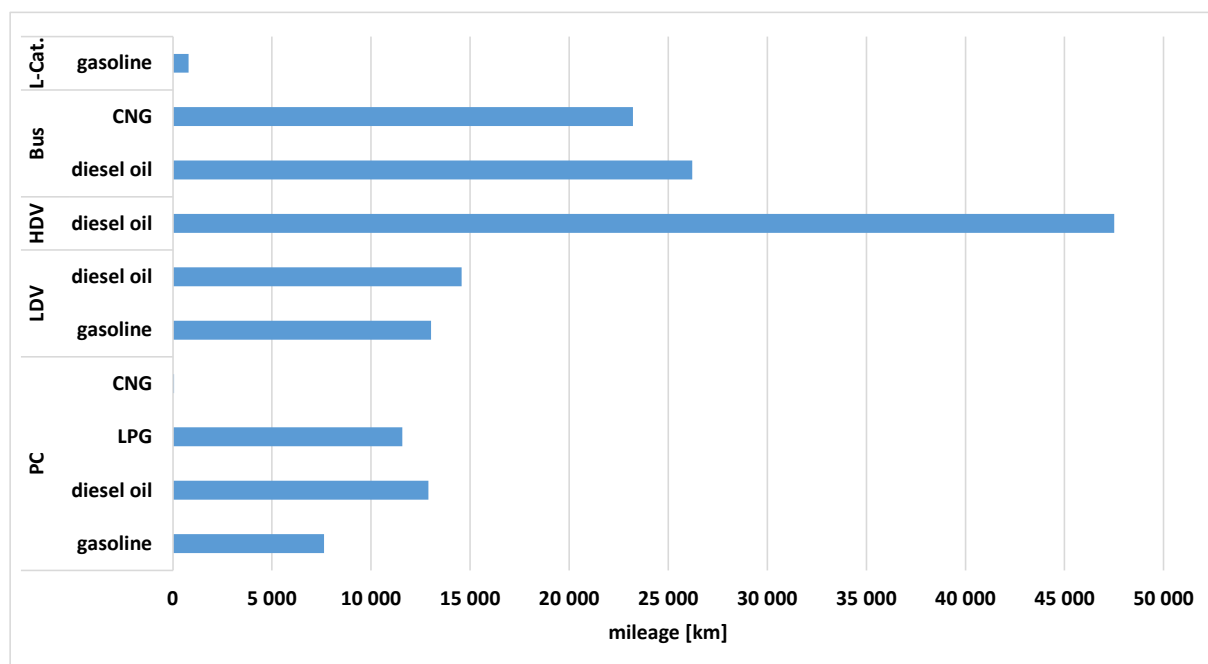


Figure 3.2.8.6. Average annual mileage driven by vehicles in 2021

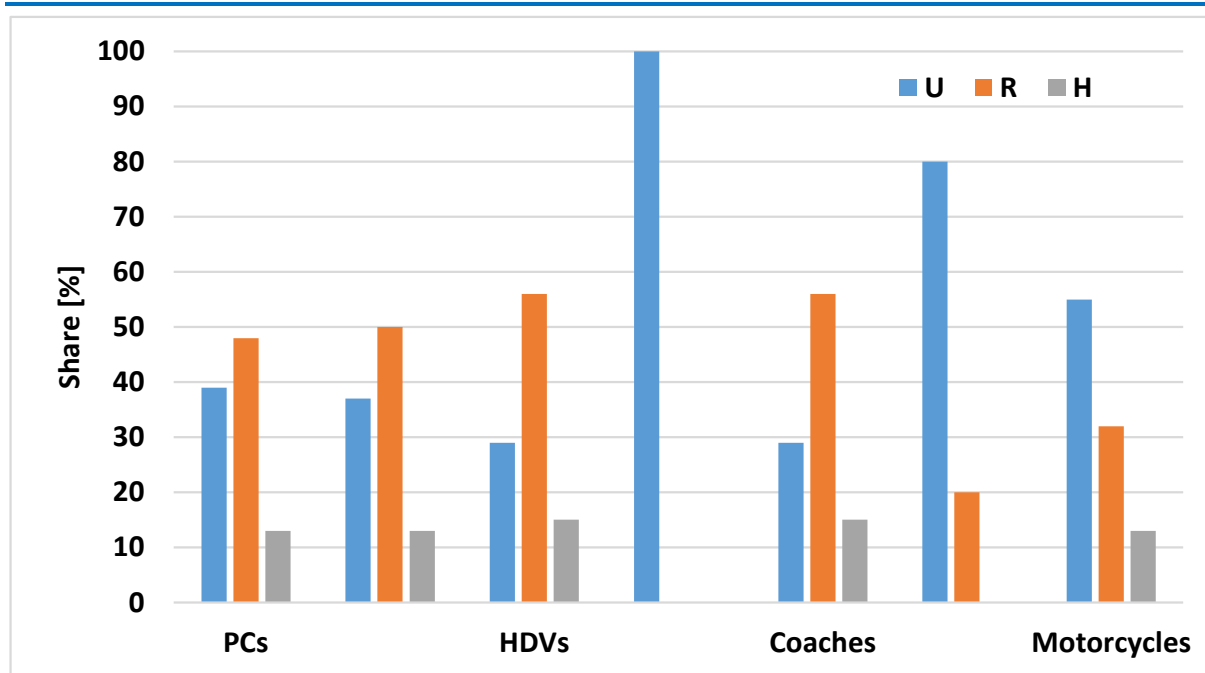


Figure 3.2.8.7. Mileage share per road class (U - urban, R - rural and H - highways) in 2021

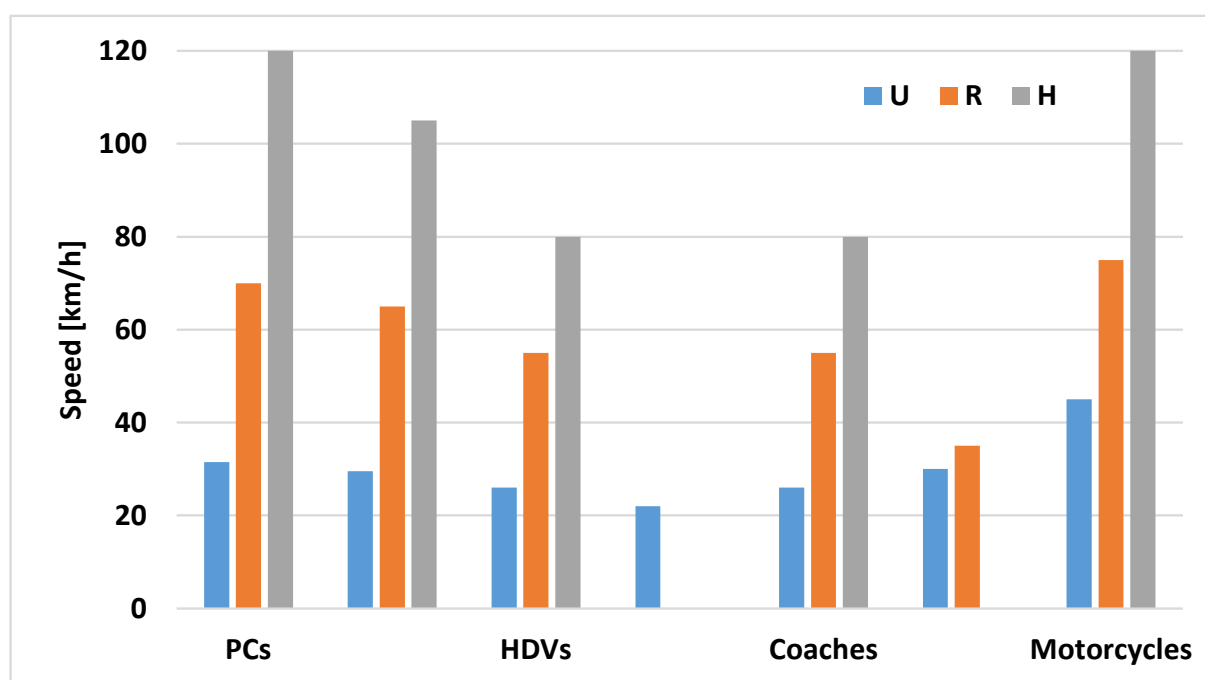


Figure 3.2.8.8. The average speed per road class (U - urban, R - rural and H - highways) in 2021

Consumption of main fuels in road transport (gasoline, diesel oil and LPG) and GHG emissions in 1988-2021 period is shown in table 3.2.8.5. Consumption of CNG/LNG by buses was published for the first time in 2020 in national statistics (with data started from year 2015). Therefore GHG emissions from this new vehicle category was reported for the first time in the previous submission. Taking into account that the CNG/LNG fuel use and number of CNG/LNG buses and passenger cars in Poland is still relatively small (from 689 buses and 1 138 passenger cars in 2015) therefore, it can be assumed that emission in years before 2015 was rather insignificant.

Following the 2006 IPCC GLs (volume 2, chapter 3, section 'CO₂ emissions from biofuels' on page 3.17) where recommendation is made to assess possible content of carbon of biofuels (and the associated CO₂ emissions) having a fossil origin, additional analysis was made to investigate and separate such fraction and results are presented in this submission.

Taking into account the "Act of the biocomponents and liquid biofuels", which has been obligatory since 2006 in Poland, the following definitions of biomass and bio-components are given:

- biomass - biodegradable parts of products, waste or residues of biological origin from agriculture, including plant and animal substances, forestry and fishing, and related industries, including fish breeding and aquaculture, as well as the biodegradable fraction of industrial waste and municipal installations, including installations for biodegradable part of industrial and municipal waste, including installations waste management processes as well as water treatment and wastewater treatment;
- bio-components - bioethanol, biomethanol, biobutanol, ester, dimethyl bioether, pure vegetable oil, liquid bio-hydrocarbons, bio-propane-butane, liquefied biomethane, compressed biomethane and biohydrogen, which are made of biomass for the production of liquid fuels or liquid biofuels.

In Poland, all fuels used in GHG emissions estimation in 1.A.3.b sector are those identified as liquid biofuels, which in the act are defined as following:

- a) gasoline containing more than 10.0% by volume of biocomponents or more than 22.0% by volume of ethers referred to: bioethanol (it is ethanol produced from biomass, including bioethanol contained in ethyl-tert-butyl vinegar or ethyl-tert-amyl ether; biomethane for the production of bioethanol is not considered to be ethyl alcohol containing more than 96% by volume of alcohol), excluding motor fuels containing liquid bio-hydrocarbons (according to the definition, liquid bio-hydrocarbons are liquid hydrocarbons or their mixtures produced from biomass in chemical and biochemical processes, including hydrated oils and synthetic hydrocarbons produced by the Fisher-Tropsch method),
- b) diesel fuel containing more than 7% by volume of biocomponents, excluding diesel fuel containing liquid bio-hydrocarbons,
- c) bioethanol, biomethanol, biobutanol, ester, dimethyl bioether, pure vegetable oil, liquid bio-hydrocarbons, bio-propane-butane, liquefied biomethane, compressed biomethane and biohydrogen - constituting spontaneous fuels.

All information described above means that within biofuels used in Poland the fossil part of biofuels occurs only in biodiesel. According to the regulation of the Minister of Economy *on the quality requirements for biocomponents, methods of testing the quality of biocomponents and the method of sampling biocomponents*, the content of FAME (Fatty Acid Methyl Esters) in biodiesel amounts to 92.15. AD and emissions related to fossil part of biodiesel are reported on CRF tables (as Other Fossil Fuels).

Table 3.2.8.6. Fuel consumption and GHG emission in years 1988-2021

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Motor gasoline	PJ	130.33	144.36	134.32	156.69	166.17	169.76	187.88	190.45	199.08	214.99
Diesel oil	PJ	155.40	161.03	118.12	117.05	118.42	108.10	101.65	105.14	136.78	139.58
LPG	PJ	0.00	0.00	0.00	0.00	0.00	1.14	3.36	8.32	11.97	15.89
Biodiesel	PJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bioethanol	PJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO ₂ emission	kt	20 926	22 354	18 440	19 975	20 758	20 333	21 306	22 077	25 291	26 903
CH ₄ emission	kt	6.48	6.98	6.33	7.17	7.62	7.63	8.09	8.02	8.28	8.51
N ₂ O emission	kt	0.62	0.66	0.55	0.61	0.72	0.84	1.13	1.45	1.86	2.15
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Motor gasoline	PJ	219.20	243.83	219.73	203.82	186.64	178.26	180.97	174.67	179.19	178.93
Diesel oil	PJ	155.70	162.45	135.11	140.91	135.15	164.56	201.46	230.35	269.40	323.96
LPG	PJ	16.56	22.09	20.10	27.72	39.21	50.61	63.43	73.27	80.41	82.78
Biodiesel	PJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	1.46	1.02
Bioethanol	PJ	0.00	0.00	0.00	0.00	0.00	1.18	0.56	1.42	2.30	3.00
CO ₂ emission	kt	28 450	31 090	27 188	26 970	26 050	28 368	32 143	34 473	38 164	42 348
CH ₄ emission	kt	8.26	8.77	7.59	6.35	5.74	5.61	5.77	5.77	6.04	6.05
N ₂ O emission	kt	2.51	3.12	2.97	3.02	2.82	1.40	1.50	1.52	1.63	1.74

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Motor gasoline	PJ	176.80	179.78	177.66	168.03	160.83	153.23	148.02	152.99	161.59	176.64
Diesel oil	PJ	353.37	365.97	402.82	421.92	401.95	369.44	379.22	407.38	484.27	578.10
LPG	PJ	81.31	76.04	76.36	73.97	73.88	73.28	73.83	74.98	79.40	84.25
CNG/LNG	PJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.61	0.47
Biodiesel	PJ	12.88	19.57	29.22	31.60	28.01	25.26	23.97	20.93	12.13	21.44
Bioetanol	PJ	5.31	7.05	7.10	6.73	5.79	6.03	5.56	6.43	11.49	12.07
CO ₂ emission	kt	44 321	45 152	47 789	48 360	46 339	43 327	43 696	46 250	52 837	61 227
CH ₄ emission	kt	5.99	5.60	5.14	4.80	4.42	4.00	4.62	4.85	5.12	5.50
N ₂ O emission	kt	1.75	1.50	1.60	1.63	1.56	1.47	1.53	1.61	1.83	2.15
		2018	2019	2020	2021						
Motor gasoline	PJ	183.67	189.90	176.97	195.69						
Diesel oil	PJ	592.50	598.36	581.16	629.14						
LPG	PJ	85.39	89.01	79.81	83.49						
CNG/LNG	PJ	0.53	0.72	0.82	1.16						
Biodiesel	PJ	36.95	39.88	41.87	41.86						
Bioetanol	PJ	11.85	12.84	12.54	14.26						
CO ₂ emission	kt	62 944	64 081	61 284	66 460						
CH ₄ emission	kt	3.94	4.02	3.57	3.66						
N ₂ O emission	kt	2.20	2.25	2.18	2.49						

Increased fuel consumption of motor gasoline and diesel oil in road transport in the last two years may be due to:

- economic growth,
- rising society's wealth,
- increase in the number of cars in Poland,
- effective fight against gray market on liquid fuel market started in 2016 and fuel prices favorable to drivers (especially in the second and third quarter of 2017).

Generally the trend of consumption of biofuels in road transport is growing – the share in 2021 accounted for 5.8%. The amounts of biofuels used in the years 1988-2021 are given in Table 3.2.8.5. Since the consumption of biofuels in item 1.A.3.b is not significant compared to the consumption of other fuels, this is not shown in the figure below.

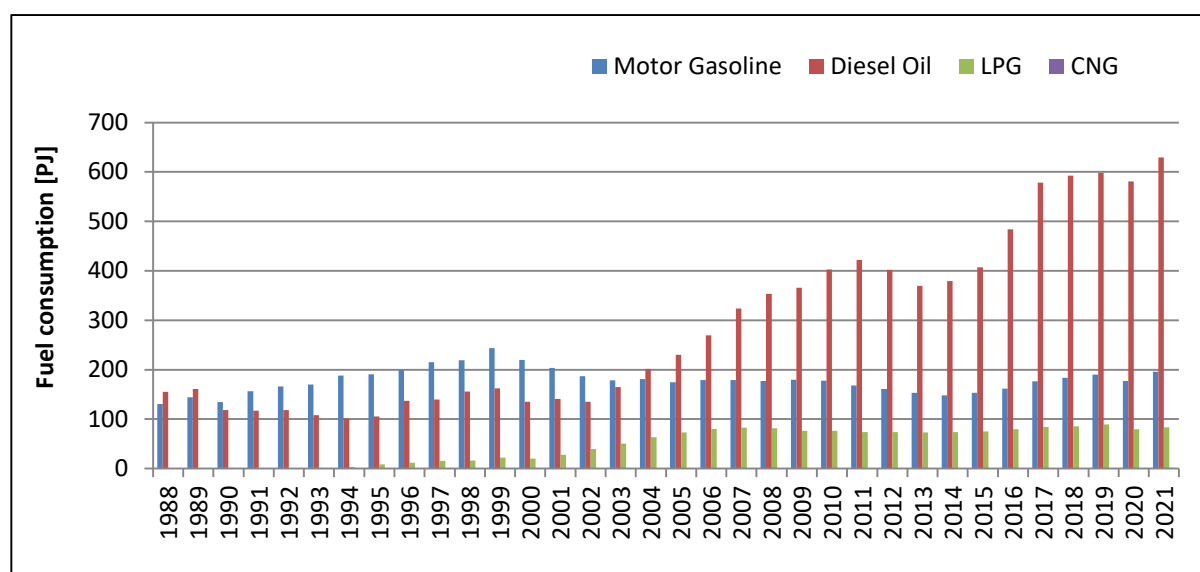


Figure 3.2.8.5. Fuel consumption in 1.A.3.b category for 1988-2021

Figure 3.2.8.6 shows CO₂ emissions in sub-category 1.A.3.b in period 1988-2021. Emissions of CH₄ and N₂O in the same sub-category are shown in figure 3.2.8.7.

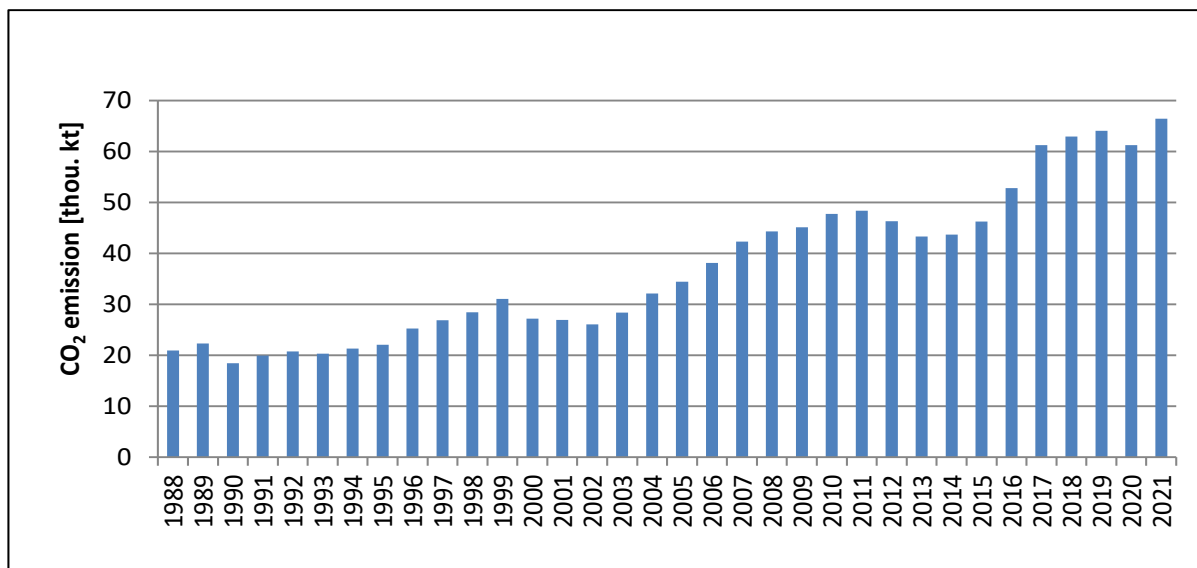


Figure 3.2.8.6. CO₂ emission for 1.A.3.b category in 1988-2021

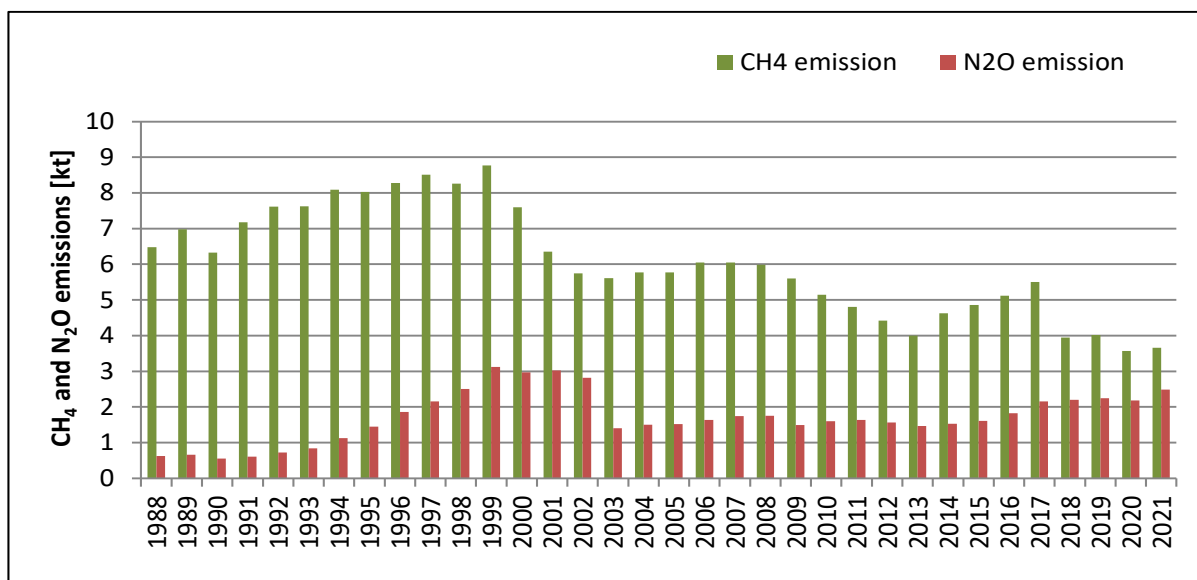


Figure 3.2.8.7. CH₄ and N₂O emissions for 1.A.3.b category in 1988-2021

CO₂ emissions from urea based catalyst

For estimating CO₂ emissions from urea-based catalyst additives in catalytic converters model COPERT 5 was used. The model assumed that consumption of urea equals a certain fraction of fuel consumption. For diesel passenger cars Euro 6/VI the consumption of urea equals 2% of fuel consumption, the selective catalytic reduction (SCR) ratio being equal to 10%; for diesel heavy duty trucks and buses, the consumption of urea is assumed to be equal 6% of fuel consumption at Euro IV and V level (SCR ratio = 76.2%) and equal 3.5% at Euro VI level (SCR ratio = 100%). The purity (the mass fraction of urea in the urea-based additive), the default value of 32.5% has been used (IPCC 2006).

CO₂ emissions from combustion of lubricants

Lubricant oil is used in engines to reduce friction and to cool down specific components. Lubricant oil enters the combustion chamber and is oxidized during combustion, before it is exhausted to the atmosphere. The hydrocarbon composition of lube oil means that it unintentionally contributes to the CO₂ emissions without taking part to the energy consumption of road transport. The only exception is two-stroke engines where the lubricant oil is intentionally delivered to the cylinder and part of the

lubricant oil could be used to deliver some energy to the engine (especially in older two-stroke engines). Emission factors of CO₂ due to lubricant oil consumption per vehicle technology are provided in this form, which are based on typical lubricant oil consumption factors for different vehicle types.

CO₂ emissions concerning non-energy use of lubricants, including those related to emissions from road transport, are estimated in 2.D.1.

As Poland uses the COPERT model to estimate CO₂ emissions in road transport, also this model is used to calculate CO₂ emissions from combustion of lubricants in 2-stroke engines (mainly L category - motorcycles and mopeds). Those emissions are included in category 1A3b and account for less than 1% of CO₂ emissions in category 1.A.3.b. (in 2021 it was 0.181%).

3.2.8.2.3. Railways (CRF sector 1.A.3.c)

This category includes emissions from railway transport for both freight and passenger traffic routes. Railway locomotives used in Poland are diesel and electric. Up to year 1998 coal was used in steam locomotives. Electric locomotives are powered by electricity generated at stationary power plants as well as other sources. The corresponding emissions are covered under the Stationary Combustion sector. Emission factors for the estimation of GHG emissions from railways are default values from the IPCC 2006 guidelines (table 3.2.8.7).

Table 3.2.8.7. Emission factors for railways [kg/GJ]

EFs	CO ₂	CH ₄	N ₂ O
Hard coal	96.10	0.002	0.0015
Diesel oil	74.10	0.004	0.0286

The amounts of fuels used in railway transport in the 1988-2021 period are shown table 3.2.8.8 and in figure 3.2.8.8.

Table 3.2.8.8. Fuel consumption and GHG emission in years 1988-2021

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Hard coal	TJ	10 972	5 785	3 169	1 686	350	293	156	132	192	181
Diesel oil	TJ	23 600	9 585	17 802	13 588	10 621	10 449	11 825	11 524	9 675	8 686
CO ₂ emission	kt	2 803	1 266	1 624	1 169	821	802	891	867	735	661
CH ₄ emission	kt	0.120	0.051	0.080	0.060	0.045	0.044	0.049	0.048	0.041	0.036
N ₂ O emission	kt	0.691	0.283	0.514	0.391	0.304	0.299	0.338	0.330	0.277	0.249
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Hard coal	TJ	138	0	0	0	0	0	0	0	0	0
Diesel oil	TJ	8 170	7 740	7 095	6 923	6 579	6 923	6 923	6 794	6 235	6 149
CO ₂ emission	kt	619	574	526	513	488	513	513	503	462	456
CH ₄ emission	kt	0.034	0.032	0.029	0.029	0.027	0.029	0.029	0.028	0.026	0.026
N ₂ O emission	kt	0.234	0.221	0.203	0.198	0.188	0.198	0.198	0.194	0.178	0.176
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Hard coal	TJ	10 972	5 785	3 169	1 686	350	293	156	132	192	181
Diesel oil	TJ	23 600	9 585	17 802	13 588	10 621	10 449	11 825	11 524	9 675	8 686
CO ₂ emission	kt	2 803	1 266	1 624	1 169	821	802	891	867	735	661
CH ₄ emission	kt	0.120	0.051	0.080	0.060	0.045	0.044	0.049	0.048	0.041	0.036
N ₂ O emission	kt	0.691	0.283	0.514	0.391	0.304	0.299	0.338	0.330	0.277	0.249
		2018	2019	2020	2021						
Hard coal	TJ	0	0	0	0						
Diesel oil	TJ	4 350	3 616	3 486	3 778						
CO ₂ emission	kt	322	268	258	280						
CH ₄ emission	kt	0.018	0.015	0.014	0.016						
N ₂ O emission	kt	0.124	0.103	0.100	0.108						

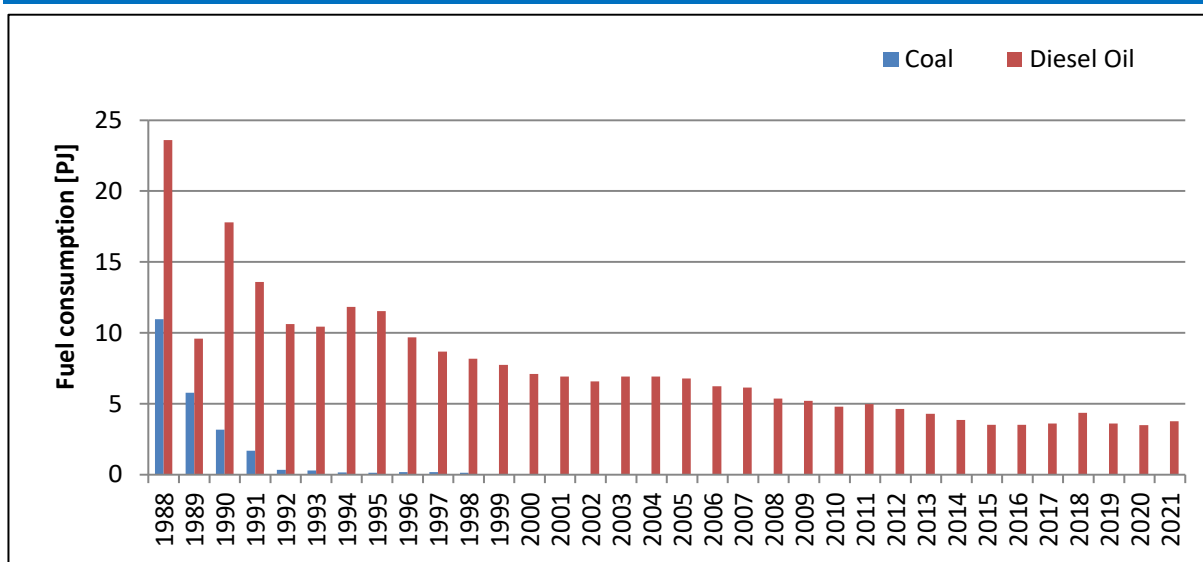
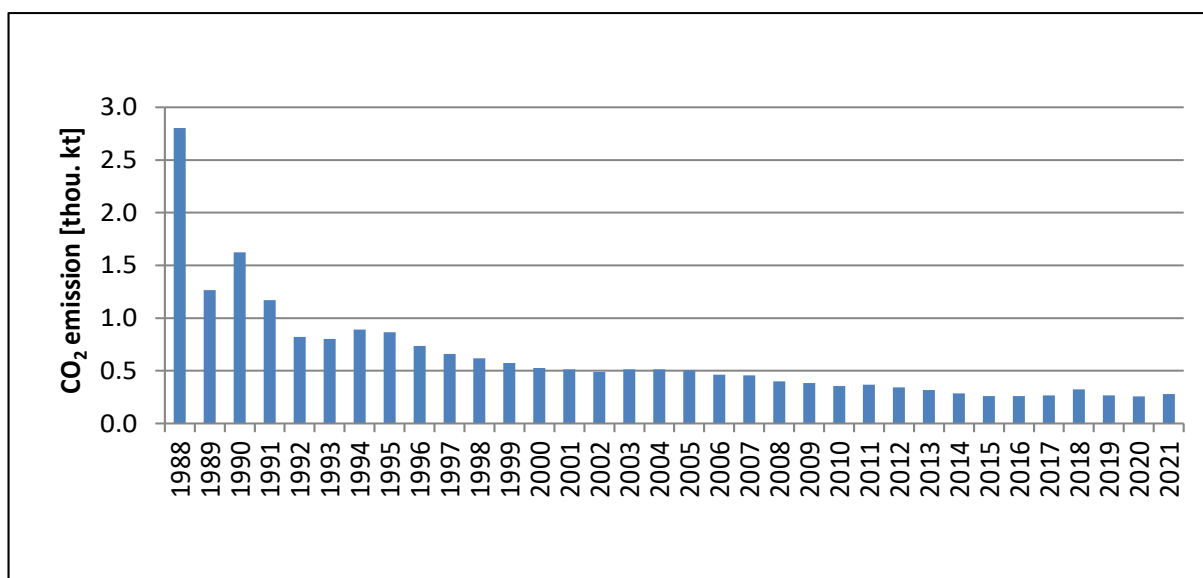
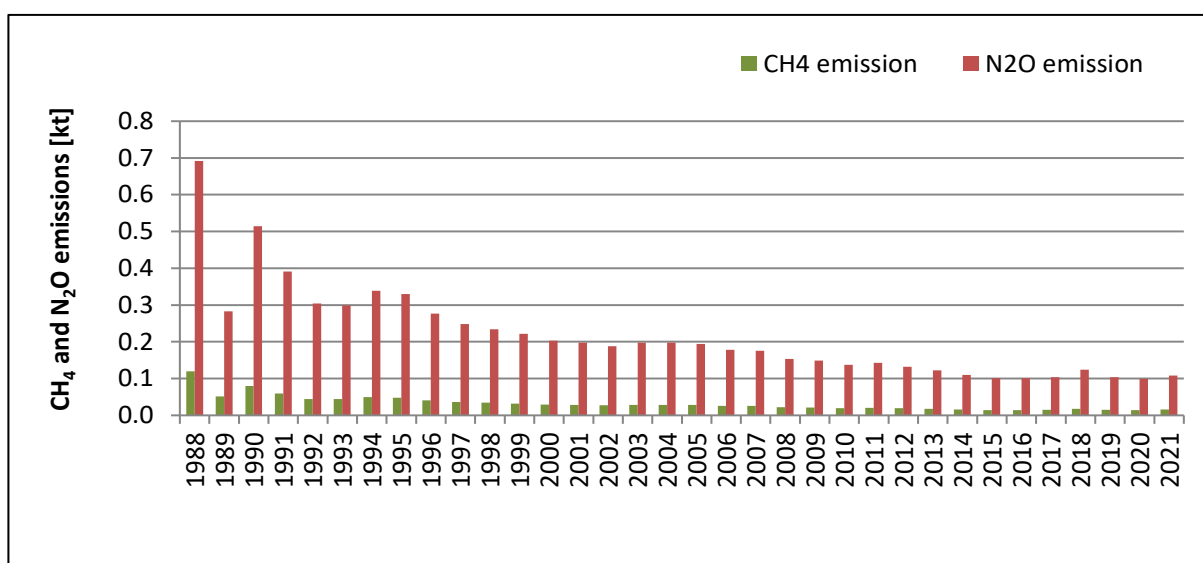


Figure 3.2.8.8. Fuel consumption in 1.A.3.c category for 1988-2021

Figures 3.2.8.9 and 3.2.8.10 show emissions of CO₂, CH₄ and N₂O, respectively in the sub-category 1.A.3.c for the entire time series beginning in the base year.

Figure 3.2.8.9. CO₂ emission for 1.A.3.c category in 1988-2021Figure 3.2.8.10. CH₄ and N₂O emissions for 1.A.3.c category in 1988-2021

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

This category relates to inland and marine domestic navigation and includes emissions from fuels used by vessels of all flags that depart and arrive in the same country. The category does not cover fishing, which should be reported under 1.A.4.c.iii.

Emission factors for the estimation of GHG emissions from domestic navigation are default values from the IPCC 2006 guidelines (table 3.2.8.9).

Table 3.2.8.9. Emission factors for domestic navigation [kg/GJ]

EF		CO ₂	CH ₄	N ₂ O
Inland navigation	Diesel oil	74.10	0.007	0.002
Maritime	Diesel oil	74.10	0.007	0.002
Maritime	Fuel oil	74.40	0.007	0.002

The structure of fuels used in Navigation has been recalculated based on G-03 questionnaires and statistical data on levels of international vs. domestic shipping activity (see table 3.2.8.9). The G-03 questionnaire it is selected data from energy statistic system published by GUS (Statistics Poland). Data connected with marine navigation activates were collected from questionnaire i.e. marine transport of goods and passengers, sea fish catches, goods loaded and unloaded in seaports. Then it was used to calculate fuel consumption in domestic navigation.

1990-2021 fuel use data for fuels classified to the international marine bunker were taken from the Eurostat database. For the years 1988-1989, the respective data were taken from the database of the International Energy Agency (IEA).

As there is no information about cargo activity in Eurostat, the structure of fuels used in domestic marine navigation has been recalculated based on G-03 questionnaires and statistical data on share of international vs domestic shipping activities. Marine Bunkers data are based on IEA and Eurostat energy statistics for Poland.

The amounts of fuels (diesel and fuel oil) used in both inland water and maritime navigation in the 1988-2021 period are shown in table 3.2.8.11 and figure 3.2.8.11.

Table 3.2.8.10. Cargo traffic at Polish seaports

Cargo traffic		1990	1991	1992	1993	1994	1995	1996	1997	1998
International	kt	45 901	40 671	43 558	49 814	51 148	48 179	47 925	50 630	50 564
Domestic	kt	1 138	1 009	744	711	1 327	1 142	1 068	355	432
Share of domestic	%	2.4	2.4	1.7	1.4	2.5	2.3	2.2	0.7	0.8
		1999	2000	2001	2002	2003	2004	2005	2006	2007
International	kt	49 227	47 334	47 220	48 404	51 020	56 011	58 489	59 137	51 604
Domestic	kt	453	537	534	562	866	907	990	1 182	830
Share of domestic	%	0.9	1.1	1.1	1.1	1.7	1.6	1.7	2.0	1.6
		2008	2009	2010	2011	2012	2013	2014	2015	2016
International	kt	47 806	44 250	58 613	56 609	57 728	62 898	68 018	68 472	70 776
Domestic	kt	1 027	829	893	1 129	1 098	1 206	726	1 264	2 150
Share of domestic	%	2.1	1.8	1.5	2.0	1.9	1.9	1.1	1.8	2.9
		2017	2018	2019	2020	2021				
International	kt	75 903	90 088	91 783	85 738	92 570				
Domestic	kt	2 173	1 710	2 081	2 782	4 093				
Share of domestic	%	2.8	1.9	2.2	3.1	4.2				

Table 3.2.8.11. Fuel consumption and GHG emission in years 1988-2021

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Diesel oil-inland navigation	TJ	968.83	681.61	860.00	688.00	817.00	688.00	301.00	688.00	688.00	645.00
Marine diesel oil	TJ	239.59	236.54	232.96	183.59	119.30	82.08	97.98	93.40	72.68	27.93
Marine fuel oil	TJ	894.34	878.75	900.55	825.50	546.35	340.58	425.53	428.31	399.10	127.94
CO ₂ emission	Gg	158.77	136.05	150.69	128.48	111.67	83.42	62.50	91.05	87.26	59.77
CH ₄ emission	Gg	0.015	0.013	0.014	0.012	0.010	0.008	0.006	0.008	0.008	0.006
N ₂ O emission	Gg	0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002

		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Diesel oil-inland navigation	TJ	387.00	301.00	258.00	258.00	215.00	301.00	258.00	215.00	258.00	215.00
Marine diesel oil	TJ	27.25	25.20	24.52	19.76	19.60	31.67	22.84	30.42	31.48	24.15
Marine fuel oil	TJ	156.91	142.74	138.76	133.80	133.37	182.04	85.41	60.55	80.26	65.28
CO ₂ emission	Gg	42.84	35.22	31.67	30.94	27.71	38.74	27.42	22.87	27.66	22.77
CH ₄ emission	Gg	0.004	0.003	0.003	0.003	0.003	0.004	0.003	0.002	0.003	0.002
N ₂ O emission	Gg	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Diesel oil-inland navigation	TJ	215.00	129.90	129.90	129.90	129.90	129.90	129.90	86.00	86.00	196.34
Marine diesel oil	TJ	26.70	16.49	9.22	10.46	10.14	13.39	7.18	68.63	207.72	94.89
Marine fuel oil	TJ	63.97	38.21	12.78	14.79	11.06	23.32	12.19	0.00	0.00	0.00
CO ₂ emission	Gg	22.86	13.80	11.30	11.54	11.23	12.42	11.10	11.46	21.76	21.58
CH ₄ emission	Gg	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
N ₂ O emission	Gg	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
		2018	2019	2020	2021						
Diesel oil-inland navigation	TJ	84.84	78.69	43.30	46.91						
Marine diesel oil	TJ	69.77	52.51	163.71	334.32						
Marine fuel oil	TJ	0.00	0.00	0.00	0.00						
CO ₂ emission	Gg	11.46	9.72	15.34	28.25						
CH ₄ emission	Gg	0.001	0.001	0.001	0.003						
N ₂ O emission	Gg	0.000	0.000	0.000	0.001						

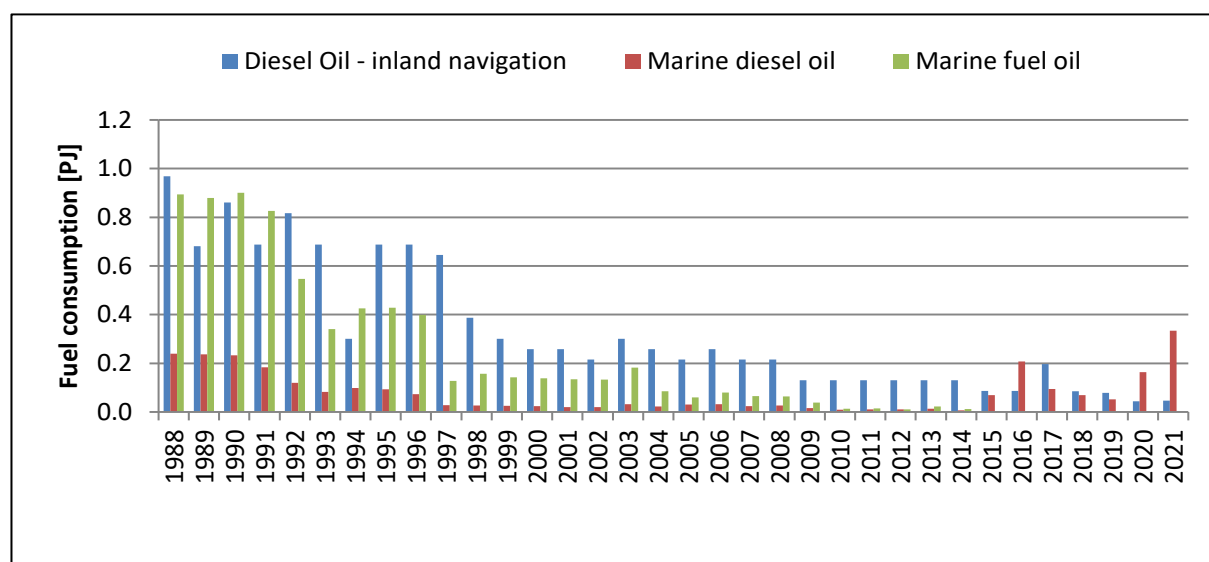
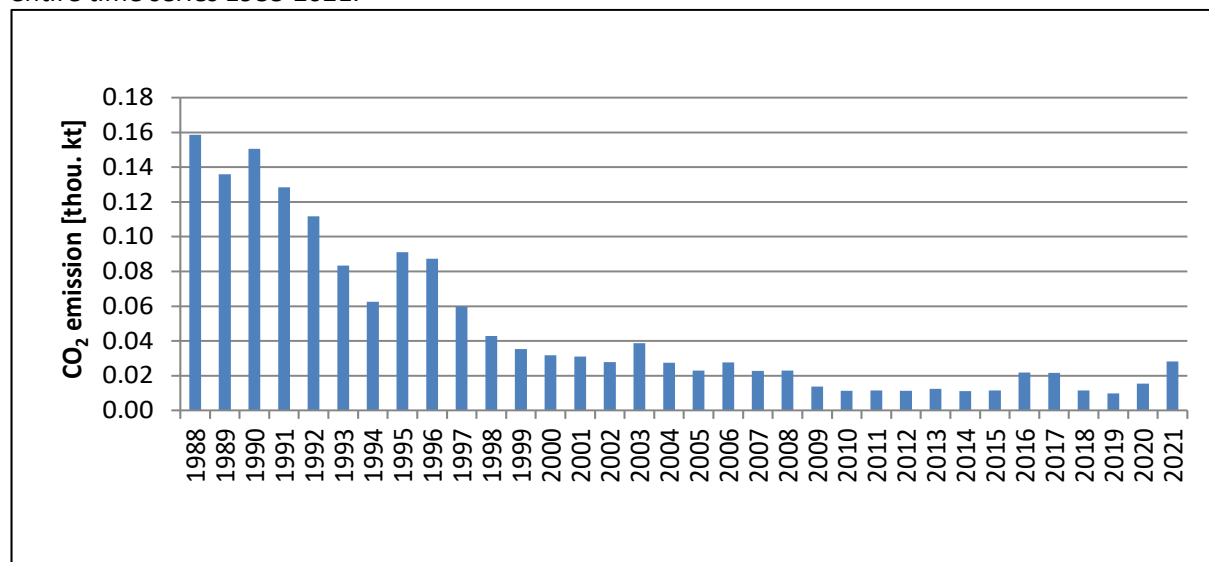
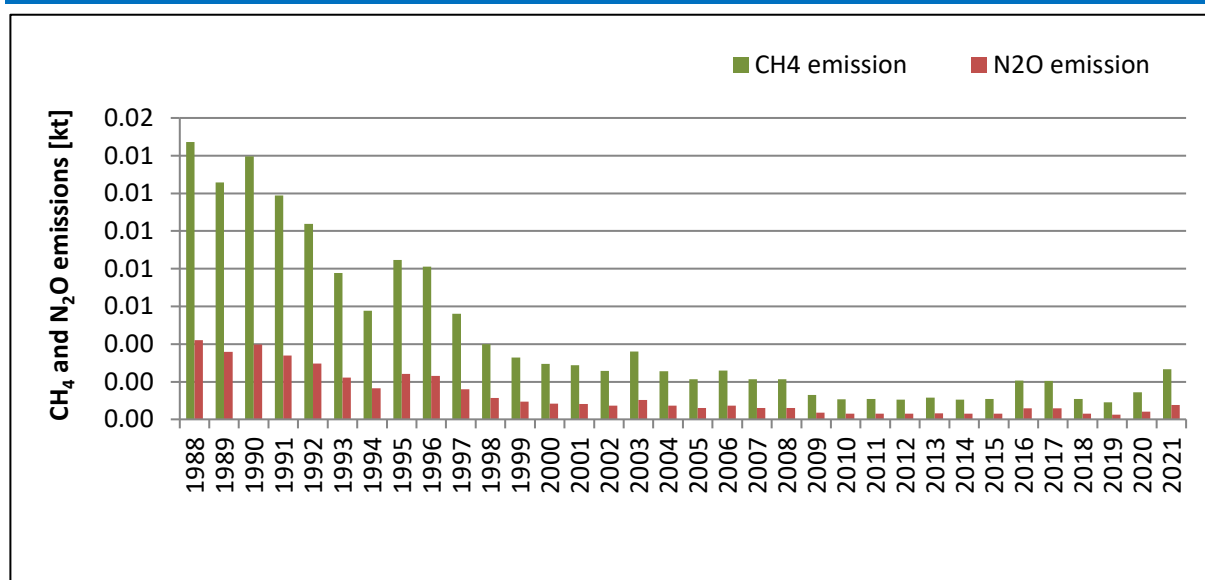


Figure 3.2.8.11. Fuel consumption in 1.A.3.d category for 1988-2021

Figures 3.2.8.12 and 3.2.8.13 show emissions of CO₂, CH₄ and N₂O in the sub-category 1.A.3.d for the entire time series 1988-2021.

Figure 3.2.8.12. CO₂ emission for 1.A.3.d category in 1988-2021

Figure 3.2.8.13. CH₄ and N₂O emissions for 1.A.3.d category in 1988-2021

3.2.8.2.5. Other transportation (CRF sector 1.A.3.e)

Pipeline transport contains combustion related emissions from the operation of pump stations and maintenance of pipelines. From year 2000, when gas pipeline Jamal was completed, the amount of this fuel increased sharply from 21 TJ in 1999 to 2498 TJ in 2000.

The amounts of fuels consumption in the sub-category 1.A.3.e.i *Pipelines transport* in the 1988-2021 period are shown in table 3.2.8.12. Natural gas consumption is shown on figure 3.2.8.14.

Table 3.2.8.12. Fuel consumption and GHG emission in years 1988-2021

		1988	1989	1990	1991	1992	1993	1994	1995	1996
Gasoline	TJ	0	0	0	0	0	0	0	0	0
Diesel oil	TJ	0	0	0	0	0	0	0	0	0
Natural gas	TJ	0	0	0	0	0	0	1	7	24
CO ₂ emission	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.39	1.34
CH ₄ emission	kt	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000007	0.000024
N ₂ O emission	kt	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000002
		1997	1998	1999	2000	2001	2002	2003	2004	2005
Gasoline	TJ	0	0	0	0	44.3	44.3	44.3	44.3	44.3
Diesel oil	TJ	0	0	0	43	43	0	43	43	43
Natural gas	TJ	26	23	21	2498	3262	3502	5257	7381	9866
CO ₂ emission	kt	1.45	1.28	1.17	142.62	188.34	198.55	299.70	418.26	556.97
CH ₄ emission	kt	0.000026	0.000023	0.000021	0.002627	0.003524	0.003635	0.005519	0.007643	0.010128
N ₂ O emission	kt	0.000003	0.000002	0.000002	0.000276	0.000379	0.000377	0.000578	0.000790	0.001039
		2006	2007	2008	2009	2010	2011	2012	2013	2014
Gasoline	TJ	0	44.3	0	45	0	0	0	0	0
Diesel oil	TJ	43	43	43	43.3	43.3	43.3	43.3	43.3	43.3
Natural gas	TJ	12912	11828	13442	11084	9269	9299	10806	15422	15143
CO ₂ emission	kt	723.93	666.49	742.83	619.13	513.49	515.31	600.58	864.06	848.48
CH ₄ emission	kt	0.013041	0.012090	0.013571	0.011349	0.009399	0.009429	0.010936	0.015552	0.015273
N ₂ O emission	kt	0.001317	0.001235	0.001370	0.001161	0.000953	0.000956	0.001107	0.001568	0.001540
		2015	2016	2017	2018	2019	2020	2021		
Gasoline	TJ	0	0	0	0	0	0	0		
Diesel oil	TJ	43	43	42	0	4	1	1		
Natural gas	TJ	14378	15410	15548	17129	15535	13828	11803		
CO ₂ emission	kt	805.76	863.36	864.03	948.60	858.38	765.44	737.12		
CH ₄ emission	kt	0.014507	0.015539	0.015674	0.017129	0.015546	0.013829	0.011805		
N ₂ O emission	kt	0.001464	0.001567	0.001580	0.001713	0.001556	0.001383	0.001181		

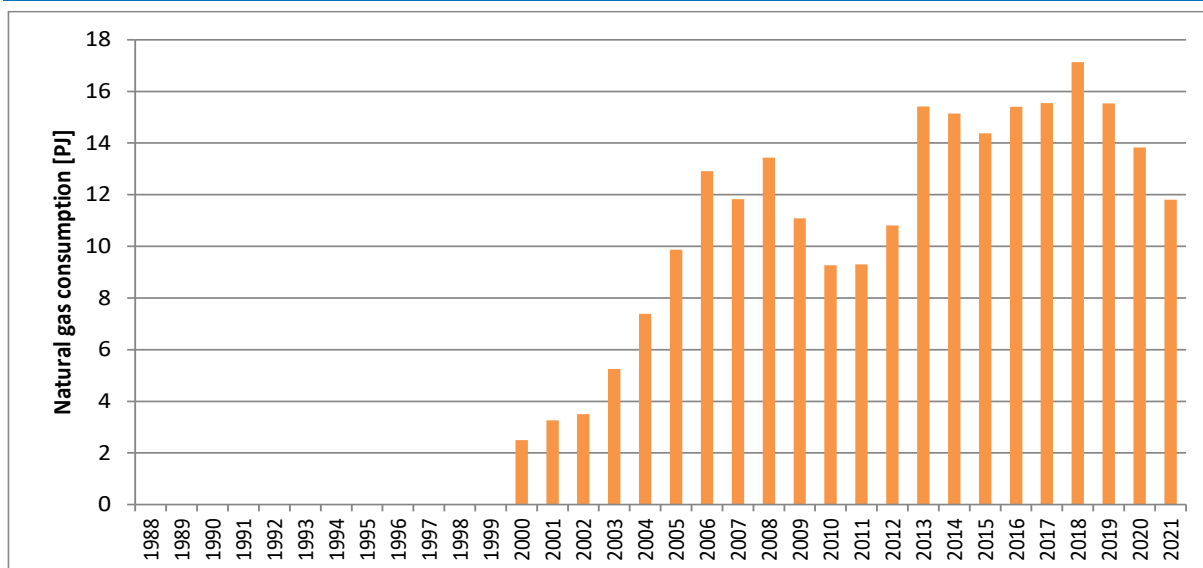


Figure 3.1.8.14. Natural gas consumption in 1.A.3.e.i category for 1988-2021

Figures 3.2.8.15 and 3.2.8.16 show emissions of CO₂, CH₄ and N₂O, in the sub-category 1.A.3.e from *Pipelines transport* for the entire time series 1988-2021.

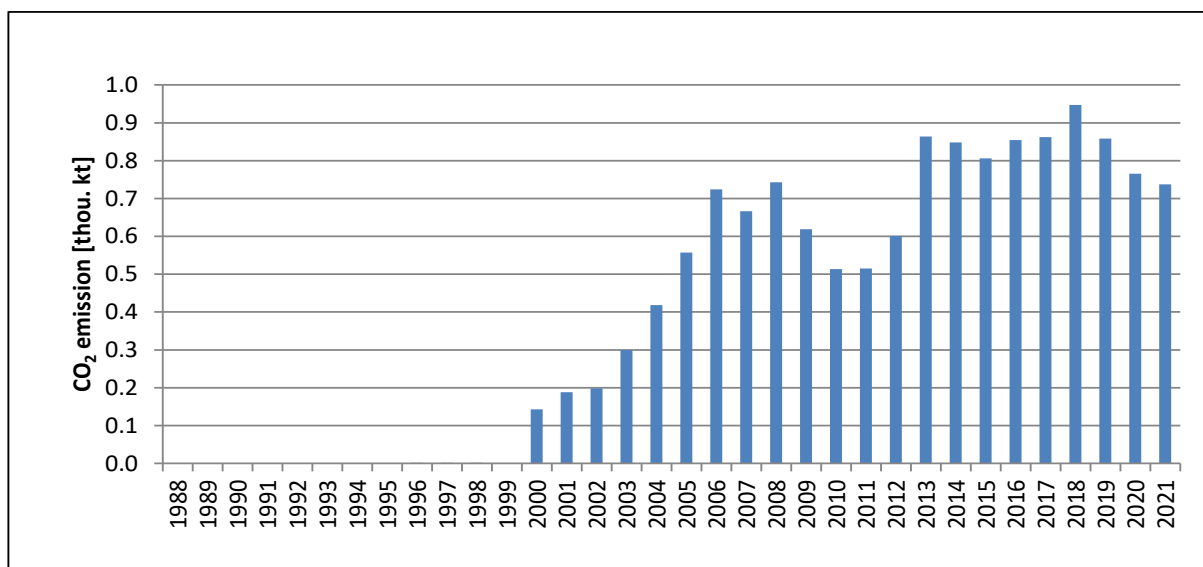


Figure 3.2.8.15. CO₂ emission from 1.A.3.e.i category in 1988-2021

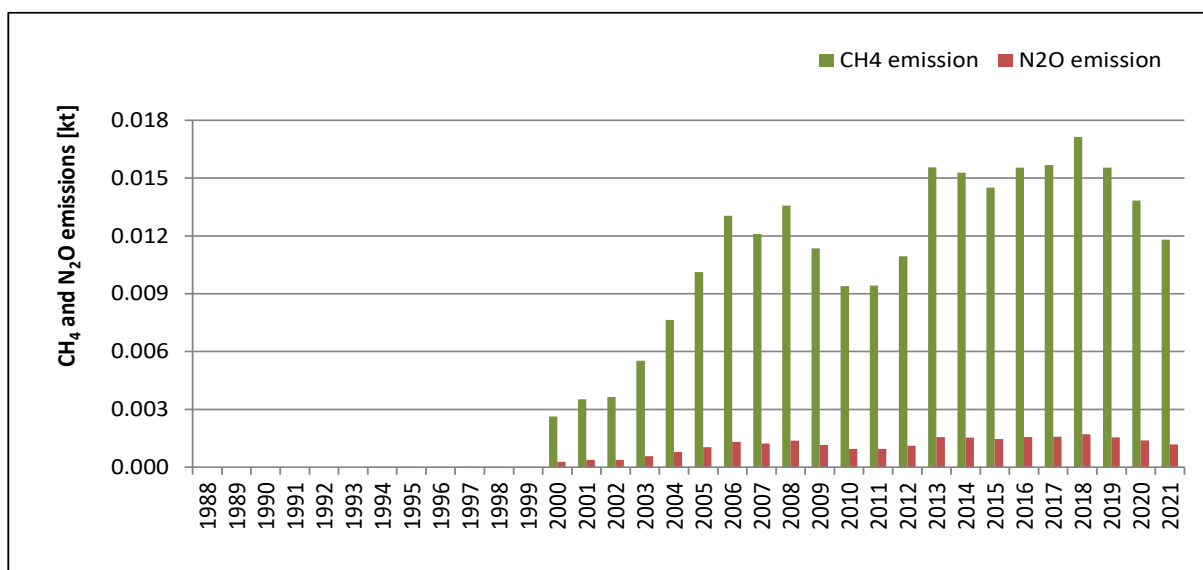


Figure 3.2.16. CH₄ and N₂O emissions from 1.A.3.e.i category in 1988-2021

3.2.8.2.6. Other mobile sources outside of the source category 1.A.3

Other mobile sources included in the national inventory in sub-categories other than 1.A.3 include:

- machinery and off-road transport in agriculture (sub-category 1.A.4.c.ii) – classified in 1.A.4,
- fishery (sub-category 1.A.4.c.iii) - classified in source category 1.A.4.

The amounts of fuels used in the above listed sub-categories in the 1988-2021 period are presented in table 3.2.8.13 and figure 3.2.8.17. The amounts of corresponding emissions of CO₂, CH₄ and N₂O are shown in tables 3.2.8.14–3.2.8.15 and figures 3.2.8.18 and 3.2.8.19.

Table 3.2.8.13. Fuel consumption in 1988-2021 in mobile sources in subcategories other than 1.A.3

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Diesel oil - 1.A.4.c.ii	PJ	49.42	47.82	50.64	48.80	57.34	72.33	78.33	82.47	92.02	107.05
Diesel oil - 1.A.4.c.iii	PJ	4.55	4.15	3.45	3.32	3.46	2.84	3.24	3.19	2.58	2.68
Fuel oil - 1.A.4.c.iii	PJ	7.54	6.87	5.67	5.46	5.69	4.67	5.33	5.24	4.24	4.41
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Diesel oil - 1.A.4.c.ii	PJ	97.39	99.75	110.51	103.02	102.71	103.92	105.85	108.28	80.41	73.91
Diesel oil - 1.A.4.c.iii	PJ	1.94	1.94	1.72	1.81	1.78	1.43	1.61	1.37	1.29	1.34
Fuel oil - 1.A.4.c.iii	PJ	3.18	3.19	2.83	2.98	2.93	2.36	2.65	2.25	2.13	2.20
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Diesel oil - 1.A.4.c.ii	PJ	73.96	71.69	71.91	72.49	73.04	71.40	68.96	68.13	72.16	86.27
Diesel oil - 1.A.4.c.iii	PJ	1.29	1.92	1.57	1.64	1.66	1.78	1.62	1.70	1.80	1.88
Fuel oil - 1.A.4.c.iii	PJ	2.11	3.11	2.53	2.65	2.68	2.88	2.62	2.77	2.94	3.06
		2018	2019	2020	2021						
Diesel oil - 1.A.4.c.ii	PJ	91.04	94.64	95.63	96.09						
Diesel oil - 1.A.4.c.iii	PJ	1.84	1.89	1.81	1.78						
Fuel oil - 1.A.4.c.iii	PJ	3.06	3.15	3.01	2.92						

Table 3.2.8.14. GHG emission in 1988-2021 in subcategory 1.A.4.c.ii

1.A.4.c.ii		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
CO ₂ emission	kt	3 662	3 544	3 753	3 616	4 249	5 359	5 804	6 111	6 819	7 933
CH ₄ emission	kt	0.205	0.198	0.210	0.203	0.238	0.300	0.325	0.342	0.382	0.444
N ₂ O emission	kt	1.413	1.368	1.448	1.396	1.640	2.069	2.240	2.359	2.632	3.062
1.A.4.c.ii		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO ₂ emission	kt	7 217	7 392	8 189	7 634	7 611	7 700	7 843	8 023	5 958	5 477
CH ₄ emission	kt	0.404	0.414	0.459	0.428	0.426	0.431	0.439	0.449	0.334	0.307
N ₂ O emission	kt	2.785	2.853	3.161	2.946	2.938	2.972	3.027	3.097	2.300	2.114
1.A.4.c.ii		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CO ₂ emission	kt	5 481	5 312	5 329	5 372	5 412	5 291	5 110	5 048	5 347	6 393
CH ₄ emission	kt	0.307	0.297	0.298	0.301	0.303	0.296	0.286	0.283	0.299	0.358
N ₂ O emission	kt	2.115	2.050	2.057	2.073	2.089	2.042	1.972	1.948	2.064	2.467
1.A.4.c.ii		2018	2019	2020	2021						
CO ₂ emission	kt	6 746	7 013	7 086	7 120						
CH ₄ emission	kt	0.378	0.393	0.397	0.399						
N ₂ O emission	kt	2.604	2.707	2.735	2.748						

Table 3.2.8.15. GHG emission in 1988-2021 in subcategory 1.A.4.c.iii

1.A.4.c.iii		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
CO ₂ emission	kt	920	838	693	667	696	570	652	640	519	540
CH ₄ emission	kt	0.085	0.077	0.064	0.061	0.064	0.053	0.060	0.059	0.048	0.050
N ₂ O emission	kt	0.024	0.022	0.018	0.018	0.018	0.015	0.017	0.017	0.014	0.014
1.A.4.c.iii		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO ₂ emission	kt	389	391	346	364	358	288	323	276	260	269
CH ₄ emission	kt	0.036	0.036	0.032	0.034	0.033	0.027	0.030	0.025	0.024	0.025
N ₂ O emission	kt	0.010	0.010	0.009	0.010	0.009	0.008	0.009	0.007	0.007	0.007
1.A.4.c.iii		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CO ₂ emission	kt	259	385	311	326	327	353	322	338	361	376
CH ₄ emission	kt	0.024	0.035	0.029	0.030	0.030	0.033	0.030	0.031	0.033	0.035
N ₂ O emission	kt	0.007	0.010	0.008	0.009	0.009	0.009	0.008	0.009	0.009	0.010

1.A.4.c.iii		2018	2019	2020	2021
CO ₂ emission	kt	373	384	367	358
CH ₄ emission	kt	0.034	0.035	0.034	0.033
N ₂ O emission	kt	0.010	0.010	0.010	0.009

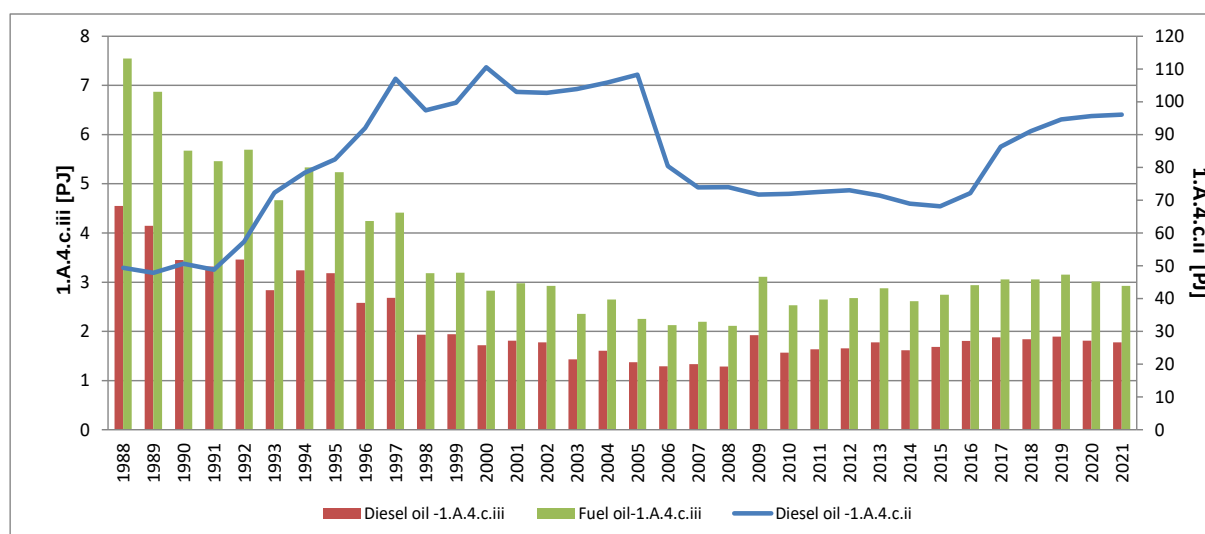


Figure 3.2.8.17. Fuel consumption in 1988-2021 in mobile sources in subcategories other than 1.A.3

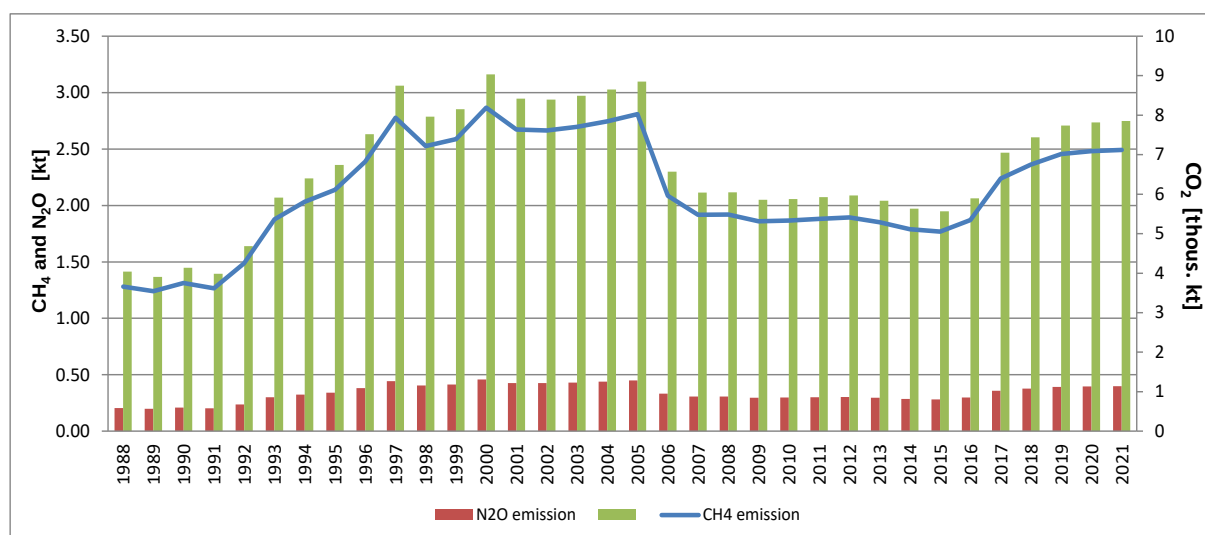


Figure 3.2.8.18. GHG emission in 1988-2021 in subcategory 1.A.4.c.ii

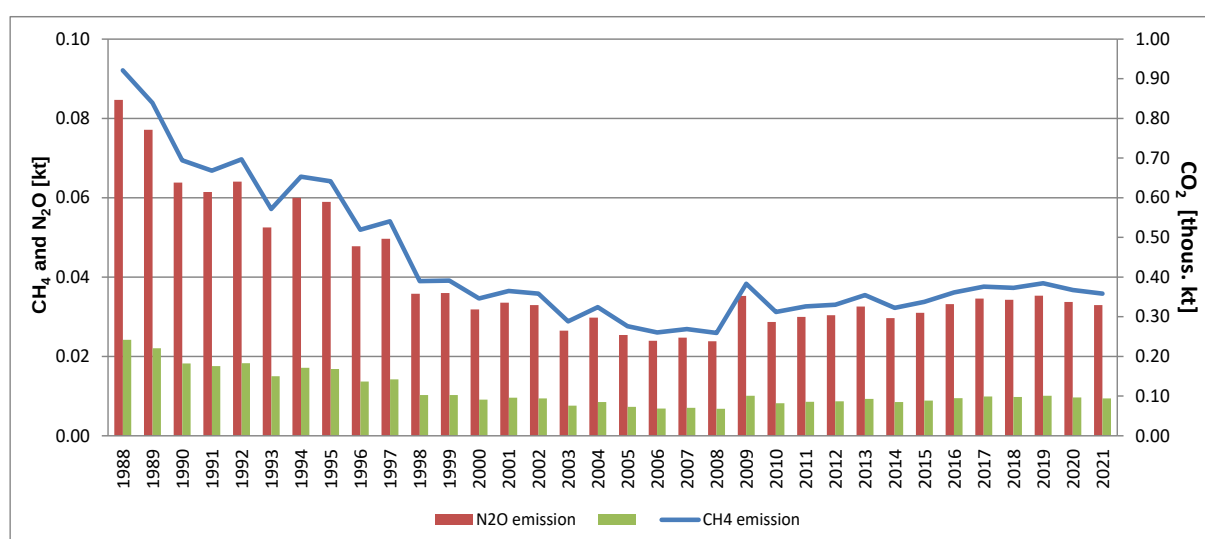


Figure 3.2.8.19. GHG emission in 1988-2021 in subcategory 1.A.4.c.iii

3.2.8.3. Uncertainties and time-series consistency

See chapter 3.2.6.3

3.2.8.4. Source-specific QA/QC and verification

See chapter 3.2.6.4

3.2.8.5. Source-specific recalculations

The following recalculations have been implemented:

- fuel consumption was corrected based on updated Eurocontrol and Eurostat database;
- new version of COPERT 5 software were used to recalculate emissions from road transport in years 1990 – 2020;
- the update of vehicles miliage in road transport based on data from Polish Central Vehicle and Driver Register database;
- EF CO₂ for fuel oil in 1.A.4.c.iii Fishing has been changed. Detailed information is contained in 3.2.9.5. Source-specific recalculations.

Table 3.2.8.16. Changes in GHG emission in subsector 1.A.3.a. *Domestic aviation* resulting from recalculations

Difference	1988	1989	1990	1991	1992	1993	1994	1995	1996
kt CO ₂ eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Difference	1997	1998	1999	2000	2001	2002	2003	2004	2005
kt CO ₂ eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Difference	2006	2007	2008	2009	2010	2011	2012	2013	2014
kt CO ₂ eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Difference	2015	2016	2017	2018	2019	2020			
kt CO ₂ eq.	0.00	0.00	-45.01	-43.11	-40.95	-22.45			
%	0.00	0.00	-0.35	-0.33	-0.32	-0.30			

Table 3.2.8.17. Changes in GHG emission in subsector 1.A.3.b *Road transport* resulting from recalculations

Difference	1988	1989	1990	1991	1992	1993	1994	1995	1996
kt CO ₂ eq.	0.46	0.47	0.47	0.13	7.23	9.85	36.95	88.18	159.64
%	0.00%	0.00%	0.00%	0.00%	0.03%	0.05%	0.17%	0.39%	0.62%
Difference	1997	1998	1999	2000	2001	2002	2003	2004	2005
kt CO ₂ eq.	216.30	277.74	380.67	398.74	427.45	396.04	36.34	35.45	31.73
%	0.79%	0.95%	1.19%	1.43%	1.55%	1.49%	0.13%	0.11%	0.09%
Difference	2006	2007	2008	2009	2010	2011	2012	2013	2014
kt CO ₂ eq.	34.15	35.03	33.83	5.72	5.87	4.26	2.74	1.46	28.45
%	0.09%	0.08%	0.08%	0.01%	0.01%	0.01%	0.01%	0.00%	0.06%
Difference	2015	2016	2017	2018	2019	2020			
kt CO ₂ eq.	32.60	34.37	41.02	-2.50	-4.69	-69.47			
%	0.07%	0.06%	0.07%	0.00%	-0.01%	-0.11%			

3.2.8.6. Source-specific planned improvements

Poland intends to investigate the correlation between cargo activity and shipping emissions and on cross-checks between emissions estimated on the basis of cargo activity and emissions estimated on the basis of Eurostat data.

3.2.9. Other sectors (CRF sector 1.A.4)

3.2.9.1. Source category description

Emissions in 1.A.4 *Other Sectors* are estimated for each fuel in detailed sub-categories given below:

- a) *Commercial/institutional* (1.A.4.a),
- b) *Residential* (1.A.4.b),
- c) *Agriculture/forestry/fishing* (1.A.4.c):
 - *Stationary* - 1.A.4.c.i,
 - *Off-road vehicles and other machinery* - 1.A.4.c.ii,
 - *Fishing* - 1.A.4.c.iii.

Subsector 1.A.4.b *Residential* is by far the largest contributor to emissions from this category (see figure 3.2.9.1) – about 64.8% in 2021.

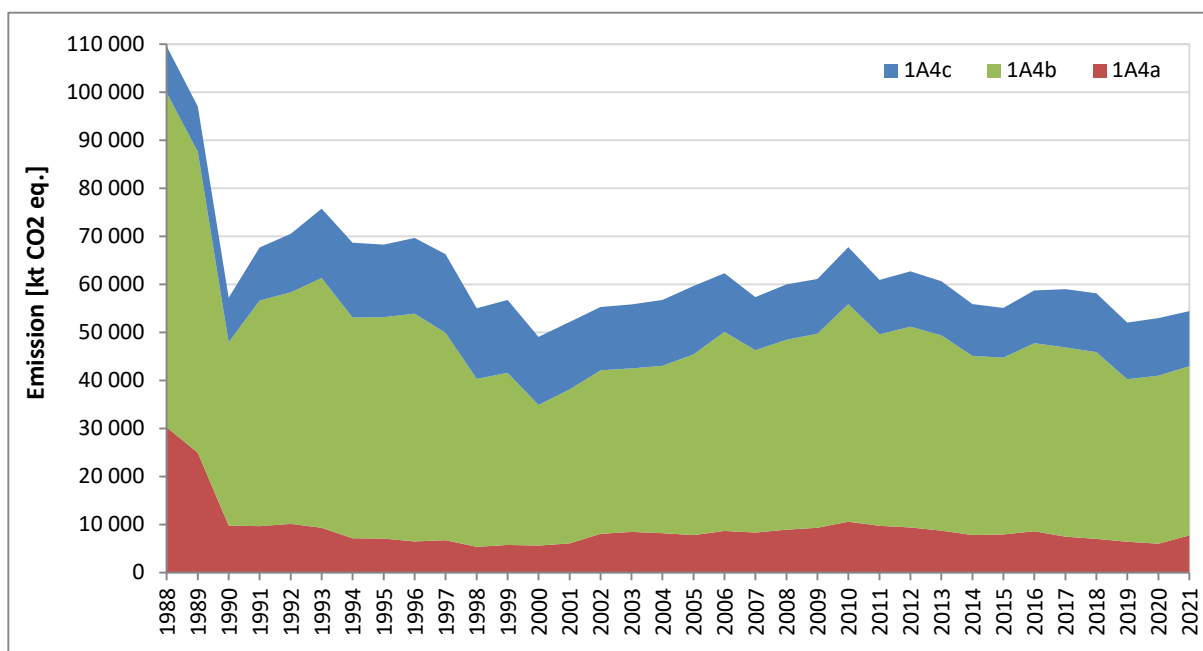


Figure 3.2.9.1. GHG emissions from 1.A.4 *Other sectors* in years 1988-2021 according to subcategories

3.2.9.2. Methodological issues

Methodology of emission estimation in 1.A.4 subcategory corresponds with methodology described for fuel combustion in stationary sources. Detailed information on fuel consumption and applied emission factors for subsectors included in 1.A.4 subcategory are presented in Annex 2.2.

3.2.9.2.1. Other sectors – Commercial/Institutional (1.A.4.a)

The data on fuel type use in the sub-category 1.A.4.a *Other Sectors – Commercial/Institutional* over the 1988-2021 period are presented in table 3.5.9.1. Detailed data concerning fuel consumption in 1.A.4.a subcategory was tabulated in Annex 2.2 (table 11).

The fuel consumption related to mobile sources (category 1.A.4.a.ii) is included in category 1.A.3.b. The reasons are difficulties in separating the consumption of this fuel, due to its purchase at gas stations and reporting in the fuel balance together with fuels in transport.

Table 3.2.9.1. Fuel consumption in 1988-2021 in 1.A.4.a subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	0.000	0.000	0.000	0.000	0.000	0.000	1.372	0.804
Gaseous Fuels	13.079	12.601	13.787	10.977	11.190	11.548	9.573	13.260
Solid Fuels	297.025	244.614	90.171	91.760	95.301	85.366	63.396	61.568

	1988	1989	1990	1991	1992	1993	1994	1995
Other Fuels	2.135	0.144	0.504	0.081	0.011	0.352	0.089	0.000
Biomass	0.084	0.123	0.379	0.187	0.206	12.374	11.968	11.983
TOTAL	312.322	257.481	104.842	103.005	106.708	109.640	86.398	87.615
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	1.793	6.178	7.843	10.426	16.622	21.423	22.950	24.218
Gaseous Fuels	18.771	24.256	32.769	37.697	38.567	49.971	61.001	67.057
Solid Fuels	51.525	47.725	28.968	27.821	21.956	17.265	29.795	29.740
Other Fuels	0.124	0.000	0.003	0.004	0.024	0.091	0.101	0.071
Biomass	10.625	9.627	9.085	9.216	9.211	6.596	6.440	6.466
TOTAL	82.839	87.786	78.668	85.163	86.380	95.346	120.287	127.552
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	21.485	17.974	28.698	27.980	27.507	25.682	30.953	28.986
Gaseous Fuels	69.564	68.410	63.517	65.489	71.250	75.746	83.433	78.278
Solid Fuels	28.299	28.032	32.148	27.840	30.808	33.484	38.065	33.598
Other Fuels	0.002	0.022	0.000	0.000	0.037	0.123	0.026	0.046
Biomass	7.366	7.803	6.190	6.949	6.823	8.779	9.859	9.781
TOTAL	126.716	122.241	130.553	128.257	136.426	143.814	162.336	150.689
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	22.451	18.007	17.712	17.567	17.754	18.376	18.735	17.101
Gaseous Fuels	80.888	76.501	67.429	71.823	80.972	60.806	56.324	56.462
Solid Fuels	34.126	31.703	28.036	27.080	28.394	27.963	25.502	20.567
Other Fuels	0.037	0.421	0.231	0.195	0.355	0.250	0.219	0.195
Biomass	9.113	9.556	8.674	9.404	10.546	10.544	10.143	10.106
TOTAL	146.614	136.188	122.081	126.068	138.021	117.939	110.924	104.431
	2020	2021						
Liquid Fuels	16.171	17.642						
Gaseous Fuels	47.900	67.306						
Solid Fuels	21.852	26.794						
Other Fuels	0.589	0.731						
Biomass	10.204	11.302						
TOTAL	96.716	123.775						

Figures 3.2.9.2 and 3.2.9.3 show emissions of CO₂, CH₄ and N₂O, respectively in the sub-category 1.A.4.a in the period 1988-2021.

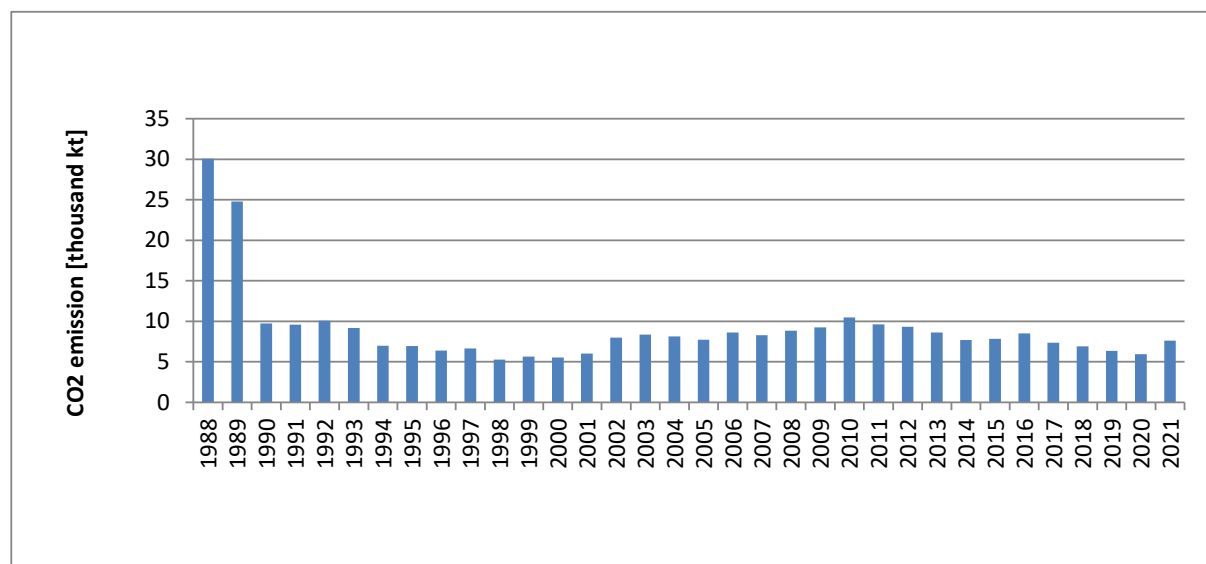
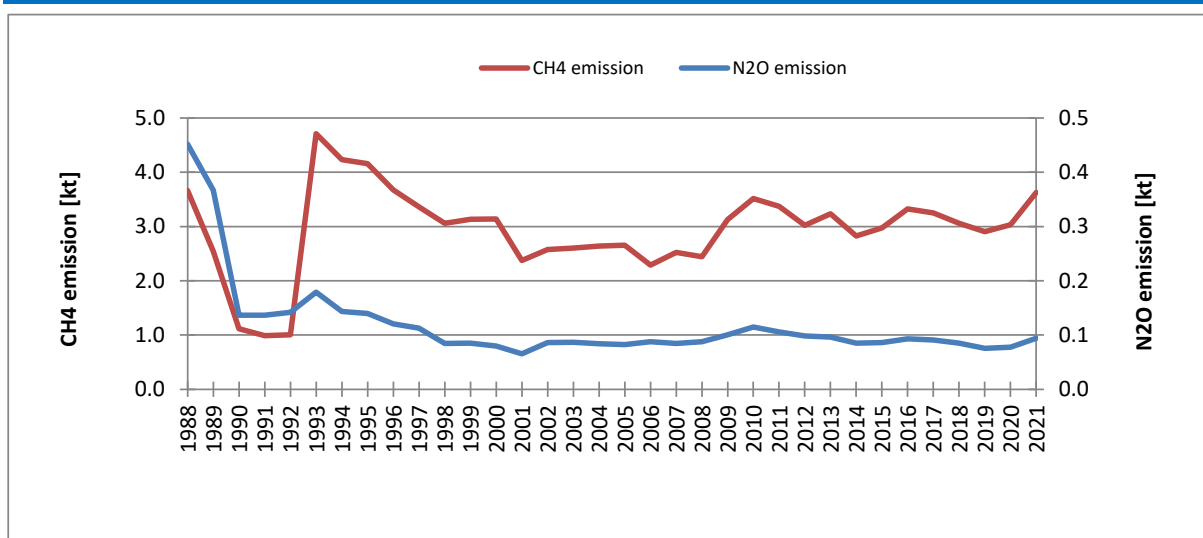


Figure 3.2.9.2. CO₂ emission for 1.A.4.a category in 1988-2021

Figure 3.2.9.3. CH₄ and N₂O emissions for 1.A.4.a category in 1988-2021

3.2.9.2.2. Other sectors – Residential (CRF sector 1.A.4.b)

The data on fuel type use in stationary sources in the sub-category 1.A.4.b *Residential* over the 1988-2021 period are presented in table 3.2.9.2 detailed information on fuel consumption for 1.A.4.b subcategory is presented in Annex 2.2 (table 12).

The fuel consumption related to mobile sources (category 1.A.4.b.ii) is included in category 1.A.3.b. The reasons are difficulties in separating the consumption of this fuel, due to its purchase at gas stations and reporting in the fuel balance together with fuels in transport subcategory.

Table 3.2.9.2. Fuel consumption in 1988-2021 in 1.A.4.b subcategory [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	6.762	7.452	1.750	1.041	1.892	6.244	9.224	13.197
Gaseous Fuels	102.581	107.619	122.204	133.674	141.212	141.590	151.671	159.559
Solid Fuels	617.874	546.675	307.009	385.556	390.063	412.793	345.629	338.768
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	33.615	32.351	38.875	30.944	34.552	106.000	104.715	105.000
TOTAL	760.831	694.097	469.838	551.214	567.718	666.627	611.238	616.524
	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	18.705	25.370	27.520	29.670	38.012	42.785	45.000	49.020
Gaseous Fuels	143.057	150.022	138.268	135.995	127.611	133.737	127.093	127.629
Solid Fuels	357.959	307.233	234.197	243.307	179.010	198.167	219.913	217.515
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	101.000	100.000	100.700	95.000	95.000	104.500	104.500	103.075
TOTAL	620.721	582.625	500.685	503.972	439.633	479.189	496.505	497.239
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	46.096	43.000	43.000	40.076	36.679	33.265	29.387	27.763
Gaseous Fuels	126.376	135.111	138.686	132.622	131.450	134.857	148.427	135.471
Solid Fuels	228.651	255.027	290.111	260.834	279.820	287.843	330.255	284.965
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	103.360	100.700	104.500	102.000	102.500	102.500	112.746	115.000
TOTAL	504.483	533.838	576.297	535.532	550.449	558.465	620.815	563.199
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	26.767	25.084	24.421	24.572	24.630	25.090	26.440	27.175
Gaseous Fuels	141.397	143.187	131.598	132.202	145.148	151.972	149.111	152.348
Solid Fuels	300.920	289.756	265.455	260.056	275.731	274.404	257.671	208.452
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	116.850	116.850	105.450	108.395	111.435	109.725	237.671	219.724
TOTAL	585.934	574.877	526.924	525.225	556.944	561.191	670.893	607.699

	2020	2021
Liquid Fuels	25.838	26.064
Gaseous Fuels	160.833	191.171
Solid Fuels	217.719	203.368
Other Fuels	0.000	0.000
Biomass	203.228	207.755
TOTAL	607.618	628.358

Figure 3.2.9.4 show emissions of CO₂ in 1.A.4.b in the 1988-2021 period while CH₄ and N₂O, emissions in the same sub-category are shown in figure 3.2.9.5.

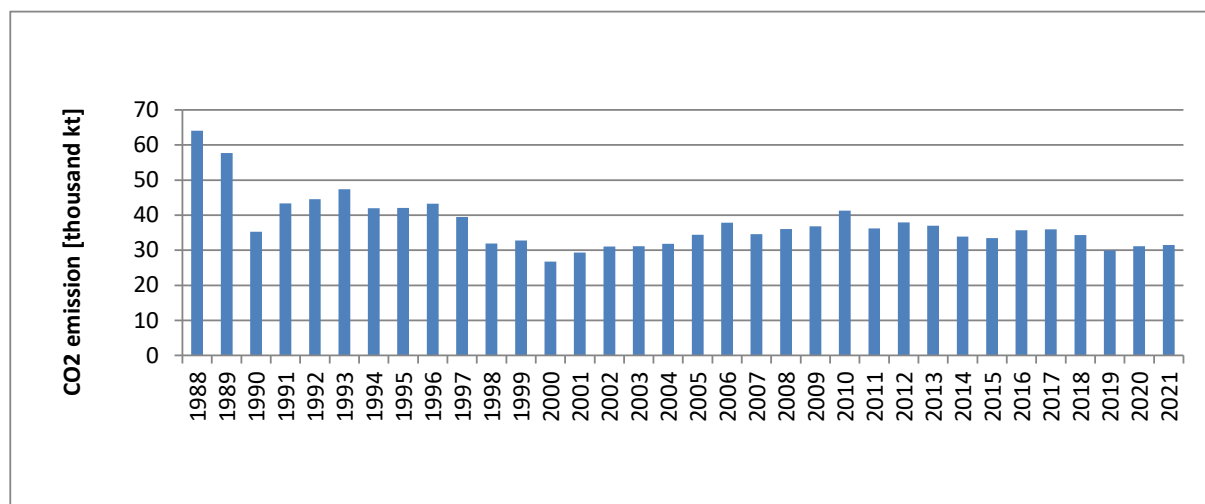


Figure 3.2.9.4. CO₂ emission for 1.A.4.b category in 1988-2021

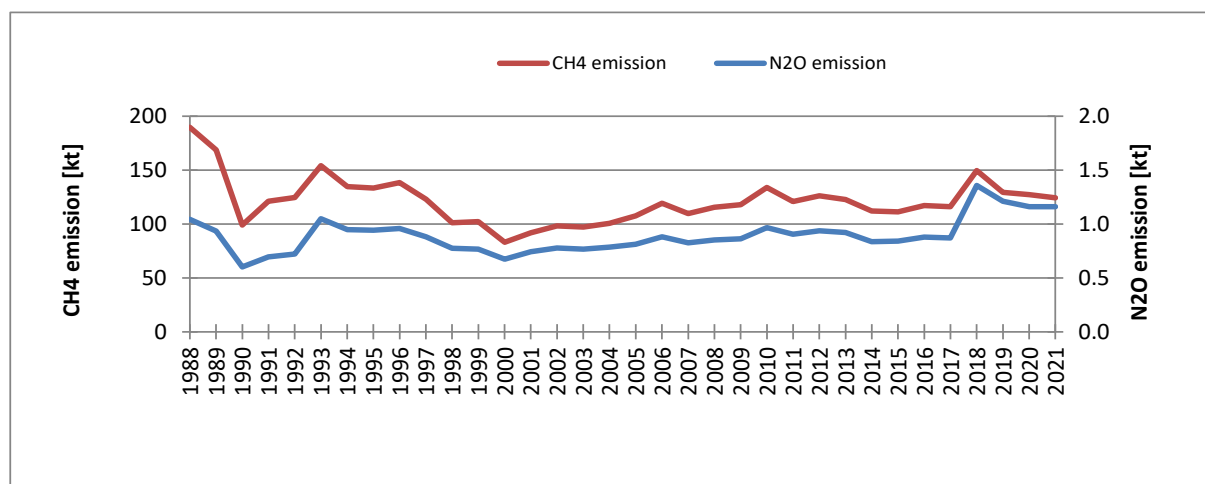


Figure 3.2.9.5. CH₄ and N₂O emissions for 1.A.4.b category in 1988-2021

3.2.9.2.3. Other sectors – Agriculture/forestry/fishing – Stationary (CRF sector 1.A.4.c.i)

The data on fuel type use in sub-category 1.A.4.c.i *Agriculture/forestry/fishing – Stationary* over the 1988-2021 period are presented in table 3.2.9.3. Detailed data concerning total fuel consumption in 1.A.4.c subcategory (including fuel consumption related to off-road vehicles and other machinery in agriculture and fuel use in fishing) was tabulated in Annex 2.2 (table 13).

Table 3.2.9.3. Fuel consumption in 1.A.4.c.i subcategory for years 1988-2021 [PJ]

	1988	1989	1990	1991	1992	1993	1994	1995
Liquid Fuels	2.720	2.600	3.596	2.747	1.454	14.199	18.468	10.624
Gaseous Fuels	0.507	0.445	0.448	0.275	0.055	0.132	0.212	0.243
Solid Fuels	42.691	42.026	39.285	59.666	64.630	63.925	66.182	64.198
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.039	0.113	0.000	0.000	0.000	20.057	18.367	18.500
TOTAL	45.956	45.185	43.328	62.689	66.139	98.313	103.229	93.566

	1996	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels	6.330	9.241	8.263	8.519	8.921	8.588	7.023	9.520
Gaseous Fuels	0.428	0.571	0.869	0.476	0.536	0.777	0.914	1.197
Solid Fuels	67.920	58.853	52.806	55.390	37.586	41.898	35.057	34.078
Other Fuels	0.000	0.000	0.000	0.006	0.012	0.011	0.000	0.000
Biomass	17.567	17.000	17.100	17.106	17.113	19.053	19.010	19.017
TOTAL	92.245	85.664	79.038	81.497	64.168	70.327	62.004	63.811
	2004	2005	2006	2007	2008	2009	2010	2011
Liquid Fuels	9.552	10.849	4.412	3.799	4.007	3.495	3.265	3.671
Gaseous Fuels	1.182	1.084	1.492	1.841	1.900	1.577	1.486	1.531
Solid Fuels	35.787	38.979	45.996	40.708	45.296	44.910	49.905	43.833
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	19.878	19.047	19.978	19.062	19.118	19.127	21.127	24.154
TOTAL	66.398	69.958	71.879	65.409	70.322	69.109	75.783	73.189
	2012	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	3.705	2.905	2.962	3.065	3.363	3.490	3.305	3.447
Gaseous Fuels	1.796	1.501	1.438	1.144	1.305	1.519	1.267	1.558
Solid Fuels	45.502	44.474	42.312	38.431	40.873	40.583	38.087	30.776
Other Fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	21.200	21.223	19.638	20.641	21.831	21.672	21.093	20.013
TOTAL	72.203	70.103	66.350	63.281	67.372	67.264	63.751	55.794
	2020	2021						
Liquid Fuels	3.307	2.975						
Gaseous Fuels	1.806	2.176						
Solid Fuels	31.579	25.899						
Other Fuels	0.000	0.000						
Biomass	20.464	24.241						
TOTAL	57.154	55.291						

Figures 3.2.9.6 and 3.2.9.7 show emissions of CO₂, and CH₄ and N₂O, respectively in the sub-category 1.A.4.c.i in the period: 1988-2021.

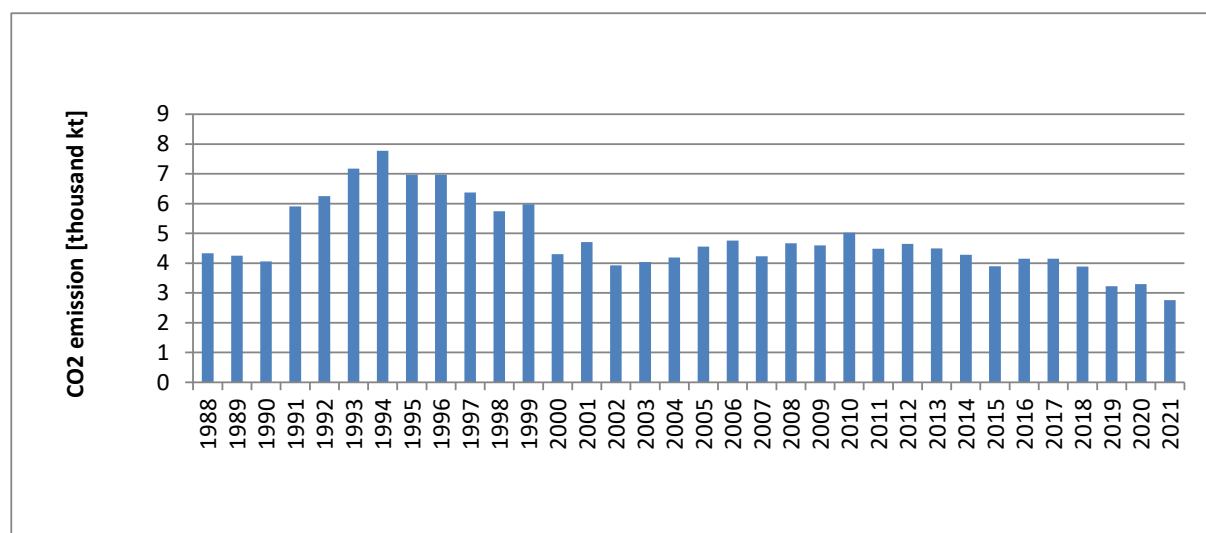


Figure 3.2.9.6. CO₂ emission in 1.A.4.c.i category in 1988-2021

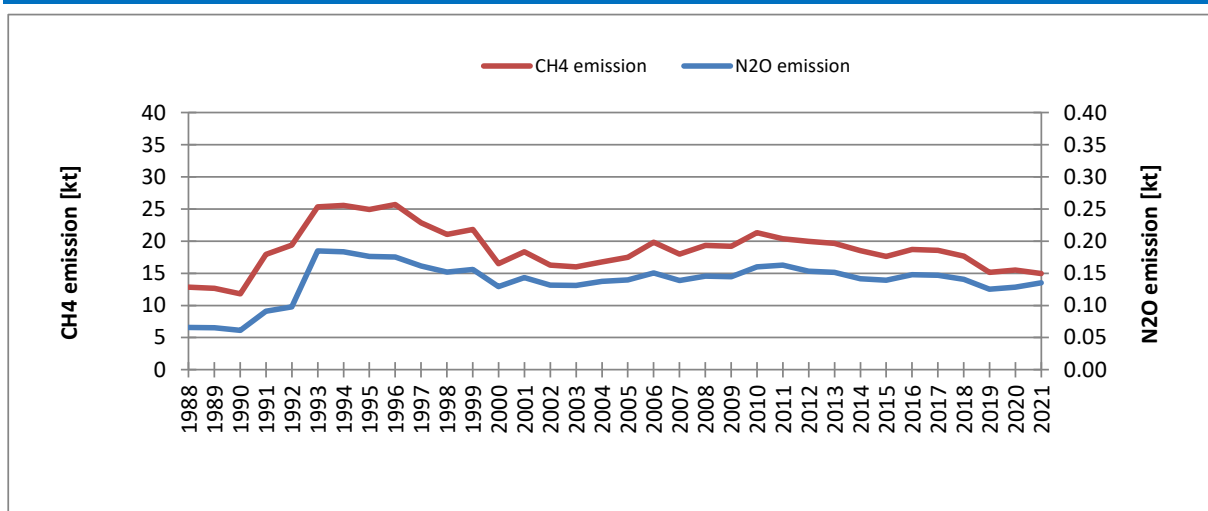


Figure 3.2.9.7. CH₄ and N₂O emissions in 1.A.4.c.i category in 1988-2021

The mobile sources classified in the sub-category 1.A.4.c (i.e. 1.A.4.c.ii *Off-road vehicles and other machinery* and 1.A.4.c.iii *Fishing*) are described in chapter 3.2.8.2.6.

3.2.9.3. Uncertainties and time-series consistency

See chapter 3.2.6.3

3.2.9.4. Source-specific QA/QC and verification

See chapter 3.2.6.4

3.2.9.5. Source-specific recalculations

Insignificant corrections in CO₂ emissions for the entire trend result from the slight adjustments of the CO₂ EF for fuel oil combustion in 1.A.4.c.iii.

Recalculation in case of CH₄ and N₂O for 2018-2020 is connected with changes in updated energy balance and increase of solid biomass consumption in 1.A.4.b subcategory.

Other slight corrections for 2020 are related to negligible adjustments in fuel consumption (i.a. coal) introduced as a data update of EUROSTAT database.

Table 3.2.9.4. Changes of GHG emission values in 1.A.4 subcategory as a result of recalculations

Changes	1988	1989	1990	1991	1992	1993	1994	1995
CO₂								
kt	1.54	1.40	1.16	1.12	1.16	0.95	1.09	1.07
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH₄								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N₂O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Changes	1996	1997	1998	1999	2000	2001	2002	2003
CO₂								
kt	0.87	0.90	0.65	0.65	0.58	0.61	0.60	0.48
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH₄								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

N ₂ O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Changes	2004	2005	2006	2007	2008	2009	2010	2011
CO ₂								
kt	0.54	0.46	0.25	-0.35	-0.11	-1.45	1.09	0.30
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH ₄								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N ₂ O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Changes	2012	2013	2014	2015	2016	2017	2018	2019
CO ₂								
kt	3.05	1.34	0.60	2.39	-0.14	0.05	0.01	2.64
%	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
CH ₄								
kt	0.000	0.000	0.000	0.000	0.000	0.000	38.897	35.137
%	0.00	0.00	0.00	0.00	0.00	0.00	29.38	30.28
N ₂ O								
kt	0.000	0.000	0.000	0.000	0.000	0.000	0.519	0.468
%	0.00	0.00	0.00	0.00	0.00	0.00	14.07	12.74
Changes	2020							
CO ₂								
kt	42.72							
%	0.09							
CH ₄								
kt	29.166							
%	24.92							
N ₂ O								
kt	0.416							
%	11.26							

3.2.9.6. Source-specific planned improvements

Analysis of the possibility of country specific CH₄ EF development for solid and biomass fuels.

3.3. Fugitive emissions (CRF sector 1.B)

3.3.1. Fugitive emission from solid fuels (CRF sector 1.B.1)

3.3.1.1. Source category description

Fugitive emission from solid fuels involves emission from coal mining and handling (CH_4) and emission from coke oven gas subsystem (CO_2 and CH_4).

The biggest share of emission in 1.B category comes from coal mining and handling. The hard coal and lignite extraction are presented at the graph below (Figure 3.3.1). The main reason for the decreasing coal extraction since late 1980s was the declining demand for coal and lignite in the economy.

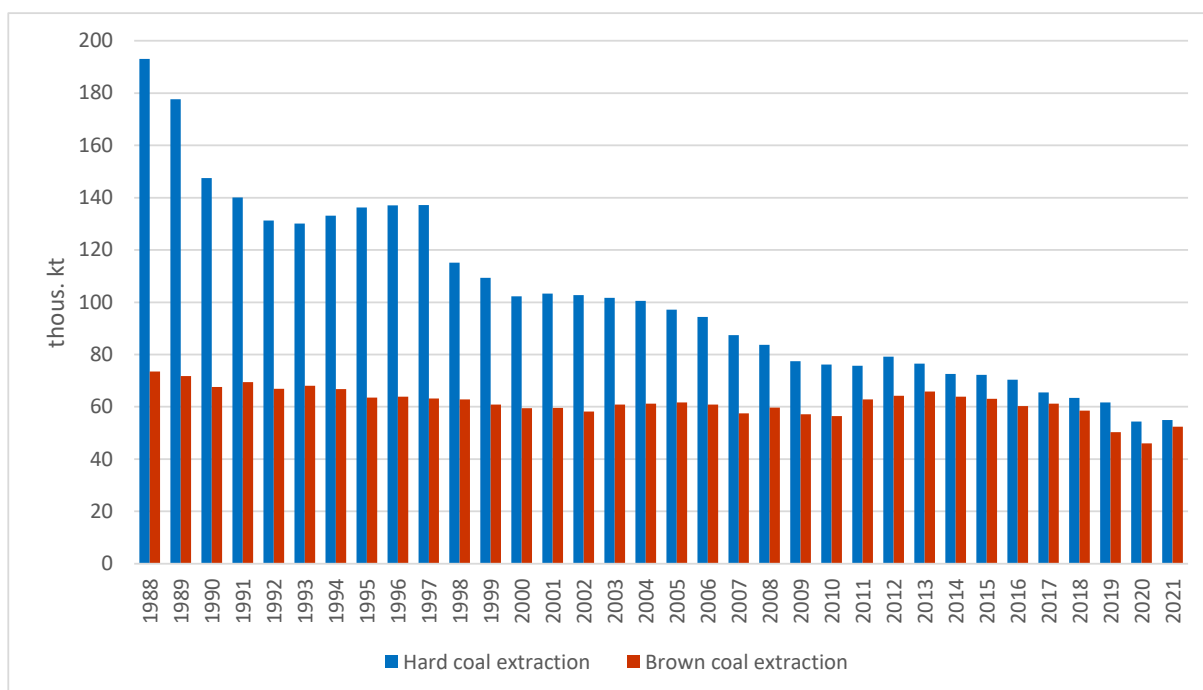


Figure 3.3.1. Hard coal and lignite extraction in 1988-2021

3.3.1.2. Methodological issues

3.3.1.2.1 Fugitive emissions from fuels – coal mining (CRF sector 1.B.1.a.)

Coal Mining and Handling – underground mines (1.B.1.a.i.)

The case study has been developed for estimating methane emission from coal mining – “The national methodology for estimating methane emissions from coal mining for reporting to the national inventory of greenhouse gases emissions and removals” (National Centre for Emission Management 2016, in Polish).

Data published by Eurostat, are used to calculate the amount of methane emitted during coal mining in each year. For 2021, data published in the report "Evaluation of work safety, mine rescue and public safety related with the activities of mining and geology in 2021" (https://www.wug.gov.pl/bhp/stan_bhp_w_gornictwie), on methane emission intensity and use (table 11, page 21) were applied to calculate the actual total emissions of methane from coal mines.

Table 3.3.1. shows data on methane emissions and accompanying data related to coal mining, including the CH_4 implied emission factors for each year, in relation to hard coal extraction, for comparison purposes.

Table 3.3.1. Activity data used to calculate the CH₄ emissions from coal mining in 1988-2021

Year	Methane content [mln m ³]	Methane use for energy production [mln m ³]	CH ₄ emission from underground mining as published by State Mining Authority [kt]	Underground coal production [Mg]	Annual CH ₄ emission factor [kg/t]	Implied CH ₄ emission factor [m ³ /t]
	a	b	a-b			
1988	1037.20	207.90	555.63	193 015 000.00	2.88	4.30
1989	1045.73	208.43	560.99	177 633 000.00	3.16	4.71
1990	988.92	188.53	536.26	147 493 000.00	3.64	5.43
1991	829.24	185.10	431.57	140 027 000.00	3.08	4.60
1992	848.09	174.06	451.60	131 313 000.00	3.44	5.13
1993	779.96	167.60	410.28	130 047 000.00	3.15	4.71
1994	764.53	136.30	420.91	133 127 000.00	3.16	4.72
1995	745.31	137.10	407.50	136 190 000.00	2.99	4.47
1996	748.40	147.50	402.60	137 048 000.00	2.94	4.38
1997	748.40	134.40	411.38	137 129 000.00	3.00	4.48
1998	763.30	152.70	409.10	115 145 000.00	3.55	5.30
1999	744.50	136.90	407.09	109 322 000.00	3.72	5.56
2000	746.90	124.00	417.34	102 219 000.00	4.08	6.09
2001	743.70	131.50	410.17	103 280 000.00	3.97	5.93
2002	752.60	122.40	422.23	102 723 000.00	4.11	6.13
2003	798.10	127.80	449.10	101 659 000.00	4.42	6.59
2004	825.90	144.20	456.74	100 517 000.00	4.54	6.78
2005	851.10	144.80	473.22	97 110 000.00	4.87	7.27
2006	870.30	158.30	477.04	94 407 000.00	5.05	7.54
2007	878.90	165.70	477.84	87 406 000.00	5.47	8.16
2008	880.90	156.50	485.35	83 661 000.00	5.80	8.66
2009	855.70	159.50	466.45	77 478 000.00	6.02	8.99
2010	836.40	161.10	452.45	76 172 000.00	5.94	8.87
2011	828.80	166.30	443.88	75 668 000.00	5.87	8.76
2012	828.20	178.60	435.23	79 234 000.00	5.49	8.20
2013	847.80	187.70	442.27	76 466 000.00	5.78	8.63
2014	891.10	211.40	455.40	72 540 000.00	6.28	9.37
2015	933.00	197.10	493.05	72 176 000.00	6.83	10.20
2016	933.80	195.00	495.00	70 385 000.00	7.03	10.50
2017	948.50	212.00	493.46	65 479 946.00	7.54	11.25
2018	916.10	203.10	477.71	63 384 046.00	7.54	11.25
2019	803.80	189.40	411.65	61 623 387.00	6.68	9.97
2020	819.62	187.90	423.25	54 385 927.00	7.78	11.62
2021	815.30	214.20	402.74	55 006 381.00	7.32	10.93

It should be stressed that the data on emissions are collected and analyzed in a systematic way and they are published according to the law. These data therefore meets the requirements of data quality (QA/QC) arising from IPCC Guidelines in terms of durability and consistency of methodology.

This methodology is in line with Tier 3 approach (Tier 3 approach) of the IPCC Guidelines (2006) as it is based on direct measurements and calculations fugitive emissions from coal mines. Fugitive emission of CH₄ from post-mining was estimated based on the activity data concerning hard coal extraction amount from Eurostat and emission factors presented in table 3.3.2. have been taken from IPCC 2006.

Table 3.3.2. CH₄ Emission factor for calculation post-mining emission from coal mines

CH ₄ emission factor	
Post - Mining	2.50 [m ³ CH ₄ /t; IPCC 2006, page 4.12]

Tier 1 method was used for calculation of fugitive emissions from abandoned underground mines (1.B.1.iii.) [IPCC 2006, page 4.21 equation 4.1.9.] Fugitive emission of CH₄ from mine closure was estimated based on number of abandoned underground mines provided by State Mining Authority [WUG] and emission factors from IPCC 2006 – table 4.1.5., 4.1.6. and 4.1.7.

Table 3.3.3 shows data on number of closed coal mines, emission factor used and total emission from abandoned underground mines in 1988-2021.

Table 3.3.3. Activity data on number of closed coal mines, emission factors and total emission from abandoned underground mines

Inventory year	Number of closed mines per time brand 1976-2000	Emission factor - for interval of mine closure [mln m ³ / mine]	Number of closed mines per time brand 2001 present	Emission factor - for interval of mine closure [mln m ³ / mine]	Fraction of gassy mines	Conversion factor	Total emission from closed mines [Gg CH ₄]
1988	0	1.561	0	NA	1.00	0.67	0
1989	0	1.561	0	NA	1.00	0.67	0
1990	0	1.561	0	NA	1.00	0.67	0
1991	0	1.334	0	NA	1.00	0.67	0
1992	0	1.83	0	NA	1.00	0.67	0
1993	0	1.072	0	NA	1.00	0.67	0
1994	0	0.988	0	NA	1.00	0.67	0
1995	1	0.921	0	NA	1.00	0.67	0.62
1996	2	0.865	0	NA	1.00	0.67	1.16
1997	3	0.818	0	NA	1.00	0.67	1.64
1998	4	0.778	0	NA	1.00	0.67	2.09
1999	4	0.743	0	NA	1.00	0.67	1.99
2000	10	0.713	0	NA	1.00	0.67	4.78
2001	10	0.686	17	5.735	1.00	0.67	103.75
2002	10	0.661	22	2.397	1.00	0.67	51.39
2003	10	0.639	22	1.762	1.00	0.67	37.78
2004	10	0.620	23	1.454	1.00	0.67	32.15
2005	10	0.601	23	1.265	1.00	0.67	27.97
2006	10	0.585	23	1.133	1.00	0.67	25.05
2007	10	0.569	23	1.035	1.00	0.67	22.88
2008	10	0.555	23	0.959	1.00	0.67	21.20
2009	10	0.542	23	0.896	1.00	0.67	19.81
2010	10	0.529	23	0.845	1.00	0.67	18.68
2011	10	0.518	23	0.801	1.00	0.67	17.71
2012	10	0.507	23	0.763	1.00	0.67	16.87
2013	10	0.496	23	0.73	1.00	0.67	16.14
2014	10	0.487	23	0.701	1.00	0.67	15.50
2015	10	0.478	28	0.675	1.00	0.67	14.92
2016	10	0.469	32	0.652	1.00	0.67	18.35
2017	10	0.469	34	0.652	1.00	0.67	19.22
2018	10	0.469	39	0.652	1.00	0.67	21.41
2019	10	0.469	39	0.652	1.00	0.67	21.41
2020	10	0.469	39	0.652	1.00	0.67	21.41
2021	10	0.469	39	0.652	1.00	0.67	21.41

Coal Mining and Handling – surface mines (1.B.1.a.ii.)

Tier 1 method was used for calculation of fugitive emissions from surface mining and post-mining [IPCC 2006, page 4.18-4.19]. Fugitive emission of CH₄ from surface mining and post-mining was estimated based on the activity data concerning lignite extraction amount from Eurostat database and emission factors from IPCC 2006 (table 3.3.4).

Table 3.3.4. CH₄ Emission factor for calculation mining and post-mining emission from surface coal mining

CH ₄ emission factor	
Mining	1.20 [m ³ CH ₄ /t; IPCC 2006, page 4.18]
Post - Mining	0.1 [m ³ CH ₄ /t; IPCC 2006, page 4.19]

The conversion factor applied for recalculation of emitted methane volume to mass is 0.67 kg/m³ taking into account gas density at 20°C and 1 atmosphere pressure.

In table 3.3.5 data is shown on lignite extraction and total methane emissions from lignite mines in 1988-2021.

Table 3.3.5. Lignite extraction and total methane emissions from lignite mines in 1988-2021

Year	Lignite extraction amount [Mg]	CH ₄ emission [kt]
1988	73 489 000	64.01
1989	71 816 000	62.55
1990	67 584 000	58.87
1991	69 406 000	60.45
1992	66 852 000	58.23
1993	68 105 000	59.32
1994	66 770 000	58.16
1995	63 547 000	55.35
1996	63 845 000	55.61
1997	63 169 000	55.02
1998	62 820 000	54.72
1999	60 839 000	52.99
2000	59 484 000	51.81
2001	59 552 000	51.87
2002	58 210 000	50.70
2003	60 920 000	53.06
2004	61 198 000	53.30
2005	61 636 000	53.68
2006	60 844 000	53.00
2007	57 538 000	50.12
2008	59 668 000	51.97
2009	57 108 000	49.74
2010	56 510 000	49.22
2011	62 841 000	54.73
2012	64 280 000	55.99
2013	65 849 000	57.35
2014	63 877 000	55.64
2015	63 128 000	54.98
2016	60 246 000	52.47
2017	61 160 660	53.27
2018	58 570 853	51.02
2019	50 328 578	43.84
2020	45 983 406	40.05
2021	52 355 513	45.60

3.3.1.2.2. Fugitive emission from solid fuel transformation (1.B.1.b)

Processing emission of CO₂ from coking plants in the period 1990-2021 was estimated based on carbon budgets in the coking plants (tab. 3.3.6). Data concerning input and output are based on Eurostat and Statistics Poland. Coke productions for 1990-2021 were applied according to data in Eurostat [Eurostat].

The Eurostat database does not cover energy balances for Poland for the years before 1990 so data on input and output in coking plants (i.e. coke output) applied for C balance in coke production process for the years 1988-1989 were taken from IEA database [IEA].

The amounts of carbon in the input and output components used in C balances for entire period were calculated based on IPCC factors [IPCC 1997, IPCC 2006].

Fuels given as the input in C balance for coke production process (tab. 3.3.6) did not include the fuels for energy purpose of the process. Emission from coke production given in 1.A.1.c subcategory was related to the fuel consumption for energy purpose of the coke plants, so double counting should not be the case in GHG inventory.

CH₄ emission in the period 1990-2021 was estimated based on coke production volume from [Eurostat] while for 1988 and 1989 from [IEA]. For the entire period emission factor is as 0.1 g CH₄/Mg coke produced [IPCC 2006 chapter 4, table 4.2. page 4.26] was applied.

Table 3.3.6. Carbon balance for coke production in years 1988-2021

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
INPUT [TJ]														
Coking coal	656 592	637 742	535 538	448 105	437 665	405 168	436 596	451 761	403 902	423 800	377 787	338 208	366 814	362 343
High Methane Natural Gas	0.00	1 238.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke			962	548	1 788	1 679	2 473	2 353	1 836	1 640	1 975	1 429	1 896	982
Blast furnace gas	0.00	151.98	0	0	0	0	0	0	0	0	0	0	0	0
Tar	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0
Industrial waste	6.99	0.00	0	0	0	0	0	0	0	0	0	0	0	0
NCV [MJ/kg]														
Coking coal	29.41	29.41	29.41	29.41	29.41	29.41	28.49	29.36	29.36	29.45	29.54	29.48	29.62	29.53
INPUT – Material-specific carbon content [kg C/GJ]														
Coking coal	26.02	26.02	26.02	26.02	26.02	26.02	26.06	26.03	26.03	26.02	26.02	26.02	26.02	26.02
High Methane Natural Gas	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30
Coke	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20
Blast furnace gas	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80
Tar	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Industrial waste	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00
INPUT – Carbon contents in charge components [kt]														
Coking coal	17 087.58	16 597.00	13 937.16	11 661.75	11 390.05	10 544.33	11 378.08	11 757.78	10 512.08	11 028.54	9 829.87	8 800.85	9 543.24	9 428.21
High Methane Natural Gas	0.00	18.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke	0.00	0.00	28.10	16.00	52.22	49.04	72.20	68.70	53.60	47.88	57.66	41.72	55.37	28.68
Blast furnace gas	0.00	10.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial waste	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon contents in charge – SUM [kt]	17 087.85	16 626.71	13 965.26	11 677.75	11 442.26	10 593.36	11 450.28	11 826.48	10 565.68	11 076.42	9 887.52	8 842.57	9 598.61	9 456.90
OUTPUT [TJ]														
Coke	471 501.80	455 831.82	376 934.21	319 455.64	311 718.15	288 275.40	320 980.56	322 354.68	288 272.00	298 024.62	266 036.56	228 421.30	254 374.14	252 286.15
Coke-Oven Gas	118 914.58	117 040.40	96 831.90	84 743.10	82 306.80	75 753.00	84 002.40	84 766.50	76 035.60	79 286.40	73 457.10	62 989.20	68 849.10	69 008.40
Tar	27 580.00	27 429.30	22 885.30	20 268.20	20 648.10	19 071.40	21 146.60	21 265.00	19 831.90	19 600.40	17 949.60	16 264.80	17 003.00	17 232.60
Benzol	7 701.50	7 230.90	6 166.90	5 150.70	5 646.20	5 159.10	6 010.60	6 056.50	5 446.70	5 428.60	4 856.90	4 524.70	2 498.50	4 788.60
OUTPUT – Material-specific carbon content [kg C/GJ]														
Coke	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20
Coke-Oven Gas	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10
Tar	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Benzol	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
OUTPUT – Carbon content in products [kt]														
Coke	13 767.85	13 310.29	11 006.48	9 328.10	9 102.17	8 417.64	9 372.63	9 412.76	8 417.54	8 702.32	7 768.27	6 669.90	7 427.73	7 366.76
Coke-Oven Gas	1 438.87	1 416.19	1 171.67	1 025.39	995.91	916.61	1 016.43	1 025.67	920.03	959.37	888.83	762.17	833.07	835.00
Tar	606.76	603.44	503.48	445.90	454.26	419.57	465.23	467.83	436.30	431.21	394.89	357.83	374.07	379.12
Benzol	177.13	166.31	141.84	118.47	129.86	118.66	138.24	139.30	125.27	124.86	111.71	104.07	57.47	110.14
Carbon content in products – SUM [kt]	15 990.61	15 496.23	12 823.46	10 917.86	10 682.20	9 872.48	10 992.53	11 045.56	9 899.15	10 217.75	9 163.70	7 893.96	8 692.33	8 691.01
C process emission[kt]	1 097.23	1 130.48	1 141.80	759.89	760.06	720.88	457.75	780.92	666.53	858.67	723.83	948.60	906.28	765.88
CO₂ process emission[kt]	4 023.19	4 145.10	4 186.60	2 786.25	2 786.88	2 643.23	1 678.42	2 863.36	2 443.93	3 148.45	2 654.03	3 478.21	3 323.04	2 808.24
Coke output [kt]	17 007.00	16 499.00	13 516.00	11 356.00	11 066.00	10 275.00	11 455.00	11 578.00	10 339.00	10 535.00	9 746.00	8 368.00	8 972.00	8 946.00
EF [kg CO₂/Mg of coke]	237	251	310	245	252	257	147	247	236	299	272	416	370	314

Table 3.3.6. (cont.) Carbon balance for coke production in years 1988-2021

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
INPUT [TJ]														
Coking coal	353 752	410 854	400 604	332 566	380 135	402 391	389 792	274 662	381 938	364 348	350 150	371 333	375 885	382 750
High Methane Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke	1 642	1 435	1 505	1 926	2 076	2 278	2 735	1 681	2 625	2 570	1 976	1 403	1 677	2 319
Blast furnace gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial waste	0	0	6	14	0	0	0	0	4	0	0	0	0	0
NCV [MJ/kg]														
Coking coal	29.53	29.56	29.55	29.51	29.59	29.50	29.57	29.56	29.49	29.52	29.60	29.59	29.55	29.54
INPUT – Material-specific carbon content [kg C/GJ]														
Coking coal	26.02	26.02	26.02	26.02	26.02	26.02	26.02	26.02	26.02	26.02	26.02	26.02	26.02	26.02
High Methane Natural Gas	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30
Coke	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20
Blast furnace gas	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80	70.80
Tar	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Industrial waste	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00
INPUT – Carbon contents in charge components [kt]														
Coking coal	9 204.60	10 689.96	10 423.35	8 653.64	9 890.18	10 470.63	10 141.78	7 146.40	9 938.58	9 480.46	9 109.96	9 661.19	9 780.18	9 959.00
High Methane Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke	47.95	41.91	43.96	56.24	60.63	66.51	79.85	49.07	76.64	75.06	57.71	40.96	48.98	67.71
Blast furnace gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial waste	0.00	0.00	0.22	0.53	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Carbon contents in charge – SUM [kt]	9 252.55	10 731.86	10 467.53	8 710.41	9 950.81	10 537.14	10 221.63	7 195.48	10 015.36	9 555.51	9 167.67	9 702.15	9 829.16	10 026.71
OUTPUT [TJ]														
Coke	246 206.68	285 906.69	285 926.85	237 152.48	270 125.30	287 632.38	281 354.45	196 753.98	273 830.55	261 046.30	249 973.34	261 200.16	265 751.20	274 176.00
Coke-Oven Gas	65 570.40	75 090.60	72 946.80	61 947.00	71 712.00	76 950.00	73 935.00	53 376.30	73 008.00	69 440.40	65 321.10	68 843.70	69 753.60	71 336.70
Tar	16 462.60	18 188.10	17 796.24	14 907.24	16 219.60	17 351.20	15 729.24	11 844.08	16 483.64	15 276.60	14 182.72	14 861.68	14 484.48	14 258.16
Benzol	4 474.80	5 253.30	5 358.28	4 403.18	3 803.70	5 315.63	4 711.94	3 373.43	4 892.60	4 518.80	4 125.10	4 465.40	4 455.90	4 548.20
OUTPUT – Material-specific carbon content [kg C/GJ]														
Coke	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20	29.20
Coke-Oven Gas	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10
Tar	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Benzol	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
OUTPUT – Carbon content in products [kt]														
Coke	7 189.23	8 348.48	8 349.06	6 924.85	7 887.66	8 398.87	8 215.55	5 745.22	7 995.85	7 622.55	7 299.22	7 627.04	7 759.94	8 005.94
Coke-Oven Gas	793.40	908.60	882.66	749.56	867.72	931.10	894.61	645.85	883.40	840.23	790.39	833.01	844.02	863.17
Tar	362.18	400.14	391.52	327.96	356.83	381.73	346.04	260.57	362.64	336.09	312.02	326.96	318.66	313.68
Benzol	102.92	120.83	123.24	101.27	87.49	122.26	108.37	77.59	112.53	103.93	94.88	102.70	102.49	104.61
Carbon content in products – SUM [kt]	8 447.73	9 778.04	9 746.48	8 103.64	9 199.69	9 833.95	9 564.58	6 729.23	9 354.42	8 902.80	8 496.50	8 889.71	9 025.10	9 287.40
C process emission[kt]	804.82	953.83	721.05	606.77	751.12	703.20	657.05	466.25	660.94	652.72	671.16	812.44	804.06	739.30
CO₂ process emission[kt]	2 950.99	3 497.37	2 643.85	2 224.83	2 754.11	2 578.38	2 409.19	1 709.58	2 423.44	2 393.29	2 460.93	2 978.93	2 948.23	2 710.78
Coke output [kt]	8 723.00	10 112.00	10 097.00	8 404.00	9 613.00	10 168.00	10 075.00	7 091.00	9 844.00	9 377.00	8 893.00	9 360.00	9 568.00	9 792.00
EF [kg CO₂/Mg of coke]	338	346	262	265	286	254	239	241	246	255	277	318	308	277

Table 3.3.6. (cont.) Carbon balance for coke production in years 1988-2021

	2016	2017	2018	2019	2020	2021
INPUT [TJ]						
Coking coal	378 556	369 738	374 507	351 579	307 415	362 235
High Methane Natural Gas	0.00	0	0	0	0	0
Coke	2 066	2 287	2 413	2 132	2 013	2 949
Blast furnace gas	0	0	0	0	0	0
Tar	0	0	0	0	0	0
Industrial waste	0	0	0	0	0	0
NCV [MJ/kg]						
Coking coal	29.55	29.54	29.23	29.43	29.44	29.59
INPUT – Material-specific carbon content [kg C/GJ]						
Coking coal	26.02	26.02	26.03	26.02	26.02	26.02
High Methane Natural Gas	15.30	15.30	15.30	15.30	15.30	15.30
Coke	29.20	29.20	29.20	29.20	29.20	29.20
Blast furnace gas	70.80	70.80	70.80	70.80	70.80	70.80
Tar	22.00	22.00	22.00	22.00	22.00	22.00
Industrial waste	39.00	39.00	39.00	39.00	39.00	39.00
INPUT – Carbon contents in charge components [kt]						
Coking coal	9 849.78	9 620.43	9 748.95	9 149.40	7 999.99	9 424.57
High Methane Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00
Coke	60.32	66.79	70.46	62.26	58.77	86.12
Blast furnace gas	0.00	0.00	0.00	0.00	0.00	0.00
Tar	0.00	0.00	0.00	0.00	0.00	0.00
Industrial waste	0.00	0.00	0.00	0.00	0.00	0.00
Carbon contents in charge – SUM [kt]	9 910.09	9 687.23	9 819.40	9 211.66	8 058.76	9 510.69
OUTPUT [TJ]						
Coke	272 104.00	263 706.60	265 237.53	249 651.05	217 927.30	259 946.30
Coke-Oven Gas	70 472.70	69 167.16	70 428.16	67 301.19	58 877.35	70 230.15
Tar	14 446.76	14 030.29	14 184.71	13 605.41	11 815.35	13 736.10
Benzol	4 334.20	4 076.50	4 271.50	3 984.80	3 687.90	4 379.30
OUTPUT – Material-specific carbon content [kg C/GJ]						
Coke	29.20	29.20	29.20	29.20	29.20	29.20
Coke-Oven Gas	12.10	12.10	12.10	12.10	12.10	12.10
Tar	22.00	22.00	22.00	22.00	22.00	22.00
Benzol	23.00	23.00	23.00	23.00	23.00	23.00
OUTPUT – Carbon content in products [kt]						
Coke	7 945.44	7 700.23	7 744.94	7 289.81	6 363.48	7 590.43
Coke-Oven Gas	852.72	836.92	852.18	814.34	712.42	849.78
Tar	317.83	308.67	312.06	299.32	259.94	302.19
Benzol	99.69	93.76	98.24	91.65	84.82	100.72
Carbon content in products – SUM [kt]	9 215.67	8 939.58	9 007.42	8 495.12	7 420.65	8 843.13
C process emission[kt]	694.42	747.65	817.81	716.09	638.10	667.55
CO₂ process emission[kt]	2 546.22	2 741.37	2 998.64	2 625.66	2 339.72	2 447.70
Coke output [kt]	9 718	9 418.09	9 472.77	8 916.11	7 783.12	9 283.70
EF [kg CO₂/Mg of coke]	262	291	317	294	301	264

3.3.1.2.3. Fugitive emissions from fuels – coke oven gas (CRF sector 1.B.1.c)

Tier 1 method has been used for calculation of fugitive emissions from coke oven gas system [IPCC 2006] while emission factors presented in table 3.3.7. have been taken from domestic case study [Steczko 1994]. Activity data for 1990-2021 come from [EUROSTAT]. For years: 1988-1989 the activity data come from [IEA] database.

Table 3.3.7. Emission factors for CO₂ and CH₄ from coke oven gas system (country specific EF)

Gas system emission factor [kt/PJ]	CO ₂	CH ₄
Gas processing	0.000194	0.000546
Gas transmission	0.020629	0.057977
Gas distribution	0.038056	0.106954

For coke-oven gas subsystem there is no possibility to add activity data in PJ in the CRF Reporter database, but only in kt. This conversion into kt was done only for reporting purposes under CRF Reporter (emission is estimated on the PJ activity data basis), the mentioned change has no impact on emissions.

3.3.1.3. Uncertainties and time-series consistency

See chapter 3.2.6.3

3.3.1.4. Source-specific QA/QC and verification

QA/QC and verification are integral parts of the inventory and has been elaborated in line with the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* and *2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006)*.

Activity data used in the GHG inventory concerning sector 1.B. come from:

- Eurostat database which is provided data by the Statistics Poland (GUS),
- State Mining Authority (WUG - "Evaluation of work safety, mine rescue and public safety in connection with the activities of mining and geology in 2021" (https://www.wug.gov.pl/bhp/stan_bhp_w_gornictwie),
- and from the study published by Polish Geological Institute [PIG 2021].

GUS, PIG and WUG are responsible for QA/QC of collected and published data. Activity data applied in GHG inventory are regularly checked and updated if necessary according to adjustments made in Eurostat database.

Generally QC procedures follow QA/QC plan presented in Annex 7.

3.3.1.5. Source-specific recalculations

Recalculations for the years 1996 to 2003 were implemented as the result of revision and updating of historical activities according to EUROSTAT. However, changes are negligible. Emission recalculations for subcategory 1.B.1. are presented in table below.

Table 3.3.8. Emission recalculations for subcategory 1.B.1 *Fugitive emission from solid fuels*

Difference	1988	1989	1990	1991	1992	1993	1994	1995
kt CO ₂ eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1996	1997	1998	1999	2000	2001	2002	2003
kt CO ₂ eq.	0.94	2.10	1.10	1.19	0.93	0.83	0.77	0.83
%	0.005	0.01	0.01	0.01	0.005	0.004	0.004	0.004

	2004	2005	2006	2007	2008	2009	2010	2011
kt CO ₂ eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2012	2013	2014	2015	2016	2017	2018	2019
kt CO ₂ eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2020							
kt CO ₂ eq.	0.34							
%	0.002							

3.3.1.6. Source-specific planned improvements

Analysis for possibility of updating the emission factors for the systems of coke-oven gas.

3.3.2. Fugitive emissions from oil and natural gas (CRF sector 1.B.2)

3.3.2.1. Source category description

Fugitive emission from oil and natural gas include fugitive emissions from extraction, transport and refining of oil, from production, processing, transmission, distribution and underground storage of gas as well as from venting and flaring of gas and oil.

3.3.2.2. Methodological issues

3.3.2.2.1 Fugitive emissions from fuels – oil (CRF sector 1.B.2.a)

Tier 1 method has been used for calculation of fugitive emissions from oil system [IPCC 2006]. For years: 1988-1989 the activity data come from [IEA] database, for 1990-2021 come from Eurostat (table 3.3.9).

Table 3.3.9. Activity data for emission from oil system in years 1988-2021

Year	Oil extraction [kt]		Import	Transport	Input to oil refineries
	off shore	on shore	[kt]	[kt]	[kt]
1988	0.00	155.51	14 625.88	14 781.39	14 625.88
1989	0.00	153.19	14 367.84	14 521.03	14 856.69
1990	0.00	160.00	13 126.00	13 286.00	12 846.00
1991	0.00	158.00	11 454.00	11 612.00	11 726.00
1992	0.00	200.00	13 052.00	13 252.00	13 146.00
1993	0.00	235.00	13 674.00	13 909.00	13 366.00
1994	0.00	284.00	12 721.00	13 005.00	13 448.00
1995	0.00	292.00	12 957.00	13 249.00	13 443.00
1996	0.00	317.00	14 026.00	14 343.00	14 597.00
1997	0.00	289.00	14 713.00	15 002.00	14 884.00
1998	0.00	360.00	15 367.00	15 727.00	16 023.00
1999	0.00	434.00	16 022.00	16 456.00	16 719.00
2000	0.00	653.00	18 002.00	18 655.00	18 274.00
2001	0.00	767.00	17 558.00	18 325.00	17 962.00
2002	0.00	728.00	17 942.00	18 670.00	17 785.00
2003	271.60	493.40	17 448.00	18 213.00	17 457.00
2004	259.85	626.15	17 316.00	18 202.00	18 118.00
2005	242.37	605.63	17 912.00	18 760.00	18 165.00
2006	270.05	525.95	19 813.00	20 609.00	20 045.00
2007	196.62	524.38	20 885.00	21 606.00	20 113.00
2008	263.34	491.66	20 787.00	21 542.00	20 804.00
2009	182.73	504.27	20 098.00	20 785.00	20 304.00
2010	192.30	494.70	22 688.00	23 375.00	22 843.00
2011	153.06	463.94	23 792.00	24 409.00	24 001.00
2012	192.72	488.28	24 633.00	25 314.00	25 153.00
2013	151.19	810.81	23 347.00	24 309.00	24 302.00
2014	165.74	785.26	23 713.00	24 664.00	24 196.00
2015	167.66	760.34	26 492.00	27 420.00	26 140.00
2016	248.48	752.52	24 573.00	25 574.00	25 790.00
2017	221.63	774.42	24 647.77	25 643.82	25 139.29
2018	207.17	803.16	26 846.87	27 857.20	26 899.16
2019	203.96	768.61	26 622.01	27 594.57	27 181.30
2020	234.41	703.05	24 905.81	25 843.27	25 757.17
2021	252.50	635.58	23 619.55	24 507.63	24 755.16

CO₂ and CH₄ factors used for estimation of emissions from oil exploration and production have been sourced from IPCC 2006.

Table 3.3.10. Emission factors for CO₂ and CH₄ from oil exploration

Oil system	Emission factors	Source
CO₂		
Exploration – well drilling [kt/10 ³ m ³]	0.0001	IPCC 2006 page 4.48 table 4.2.4.
Exploration – well testing [kt/10 ³ m ³]	0.009	IPCC 2006 page 4.48 table 4.2.4.
Exploration – well servicing [kt/10 ³ m ³]	0.0000019	IPCC 2006 page 4.48 table 4.2.4.
CH₄		
Exploration – well drilling [kt/10 ³ m ³]	0.000033	IPCC 2006 page 4.48 table 4.2.4.
Exploration – well testing [kt/10 ³ m ³]	0.000051	IPCC 2006 page 4.48 table 4.2.4.
Exploration – well servicing [kt/10 ³ m ³]	0.00011	IPCC 2006 page 4.48 table 4.2.4.

Table 3.3.11. Emission factors for CO₂ and CH₄ from oil production

Oil system	Emission factors	Source
CO₂		
Oil production - offshore [kt/10 ³ m ³]	0.000043	IPCC 2006 page 4.50 table 4.2.4.
Oil production - onshore [kt/10 ³ m ³]	0.26	IPCC 2006 page 4.50 table 4.2.4.
Oil transmission [kt/10 ³ m ³]	0.00049	IPCC 2006 page 4.52 table 4.2.4.
CH₄		
Oil production - offshore [kt/10 ³ m ³]	0.00059	IPCC 2006 page 4.50 table 4.2.4.
Oil production - onshore [kt/10 ³ m ³]	3.6	IPCC 2006 page 4.50 table 4.2.4.
Oil transmission [kt/10 ³ m ³]	0.0054	IPCC 2006 page 4.52 table 4.2.4.
Refining [kt/10 ³ m ³]	0.0410	IPCC 2006 page 4.53 table 4.2.4.

3.3.2.2.2 Fugitive emissions from fuels – natural gas (CRF sector 1.B.2.b)

Estimation of CO₂ and CH₄ emissions from natural gas was performed based on *Tier 1* method [IPCC 2006]. Activity data for 1990–2021 come from [EUROSTAT]. For years 1988–1989 activity data come from [IEA] database. Activity data are given in table 3.3.12.

Table 3.3.12. Activities for natural gas system

Year	Production [PJ]	Total consumption [PJ]
1988	156.6	350.7
1989	145.0	343.0
1990	99.6	374.2
1991	111.3	348.9
1992	107.2	325.0
1993	136.9	341.4
1994	129.8	344.0
1995	132.7	376.6
1996	131.5	395.5
1997	134.2	394.3
1998	136.0	398.3
1999	129.9	387.8
2000	138.7	417.0
2001	146.2	434.4
2002	149.4	423.4
2003	151.2	471.5
2004	164.4	497.4
2005	162.6	512.2
2006	162.5	526.8
2007	163.1	523.1
2008	154.5	526.1
2009	154.0	505.0
2010	154.6	536.1
2011	161.2	537.4
2012	163.6	572.8
2013	160.1	575.1
2014	156.0	561.2
2015	154.2	576.8
2016	148.7	612.7
2017	147.0	646.6

Year	Production [PJ]	Total consumption [PJ]
2018	145.2	675.1
2019	143.7	708.6
2020	142.2	730.2
2021	139.8	763.3

Emission factors gas system for exploration, production, processing, transmission and distribution was taken from IPCC 2006. Emission factor listed in table 3.3.13.

Table 3.3.13. Emission factors for CO₂ and CH₄ from natural gas system [IPCC 2006, table 4.2.4]

Oil system	Emission factors	Source
CO₂		
Gas production - offshore [kt/10 ⁶ m ³]	0.000014	IPCC 2006 page 4.48 table 4.2.4.
Gas production - onshore [kt/10 ⁶ m ³]	0.000082	IPCC 2006 page 4.48 table 4.2.4.
Gas processing default weighted total [kt/10 ⁶ m ³]	0.00032	IPCC 2006 page 4.49 table 4.2.4.
Gas transmission and storage – transmission [kt/10 ⁶ m ³]	0.00000088	IPCC 2006 page 4.49 table 4.2.4.
Gas transmission and storage – storage [kt/10 ⁶ m ³]	0.00000011	IPCC 2006 page 4.49 table 4.2.4.
Gas distribution [kt/10 ⁶ m ³]	0.000051	IPCC 2006 page 4.50 table 4.2.4.
CH₄		
Gas production - offshore [kt/10 ⁶ m ³]	0.00038	IPCC 2006 page 4.48 table 4.2.4.
Gas production - onshore [kt/10 ⁶ m ³]	0.0023	IPCC 2006 page 4.48 table 4.2.4.
Gas processing default weighted total [kt/10 ⁶ m ³]	0.00103	IPCC 2006 page 4.49 table 4.2.4.
Gas transmission and storage – transmission [kt/10 ⁶ m ³]	0.00048	IPCC 2006 page 4.49 table 4.2.4.
Gas transmission and storage – storage [kt/10 ⁶ m ³]	0.000025	IPCC 2006 page 4.49 table 4.2.4.
Gas distribution [kt/10 ⁶ m ³]	0.0011	IPCC 2006 page 4.50 table 4.2.4.

* Other Leakage are included to underground storage of gas (1.B.2.b.6. emissions associated with the exploitation of the gas storage)

Emissions associated with the exploitation of the gas storage.

Polish gas system (high-methane gas system) has four underground gas storage tanks gas with a total capacity of 0.6 billion m³. The emission includes:

- Emissions from leaks from heads exploiting operating holes,
- Emissions from pneumatic devices,
- Emissions from gas compressor station,
- Emissions from repair and maintenance,
- Emissions from breakdown [country study: Steczko 2003].

3.3.2.2.3 Fugitive emissions from fuels – Venting and Flaring (CRF sector 1.B.2.c)

Venting and Flaring in oil subsystem

CO₂ and CH₄ emission from venting and CO₂, CH₄ and N₂O emission from flaring were calculated in oil subsystem. Emission factors for both emissions were taken default from [IPCC 2006 page 4.50. table 4.2.4.]:

CO ₂ EF from venting:	0.000095	kt/10 ³ m ³
CH ₄ EF from venting:	0.00072	kt/10 ³ m ³
CO ₂ from flaring:	0.00002500	kt/10 ³ m ³
CH ₄ from flaring:	0.04100000	kt/10 ³ m ³
N ₂ O from flaring:	0.00000064	kt/10 ³ m ³

Extraction of oil is used as activity data and is in accordance with whole oil subsystem. Other emissions from venting and flaring in oil subsystem are included in 1.B.2.a.

Flaring in natural gas subsystem

CO₂, CH₄ and N₂O emissions from flaring in gas extraction and consumption were calculated in natural gas subsystem. Emission factors for those emissions were taken default from [IPCC 2006 page 4.48. table 4.2.4.]:

CO ₂ EF from flaring in gas extraction:	0.00000076	kt/10 ⁶ m ³
CH ₄ EF from flaring in gas extraction:	0.0012	kt/10 ⁶ m ³
N ₂ O EF from flaring in gas extraction:	0.000000021	kt/10 ⁶ m ³
CO ₂ EF from flaring in gas consumption:	0.00360	kt/10 ⁶ m ³
CH ₄ EF from flaring in gas consumption:	0.0000024	kt/10 ⁶ m ³
N ₂ O EF from flaring in gas consumption:	0.000000054	kt/10 ⁶ m ³

Extraction and consumption of natural gas are used as activity data and are in accordance with whole natural gas subsystem. Other emissions from venting and flaring in natural gas subsystem are included in 1.B.2.b.

3.3.2.2.4 Fugitive emissions from fuels – CO₂ process emission (CRF sector 1.B.2.d)

CO₂ process emission from refineries and flaring was included into sub-category 1.B.2.d. This emission was estimated based on the verified reports for refineries which participate in EU ETS [KOBiZE 2021] and are given in Table 3.3.14.

Table 3.3.14. CO₂ process emission from refineries and flaring

Years	CO ₂ emission [kt]
2005	1 090.83
2006	1 148.86
2007	960.93
2008	1 094.27
2009	1 093.46
2010	991.64
2011	1 555.46
2012	1 673.65
2013	1 742.26
2014	1 674.85
2015	1 955.57
2016	1 922.99
2017	1 833.89
2018	1 767.35
2019	1 625.50
2020	1 789.68
2021	1 736.55

Generally CO₂ emission from refineries mainly results from the following processes:

- hydrogen production,
- regeneration of catalysts,
- discharges of hydrocarbons,
- refining of mineral oils,
- tail gas flaring,
- airdrop gas flaring etc.

3.3.2.3. Uncertainties and time-series consistency

See chapter 3.2.6.3.

3.3.2.4. Source-specific QA/QC and verification

See chapter 3.3.1.4.

3.3.2.5. Source-specific recalculations

There was no recalculation for the years 1988-2020 compared to the last submission.

3.3.2.6. Source-specific planned improvements

No improvements are planned at the moment.

4. INDUSTRIAL PROCESSES AND PRODUCT USE (CRF SECTOR 2)

4.1. Source category description

Following subcategories from sector 2 have been identified as key source (excluding LULUCF):

IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)		
2.A.1 Cement Production	CO ₂	L	T	
2.A.4 Other Process Uses of Carbonates	CO ₂	L	T	
2.B.1 Ammonia Production	CO ₂	L	T	
2.B.2 Nitric Acid Production	N ₂ O		T	
2.C.1 Iron and Steel Production	CO ₂	L	T	
2.F.1 Refrigeration and Air conditioning	F-gases	L	T	

Share of these subcategories in total Poland's GHG emissions amounts ca. 5.06%.

Figure below shows GHG emission trend in *Industrial processes and product use* sector.

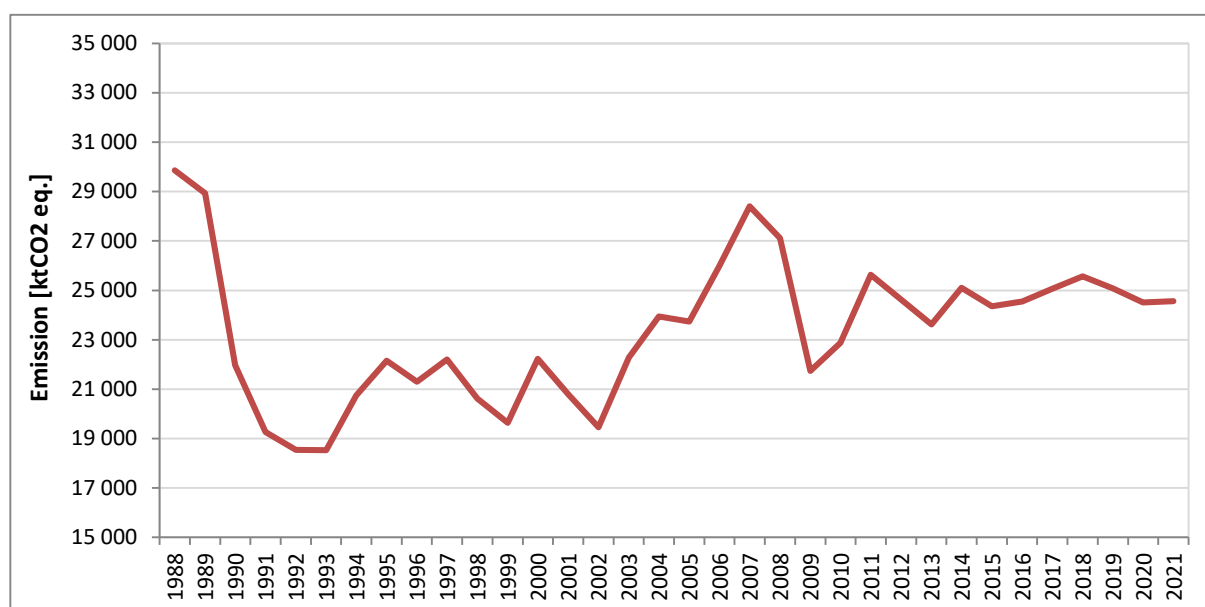


Figure 4.1.1. Emission trend in *Industrial processes and product use* sector in period 1988-2021

Figure 4.1.2 shows GHG emissions according to subcategories of sector 2:

- 2.A Mineral industry,
- 2.B Chemical industry,
- 2.C Metal industry,
- 2.D Non-energy products from fuels and solvent use,
- 2.E Electronics industry,
- 2.F Product uses as substitutes for ODS,
- 2.G Other product manufacture and use,
- 2.H Other.

For estimation of the 2021 emission in sector 2. *Industrial processes and product use* some data from EU ETS installation reports was applied in the following subcategories:

- 2.A Mineral industry: 2.A.1 Cement production, 2.A.4.a Other process uses of carbonates – Ceramics,
- 2.B Chemical industry: 2.B.1 Ammonia production,
- 2.C Metal industry: processes included into Iron and steel production (2.C.1) such as: steel production, sinter production and pig iron production.

Emissions in individual subcategories in period 1988-2021 are shown in figure 4.1.2.

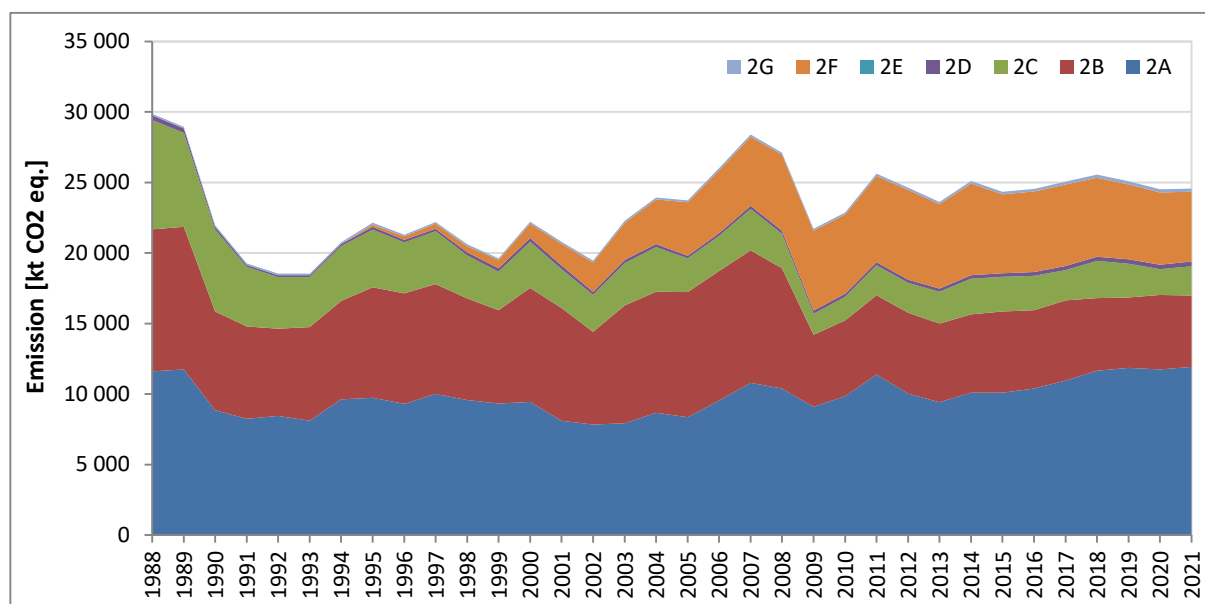


Figure 4.1.2. GHG emissions from *Industrial processes and product use* in 1988-2021 according to subcategories

4.2. Mineral industry (CRF sector 2.A)

4.2.1. Source category description

Estimation of emissions in 2.A *Mineral industry* is carried out in sub-categories listed below:

- a) *Cement production* (2.A.1),
- b) *Lime production* (2.A.2),
- c) *Glass production* (2.A.3),
- d) *Other process uses of carbonates* (2.A.4):
 - *Ceramics* (2.A.4.a),
 - *Other uses of soda ash* (2.A.4.b),
 - *Non-metallurgical magnesium production* (2.A.4.c),
 - *Other* (2.A.4.d).

Subsector 2.A.1 *Cement production* is by far the largest contributor to emissions from this category (see figure 4.2.1) – 61.8% in 2021.

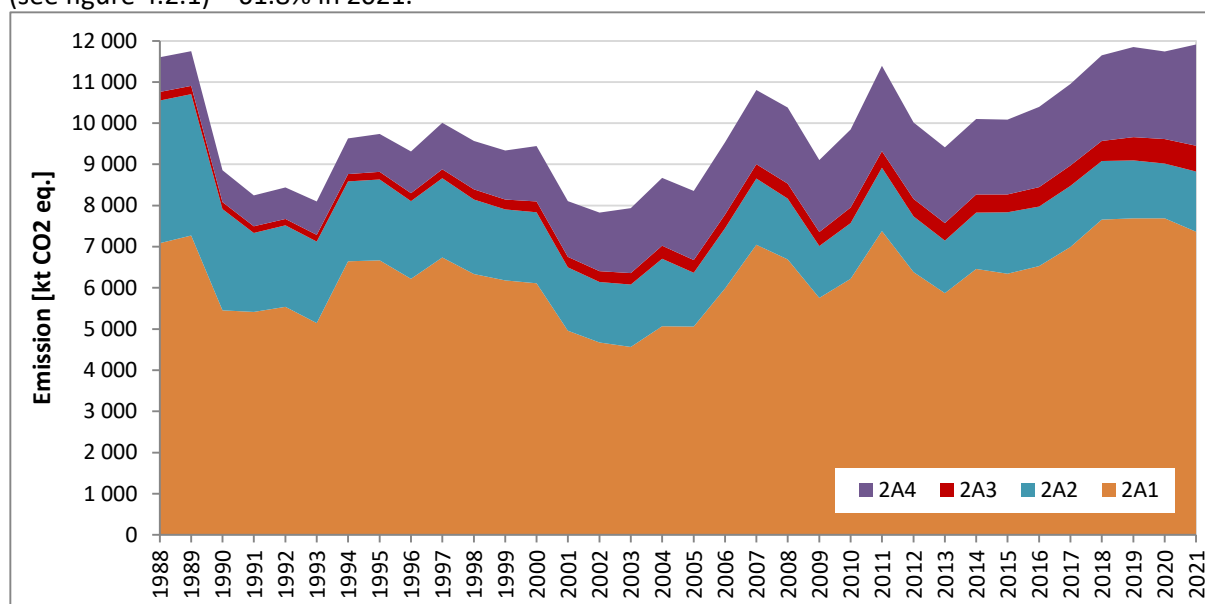


Figure 4.2.1. Emissions from *Mineral industry* sector in years 1988-2021 according to subcategories

4.2.2. Methodological issues

4.2.2.1. Cement production (CRF sector 2.A.1)

CO₂ emission from clinker production is the sum of the process emissions given in the verified reports for 2021 for installation of clinker production, which participate in the EU ETS [KOBIZE 2022]. This emission was estimated as 7365.5 kt CO₂. Data on clinker production was taken from [GUS 2022b].

The clinker production in the period 1988-2021 is shown on figure 4.2.2. Data on clinker production for the entire inventoried period was taken from [GUS 1989b-2022b].

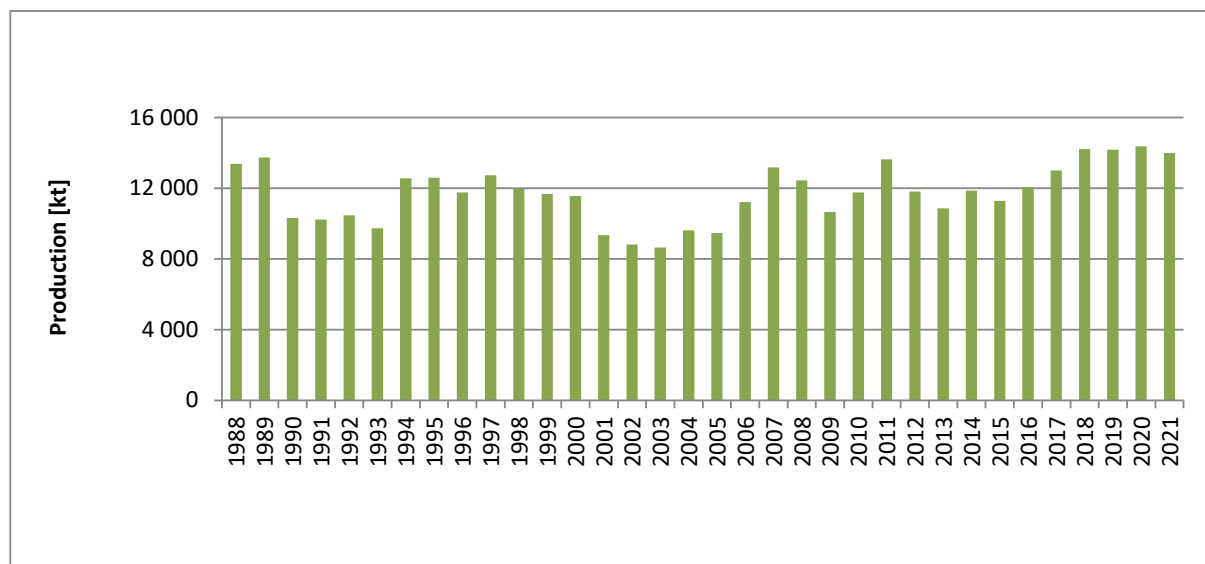


Figure 4.2.2. Clinker production in 1988-2021

Process emission of CO₂ from clinker production was taken from the EU-ETS verified reports for the years: 2005-2021. For earlier years emissions were estimated based on clinker production and emission factors. Emission factors which were used to estimate CO₂ process emissions from subcategory 2.A.1 for the period 1988-2004 are given below:

- for years: 1988-2000 – emission factor equal 529 kg CO₂/t of clinker – average from country specific factors for years: 2001-2004 (2001 – 531 kg CO₂/t, 2002 – 530 kg CO₂/t, 2003 – 528 kg CO₂/t, 2004 – 527 kg CO₂/t). Country specific EFs as listed above come from elaboration [IMMB 2006]. Cited report includes emission data for period 1988-2004 but only emission calculation for 2001-2004 was based on country specific data (chemical analysis of clinker, kiln input etc.). The CO₂ emission for the years 1988-2000 was estimated in cited reports based on default calcination factor (525 kg CO₂ /tonne clinker) because of lack of adequate country specific data. For this reason Poland uses average EFs value for 2001-2004 as CS EF for the period before 2001 in the inventory.
- Re-attempts to obtain data for calculation of national indicators for clinker production for the years 1988-2000 (in response to the review recommendations) have confirmed that full information needed for that estimation is not available. The difficulty in gathering the necessary information results mainly from the fact that some plants operating in the period 1988-2000 no longer exist. Therefore historical data on input components for cement production process collected currently could be incomplete and unrepresentative. Additionally, Polish Cement Association and the main author of the study [IMMB 2006] confirmed that the data for the 1988-2004 analysis purpose was obtained directly from the cement plants. Wherein clinker production installations provided the best available data for that study.
- for years: 2001-2004 – country specific factors (given above) from [IMMB 2006].

As already mentioned, since 2005 CO₂ process emission from clinker production in GHG inventory corresponds to the sums of emissions provided in the EU-ETS verified reports, due to the fact that all installations for clinker production participate in EU-ETS.

Emissions of CO₂ for installations covered by the EU ETS are calculated since 2021 following the Commission Regulation (EU) No 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (Monitoring and Reporting Regulation – MRR) with further amendments.

Since the beginning of 2013 until the end of 2020 emission of CO₂ for installations covered by the EU ETS were calculated in accordance with the Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (Monitoring and Reporting Regulation – MRR).

For the earlier years (before 2013) the emission in ETS reports was estimated based on national Ordinance of the Minister of Environment of 12 September 2008 on the way of monitoring of emission amounts of substances covered by the Community Emission Trading Scheme (Dz. U. Nr 183, poz. 1142). The ordinance transposes to the Polish law the UE Monitoring and Reporting Guidelines for ETS (Commission Decision 2007/589/EC).

Until 2012 methods applied for CO₂ process emission estimation from clinker production in the EU-ETS are described in ANNEX VII of mentioned EC Decision: Activity-specific guidelines for installations for the production of cement clinker as listed in Annex I to Directive 2003/87/EC. Starting from 2013 methods for CO₂ process emission calculation from clinker production in the EU-ETS are described in section 9 of ANNEX IV of previously mentioned Commission Regulations (From 2013 until 2020 - EU No 601/2012 and from 2021 - EU No 2018/2066).

Each of the ETS operator is required to have permit with monitoring plan (dedicated Excel template) approved by Competent Authority. Approval process consist of formal process handled by regional Competent Authority and technical opinion prepared by KOBiZE – Polish central Competent Authority. During approval process qualified unit checks operators CO₂ monitoring methodology, consistency with requirements set in EU Regulation 2018/2066, completeness of information provided including uncertainty assessment, risk analyses and sampling plans etc. Requirements and each step of approval process are described in national law - Emission Trading Scheme Act.

Based on methodology approved in monitoring plan each of the EU ETS operator needs to prepare annual emission report (dedicated Excel template). Each annual emission report prepared by operator is verified (reviewed) by independent verifier. Verification process includes in-site visit and checking if report is in line with installation approved monitoring plan and with requirements set in Monitoring and Reporting Regulation. During verification process of annual emission report verifier checks:

- If permit with complete monitoring plan is approved by Competent Authority;
- list of emission sources;
- types and amount of fuel used in reporting year (with control over measurements instruments – like calibration of meters etc.);
- tiers with uncertainty levels for each emission source and each part of calculation;
- appropriate usage of worldwide/national net caloric values, emission factors and oxidation factors;
- accreditation and standards used in laboratories;
- sampling methodology and frequency;
- control and management of data;
- CEMS technology and meters (if used);
- CO₂ exported outside of the installation (as a part of a fuel or as a product).

After verification process is over verifier issue verification opinion (positive, positive with minor misstatements or negative) with information about action undertake during verification, with precise information about mistakes that he found (if any) and with any recommendation for improvement (if any). Both report and opinion are send to central Competent Authority (in case of Poland – KOBiZE)

where they are once again checked (calculation, tiers used etc.) by qualified unit before emission data is uploaded into National Registry.

Each Member State have one or more Accreditation Body that are responsible for accreditation process of Verifiers. Before verifier receive his accreditation he must prove that he have enough experience and knowledge in audit and EU ETS field. Most of EU Accreditation Bodies are organized into European Co-operation for Accreditation and work very closely with each other. They publish standard book for accreditation and verification process (EA document for recognition of Verifiers under EU ETS Directive - <http://www.european-accreditation.org>) with detailed information about competences of verifiers and with precise information how verification process should look like (with mandatory steps and outcomes).

Starting from 2013 whole verification and accreditation process is described in details in Commission Regulation (EU) No 600/2012 of 21 June 2012 *on the verification of greenhouse gas emission reports and tonne-kilometre reports and the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council* (Accreditation and Verification Regulation – AVR). Since 1st January 2019 Commission Implementing Regulation (EU) 2018/2067 of 19 December 2018 *on the verification of data and on the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council* is applied.

Until 2012 information about production activities from installations covered by EU ETS were additionally collected in Poland in accordance with Ordinance of the Minister of Environment of 12 September 2008 on the way of monitoring of emission amounts of substances covered by the Community Emission Trading Scheme (Dz. U. Nr 183, poz. 1142) because according to Commission Decision 2007/589/EC there was no obligation to provide information concerning production.

Starting from 2013 production amounts were collected in line with requirements set in national law - Emission Trading Scheme Act based on dedicated sub sheet in annual emission report template.

Data on clinker production provided in ETS reports are comparable to data collected by GUS (differences in production values between GUS data and data based on ETS reports are mostly below 1%).

CO₂ emissions from clinker production in period 1988-2021 are shown in the figure 4.2.3.

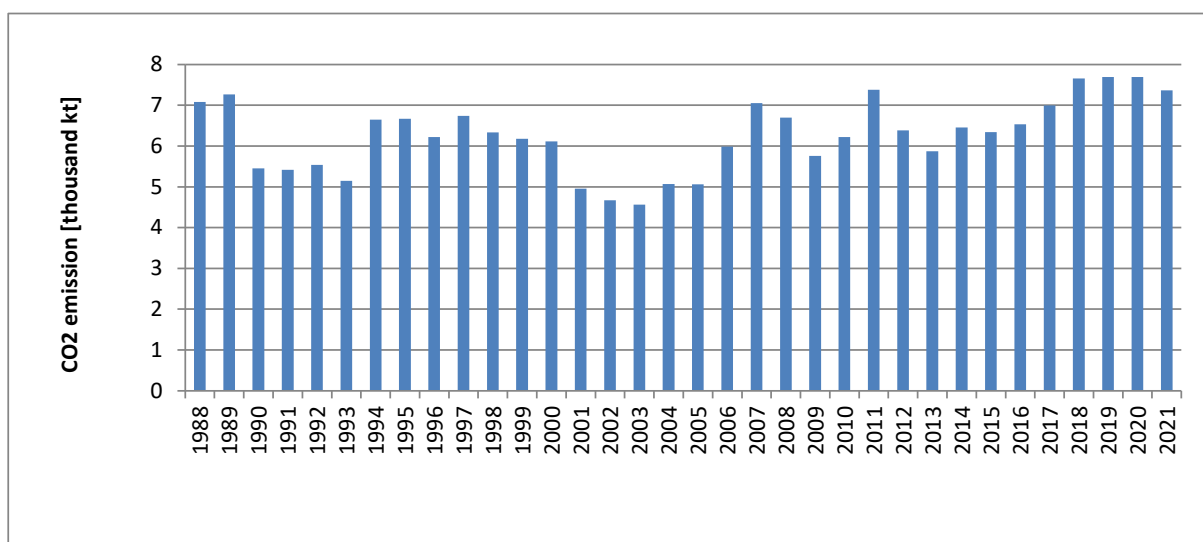


Figure 4.2.3. CO₂ process emission for clinker production in 1988-2021

4.2.2.2. Lime production (CRF sector 2.A.2)

Emission of CO₂ from lime production was calculated based on lime production data from Statistics Poland. Since 2000 activity data divided into quicklime, hydrated lime and hydraulic lime has been applied and emission has been estimated for each type of lime separately using default emission factors for high calcium lime and hydraulic lime from IPCC 2006 GLs (tab. 2.4. p. 2.22). For hydrated lime appropriate correction was considered. Due to the lack of the disaggregated lime production data for the years before 2000, the IEFs (average emission factor from the years 2000-2013) and total lime production was used for CO₂ emission estimation.

Dolomite lime production is given separately in the Polish statistical yearbook, as calcined and sintered dolomite [GUS 1989b-2022b]. Emission from production of this type of lime was estimated based on dolomite consumption in production process according to the study [Galos 2013]. Emission from dolomite lime production was added to the emission from production of other lime types.

According to information from lime production sector vertical shaft kilns are used in lime production in Poland. This type of kilns generate small amounts of LKD, and it is judged that correction factor for LKD would be negligible and do not need to be estimated (2006 IPCC GLs, Vol. 3, p. 2.24).

The figure 4.2.4 presents data concerning lime production (including dolomite lime) for the entire period. CO₂ emissions in period 1988-2021 are shown in the figure 4.2.5.

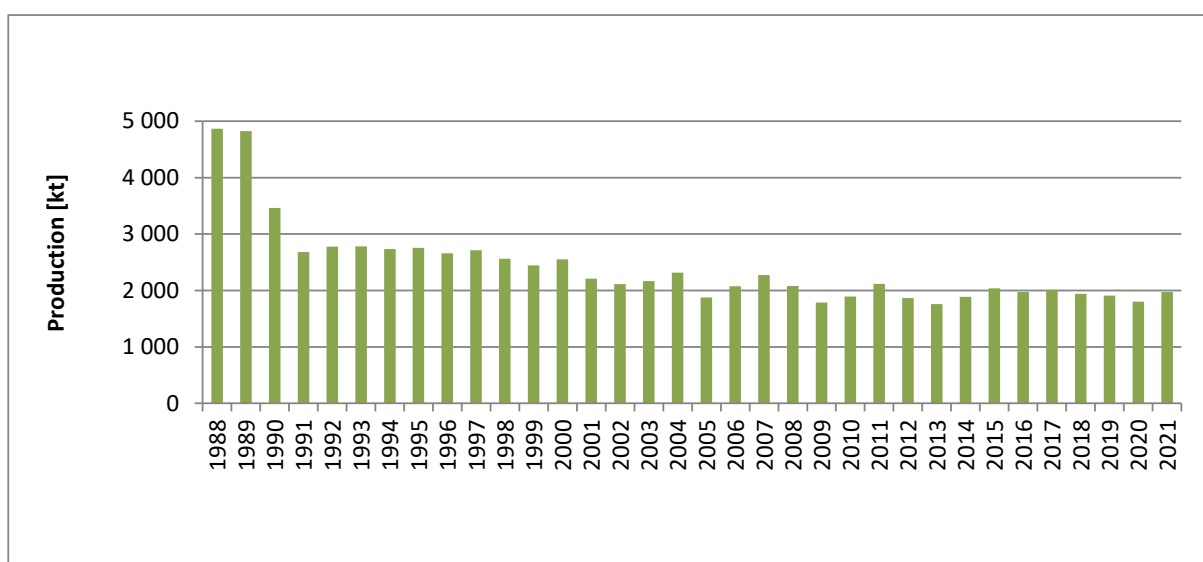


Figure 4.2.4. Lime (including dolomite lime) production in 1988-2021

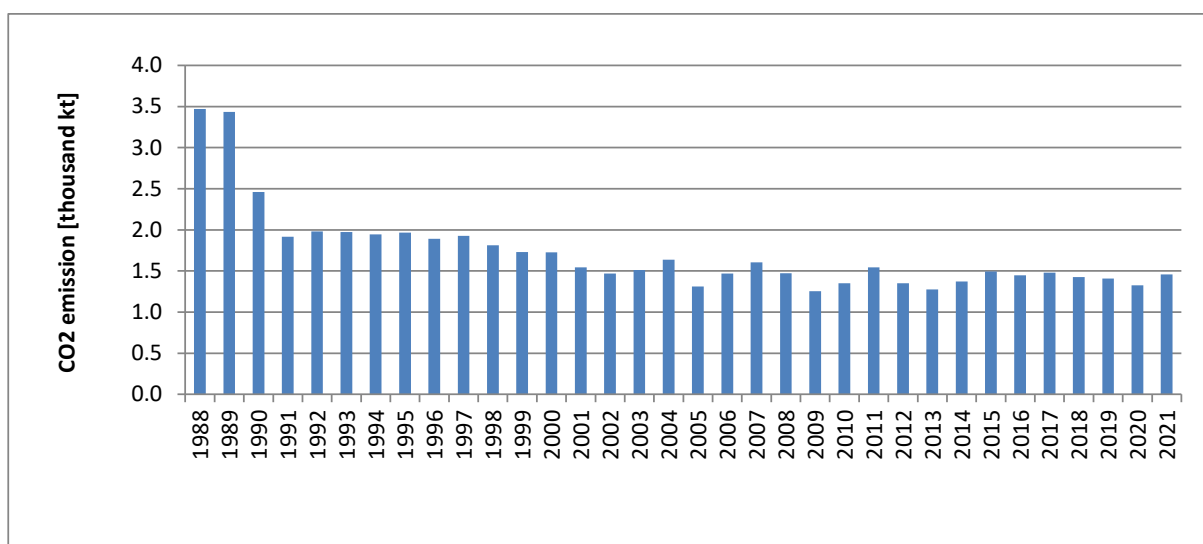


Figure 4.2.5. CO₂ process emission for lime production in 1988-2021

4.2.2.3. Glass production (CRF sector 2.A.3)

Emission of CO₂ from glass production was calculated based on glass production data from Statistics Poland. Default CO₂ emission factor amounted to 0.2 tonnes CO₂/tonne glass was applied for emission estimation in entire period, according to IPCC 2006 GLs – equation 2.13 p. 2.29. In accordance with information obtained from glass production sector and analysis of available statistical data, cullet ratio in glass production was assumed at the level of 20%. It was decided to adopt the constant value for the entire period. Such a rough ratio was adopted on the basis of the analysis of data on turnover of waste suitable for recycling in production and commercial units. Mentioned information is available in the statistical yearbooks: *Materials management* (<https://stat.gov.pl/en/topics/industry-construction-fixed-assets/industry/materials-management-in-2021,6,16.html>) and *Environment* (<https://stat.gov.pl/en/topics/environment-energy/environment/environment-2022,1,14.html>). The data is based mainly on the information from the annual forms: G-06 - *Report on wastes suitable for recycling* (<http://form.stat.gov.pl/formularze/2022/passive/G-06.pdf>).

The analysis of the data on waste turnover indicated that the amount of cullet used in the glass production process in Poland is lower than the assumed default value in the 2006 IPCC GLs. For the analyzed years, the consumption sum of glass cullet in production and commercial units in relation to the AD applied in GHG inventory for glass production amounted to 23-39% (on average approx. 30%). It should additionally be taken into account, that estimated cullet consumption did not apply only to the use of it for the production of glass in glassworks. Glass cullet can also be used, inter alia, for the production of grits, cleaning pastes, as a filler for the production of insulation boards, for road construction, in the building and bonding material industry. It should be underlined that accepted share of cullet use is of relatively high uncertainty. In case of availability of new verified data reanalyse this ratio should be considered.

Glass production and CO₂ emission values from that process in period 1988-2021 are shown in the figures 4.2.6 and 4.2.7 respectively.

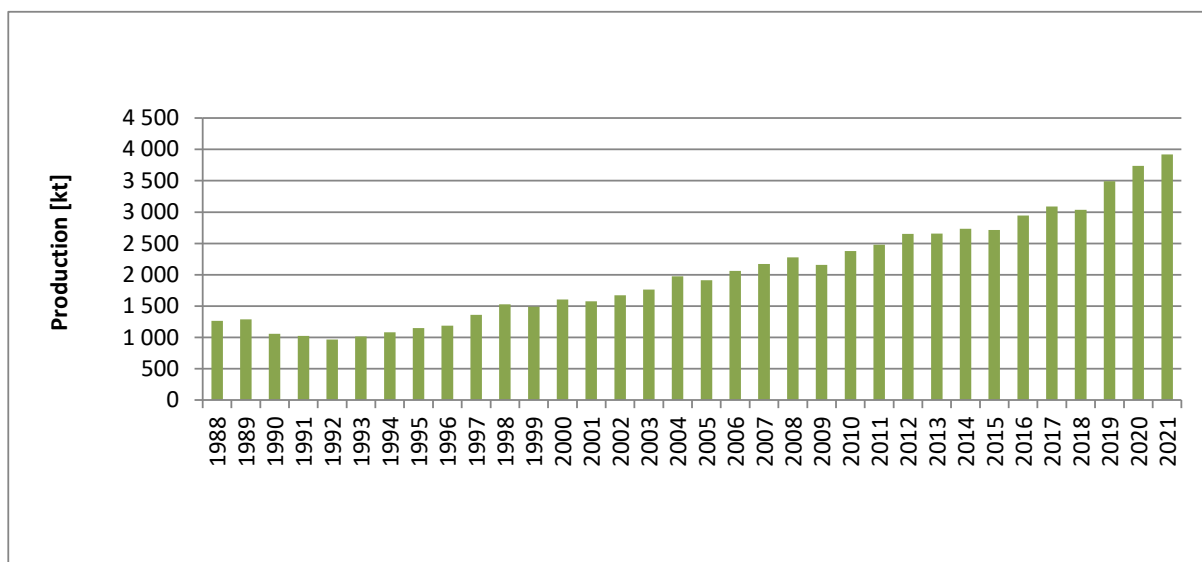


Figure 4.2.6. Glass production in 1988-2021

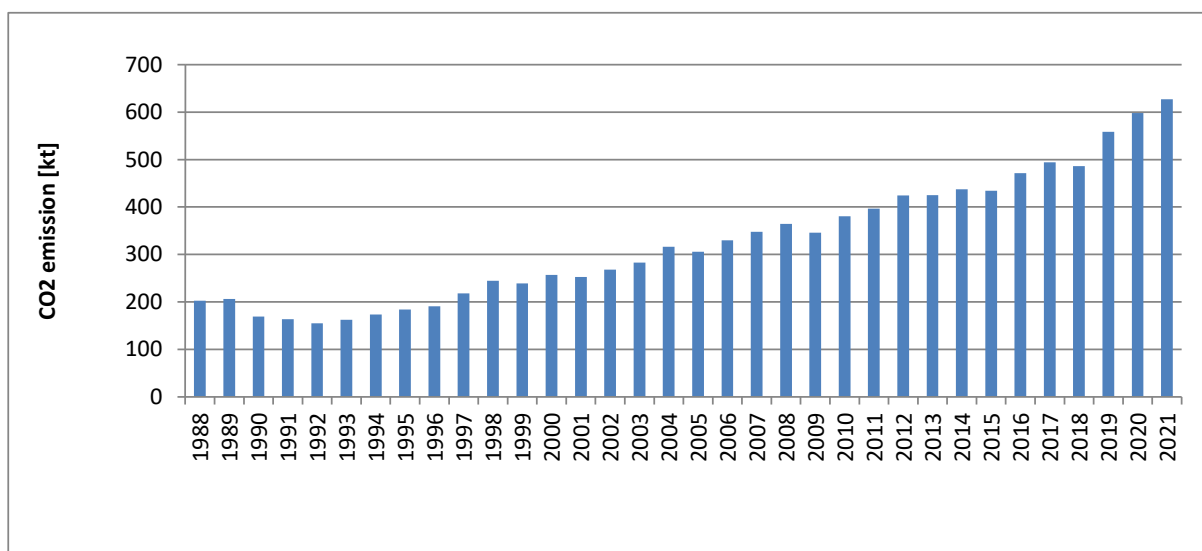


Figure 4.2.7. CO₂ process emission for glass production in 1988-2021

4.2.2.4. Other processes uses of carbonates (CRF sector 2.A.4)

This category includes CO₂ emission from sources as follows:

- Ceramics (2.A.4.a),
- Other uses of soda ash (2.A.4.b),
- Non-metallurgical magnesium production (2.A.4.c),
- Other (2.A.4.d).

2.A.4.a. Ceramics

Estimation of CO₂ emission from ceramics was based on ceramics production data from Statistics Poland (fig. 4.2.8). CO₂ emission factors for the years 2005-2021 (Table 4.2.1) was grounded on the verified reports for ceramic installation covered by EU ETS [KOBiZE 2022]. For the years before 2005 average value of EFs from 2005-2013, amounted to 51.23 kg CO₂/t of ceramics, was applied.

Table 4.2.1. CO₂ EFs values [kg CO₂/t] in *Ceramics* subcategory

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
56.69	48.20	54.30	53.88	48.52	51.44	48.77	49.41	49.86	43.52	50.99
2016	2017	2018	2019	2020	2021					
51.95	52.97	51.85	48.58	46.48	45.71					

Due to the fact that the ETS specifies threshold values for installations producing ceramics, it was assumed that the data on the production volume from the Statistics Poland (GUS) for this subcategory would be more appropriate to determine AD. Data on the volume of production are collected through GUS reporting. The data is the results of annual survey of production of industrial goods in P-01 form "Questionnaire on production" (<http://form.stat.gov.pl/formularze/2022/passive/P-01.pdf>).

The entities obliged to prepare the P-01 report are entities of the national economy employing 10 people and more, which manufacture products or provide services specified in the PRODPOL nomenclature. The nomenclature is based on the Polish Classification of Goods and Services (PKWiU 2015) – introduced on January 1, 2016 for use in statistics, registration, documentation and accounting, and also in official registers and public administration information systems (Regulation of the Council of Ministers of 4 September 2015, Journal of Laws, item 1676) and on the PRODCOM List used in the European Union.

It is assumed that the data from official statistics (i.e. from GUS) is the best available verified national data. Due to the fact that in 2006 IPCC GLs no default emission factors of CO₂ emissions from the production of ceramic products are available, CS EFs were determined for each year on the basis of reports of installations covered by the ETS system, which provided the emission volume with the corresponding production volume.

CO₂ emission values in 2.A.4.a subcategories for entire period 1988-2021 were presented in the figure 4.2.9.

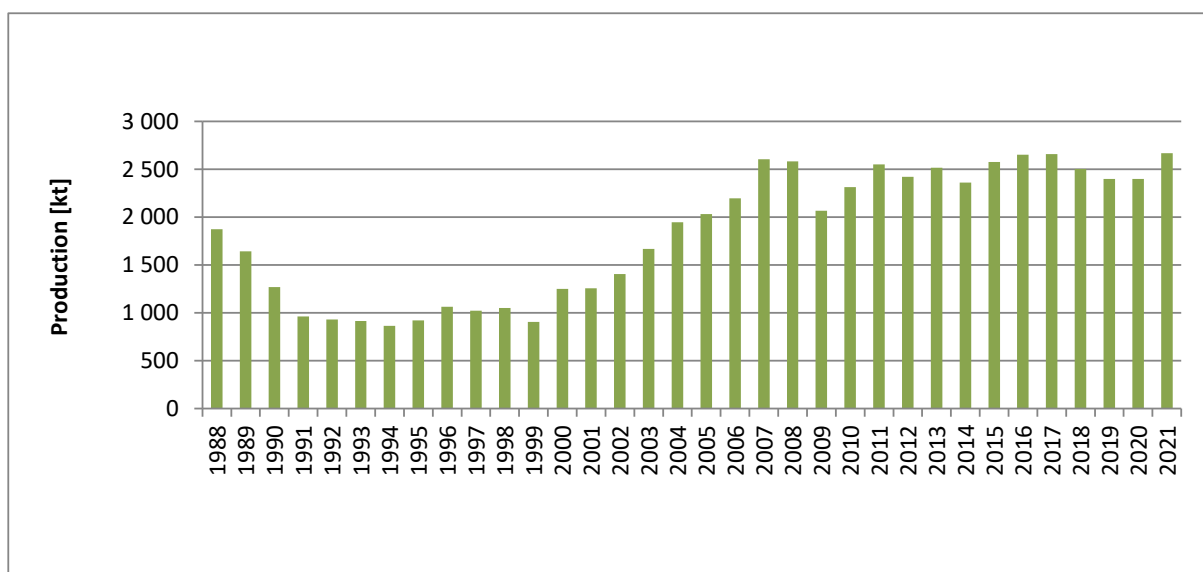


Figure 4.2.8. Ceramic production in 1988-2021

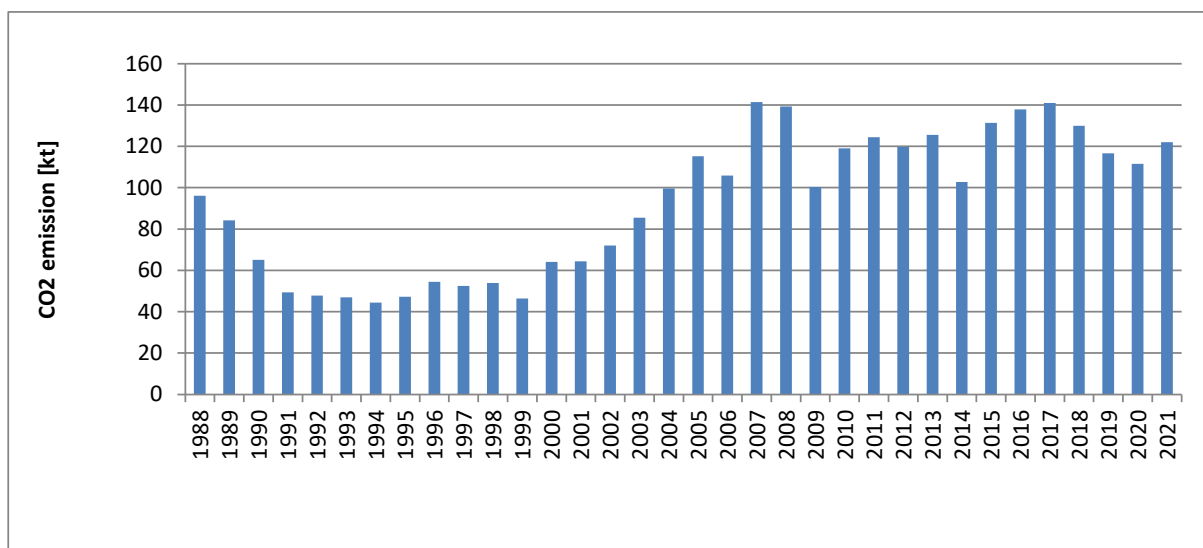


Figure 4.2.9. CO₂ process emission from ceramics in 1988-2021

2.A.4.b. Other uses of soda ash

CO₂ emission from soda ash use was estimated based on annually consumption of soda ash, which was published in GUS yearbook: *Materials Management in 2021* [GUS 2022f]. Additionally to assumed that half of soda ash use was consumed in glass and ceramics production and that amount was subtracted from AD because it was included in 2.A.3 and 2.A.4.a subcategories respectively.

EF amounting to 414.92 kg CO₂/t of soda ash used was applied for inventory calculation for the entire period (EF was taken from IPCC 2006 GLs, tab. 2.1. p. 2.7).

CO₂ emission for the years 1992-2021 was estimated based on data concerning soda ash consumption taken from *Materials Management* [GUS 1994f-2022f]. For the years before 1992, due to lack of the published statistical data, the assumption was made, that total soda ash consumption amounts to 50% of soda ash production. This assumption was based on the analysis, which considered production [GUS 1993e-2002e] and corresponding use of soda ash [GUS 1994f-2002f] in the period 1992-2001.

An additional assumption was applied that only 50% of the total consumption is reported in 2.A.4.b subcategory. The rest of soda ash consumption is included in the other 2.A subcategories (mainly in glass production). The adopted assumption is confirmed by the share of NACE 23 in the total consumption of soda ash in Poland calculated on the basis of data included in mentioned yearbook.

CO₂ emission values from soda ash use in 2.A.4.b subcategories, for entire period 1988-2021, were presented in the figure 4.2.10.

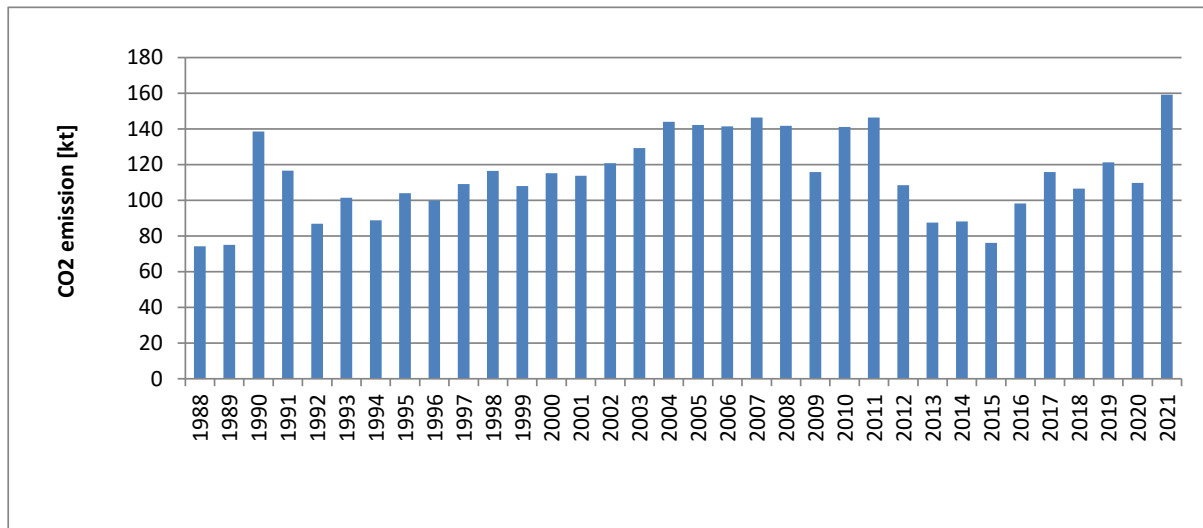


Figure 4.2.10. CO₂ emission values from soda ash use in 2.A.4.b subcategory in the years 1988-2021

2.A.4.c. Non-metallurgical magnesium production

Magnesium has not been produced in Poland.

2.A.4.d. Other

CO₂ emission from limestone use as a sorbent in lime wet flue-gas desulfurization, FGD in FBB (fluidized bed boiler) and other method of flue gas desulfurization was considered under this subcategory. Estimation of emission was based on study [Galos 2013]. The results were presented in figure 4.2.11. Details concerning calculations of CO₂ emission for 2.A.4.d category were provided in the Annex 3.1.

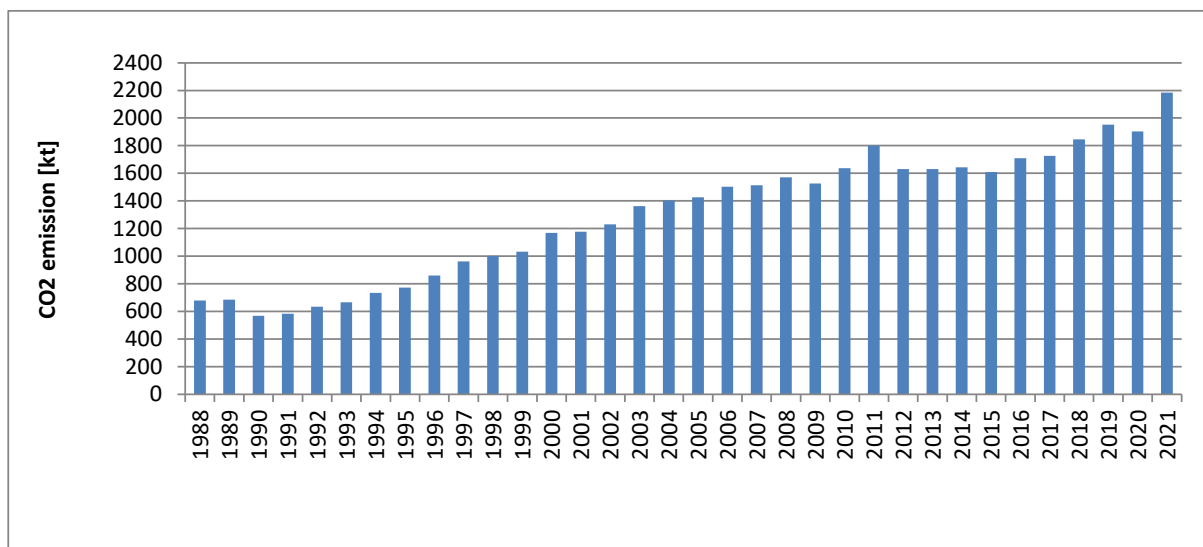


Figure 4.2.11. CO₂ emission from carbonate use in 2.A.4.d subcategory for 1988-2021

4.2.3. Uncertainties and time-series consistency

Uncertainty analysis for the year 2021 for IPCC sector 2. *Industrial processes and product use* was estimated with use of approach 1 described in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Simplified approach was based on the assumptions that every value is independent and probability distribution is symmetric. Results of the sectoral uncertainty analysis are given below. More details on uncertainty assessment of whole inventory are given in annex 8.

Recalculation of data for years 1988-2020 ensured consistency for whole time-series.

2021	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ Emission uncertainty [%]	CH ₄ Emission uncertainty [%]	N ₂ O Emission uncertainty [%]
2. Industrial processes and product use	18 882.09	2.03	2.18	3.8%	26.5%	44.8%
A. Mineral industry	11 914.85			5.8%		
B. Chemical industry	4 553.47	1.61	1.73	4.4%	33.1%	55.5%
C. Metal industry	2 072.75	0.42	0.00	4.9%	17.4%	0.0%
D. Non-energy products from fuels and solvent use	341.02			11.8%		
G. Other product manufacture and use			0.45			40.3%

4.2.4. Source-specific QA/QC and verification

Activity data used in the GHG inventory concerning industry sector come from yearbooks published by the Statistics Poland (GUS). GUS is responsible for QA/QC of collected and published data. Depending on type of emission factor and *Tier* method applied in the GHG inventory, EF is compared with plant specific emission factor or the default one, respectively.

While preparing national inventory data from ETS reports is partially used to estimate emissions from such subcategories like: mineral, chemical and metallurgical industries. In category 2.A, CO₂ emissions submitted in ETS reports by installations in the clinker production sector were directly used in the national emission inventory in category 2.A.1 *Cement production*. The aggregate production volumes given in individual years by the cement industry installations are also compared with the data published in official statistics. In subcategory 2.A.4.a *Ceramics*, information from ETS reports is used to calculate CO₂ emission factors that are used in the national GHG inventory. In sector 2.B *Chemical industry*, data from ETS reports is used to estimate emissions from ammonia production, specifically for calculating of country specific carbon content in natural gas, which is used for ammonia production. ETS reports are also used when estimating emissions from category 2.C *Metal industry*. Data sent from steel plants under the ETS allow estimation of CO₂ emissions from sinter plants (reports are the source of AD and data relating to input and output of sintering of iron ore process). They are also used to estimate CO₂ emissions from pig iron production as they are a source of data for the C balance of BF process (some quantities data on input and output components and the content of carbon in them). The estimation of CO₂ emission for the production of steel from BOF and electric furnaces in GHG inventory is also based on detailed data from reports prepared under ETS (as described in chapter 4.4.2 of the NIR). In the case of 2.C.2 *Ferroalloys production*, AD relating to ferrosilicon reported in GHG inventory, which is taken from statistical yearbook, is compared with information in the ETS database.

Emissions from the national GHG inventory and ETS for the main IPCC subcategories are reported to the EU in the form of the *MMR Annex V table (Article 10-Reporting on consistency of reported emissions with data from the emissions trading system)*. However, there may be differences that result, among others, from the use of different emission estimation methodologies. There are additional issues that complicate the comparison between inventory and ETS data, for example: the dual role of fuels i.e. action of coke or coal as an energy carrier and as a reducer in industrial processes or problem of aggregated emissions for some ETS installations, e.g. in chemistry, where the reported emissions do not correspond to the production of only one product what is required by national inventory guidelines.

It should be mentioned that data reported by ETS installations is verified by independent reviewers and by verification unit established in the National Centre for Emissions Management (KOBiZE).

Calculations in industry sector were examined with focus on formulas, units and trends consistency. Generally QC procedures follow QA/QC plan presented in Annex 7.

4.2.5. Source-specific recalculations

- CO₂ EF for 2.A.4.a *Ceramics* subcategory was slightly corrected for 2020

Table 4.2.2. Changes of GHG emission values in 2.A. subcategory as a result of recalculations

Change	1988	1989	1990	1991	1992	1993	1994	1995
CO ₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Change	1996	1997	1998	1999	2000	2001	2002	2003
CO ₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Change	2004	2005	2006	2007	2008	2009	2010	2011
CO ₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Change	2012	2013	2014	2015	2016	2017	2018	2019
CO ₂								
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Change	2020							
CO ₂								
kt	-1.19							
%	-0.01							

4.2.6. Source-specific planned improvements

No improvements are planned at the moment.

4.3. Chemical industry (CRF sector 2.B)

4.3.1. Source category description

Estimation of emissions in 2.B *Chemical industry* are carried out in sub-categories listed below:

- Ammonia production* (2.B.1),
- Nitric acid production* (2.B.2),
- Adipic acid production* (2.B.3),
- Caprolactam, glyoxal and glyoxylic acid production* (2.B.4),
- Carbide production* (2.B.5),
- Titanium dioxide production* (2.B.6),
- Soda ash production* (2.B.7),
- Petrochemical and carbon black production* (2.B.8).

Subsector 2.B.1 *Ammonia production* is the largest contributor to emissions from this category (see figure 4.3.1) – 72.5% in 2021. Adipic acid was produced up to 1994.

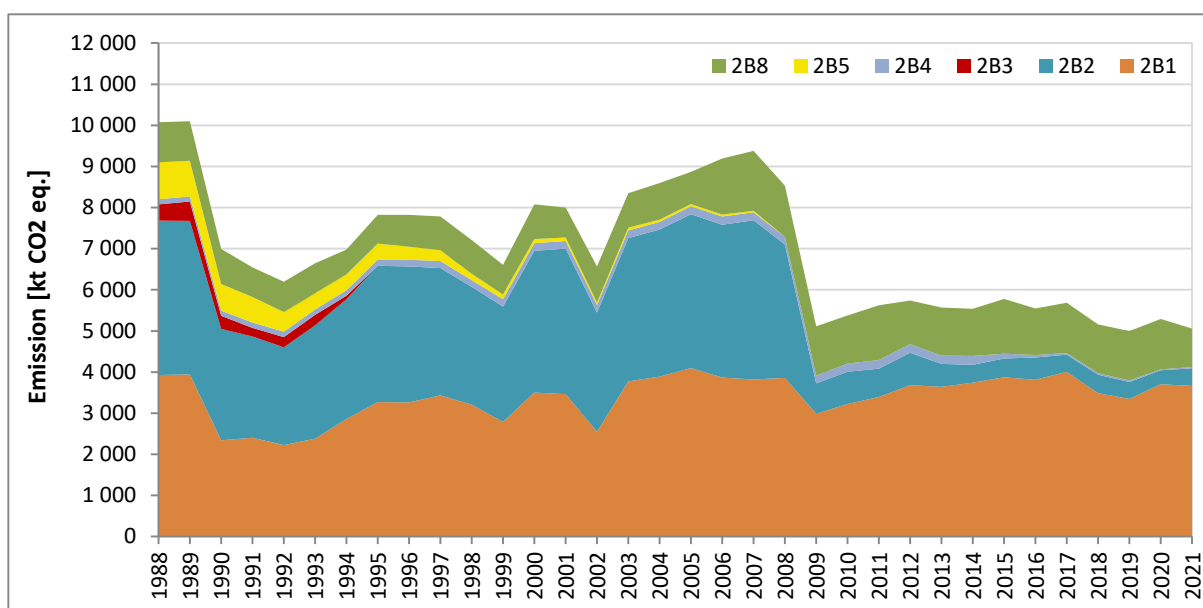


Figure 4.3.1. Emissions from *Chemical industry* category in years 1988-2021 according to subcategories

4.3.2. Methodological issues

4.3.2.1. Ammonia production (CRF sector 2.B.1)

CO₂ emissions for ammonia production are estimated based on the data on natural gas use in this process (natural gas consumption for the years 1988-2021 was presented in Annex 3.2). The amount of natural gas consumption expressed in volume units was taken from [GUS 2022e]. In order to calculate CO₂ emission, country specific carbon content in natural gas was estimated, based on the data from verified EU ETS reports provided by ammonia production installations [KOBiZE 2022]. Carbon content was estimated as 0.552 kg C/m³ for 2021 and 0.542-0.553 kg C/m³ for the years 2014-2020. For 2013 that amount was estimated at 0.544 kg C/m³ and the same value was applied for previous years back to 1988. According to above-mentioned information, the CO₂ process emission from ammonia production was calculated using the following formula:

$$E_{CO_2} = Z_{\text{natural gas}} * C_{\text{content}} * 44/12$$

where:

E_{CO_2} – CO₂ process emission from ammonia production [t]

$Z_{\text{natural gas}}$ – natural gas use [thousands m³]

C_{content} – carbon content in natural gas [kg C/m³]

This method was used for entire period: 1988-2021. In years 1988-1990, also coke-oven gas was used for ammonia production and this fact was reflected in the inventory calculations (Annex 3.2). The coke-oven gas consumption was taken in energy units – also based on G-03 reports – and the carbon content factor is taken from IPCC [IPCC 2006].

CO₂ recovered for fertilizer urea production was deducted in calculation of emission for 2.B.1 subcategory. The estimation of CO₂ amounts for subtraction in entire period 1988-2021 were detailed presented in the Annex 3.2.

Should be noted that significant elements in the urea balance in Poland, apart from production, are the export and import of this product. For example, according to data from Eurostat database (<https://ec.europa.eu/eurostat/web/prodcom/data/database>) for 2021, the main goods regarding urea (PRODCOM code 20153130 and 20153180) give a total production volume equal to 1174 kt, while exports of these products account for over 942 kt and import 693 kt (these values are amounts converted from kg N unit given in the Eurostat database to the mass of urea). Hence, it follows that consumption estimated on the basis of the relationship: Consumption = Production + Imports - Exports significantly differs from the production volume.

CO₂ process emissions from ammonia production including subtraction of CO₂ used in fertilizer urea production for the period: 1988-2021 are shown in figure 4.3.2 while the ammonia production values [GUS 1989e-2022e] are presented in figure 4.3.3.

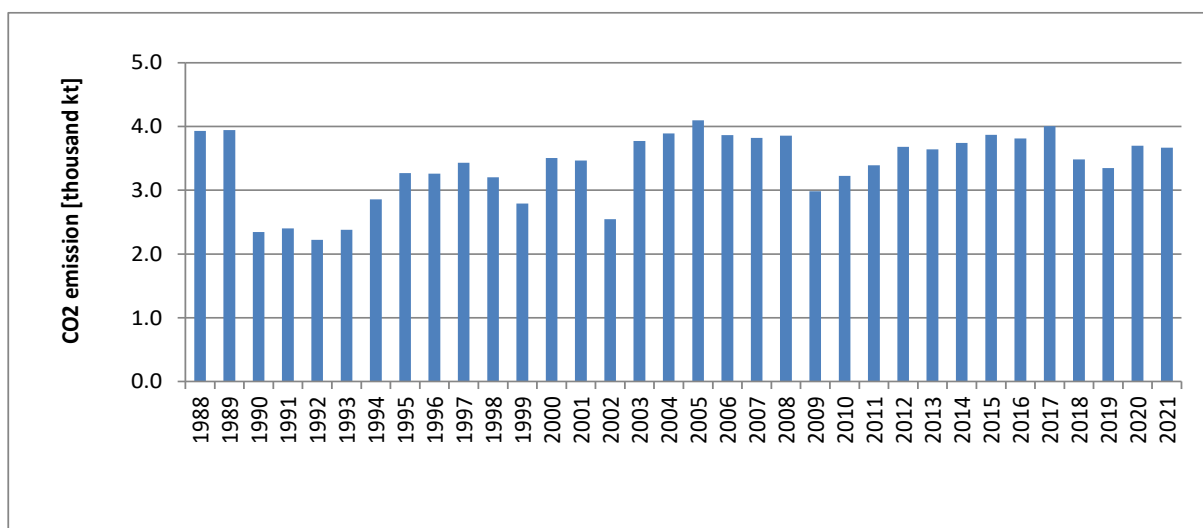


Figure 4.3.2. CO₂ process emission from ammonia production in 1988-2021 (including subtraction of CO₂ connected with fertilizer urea production)

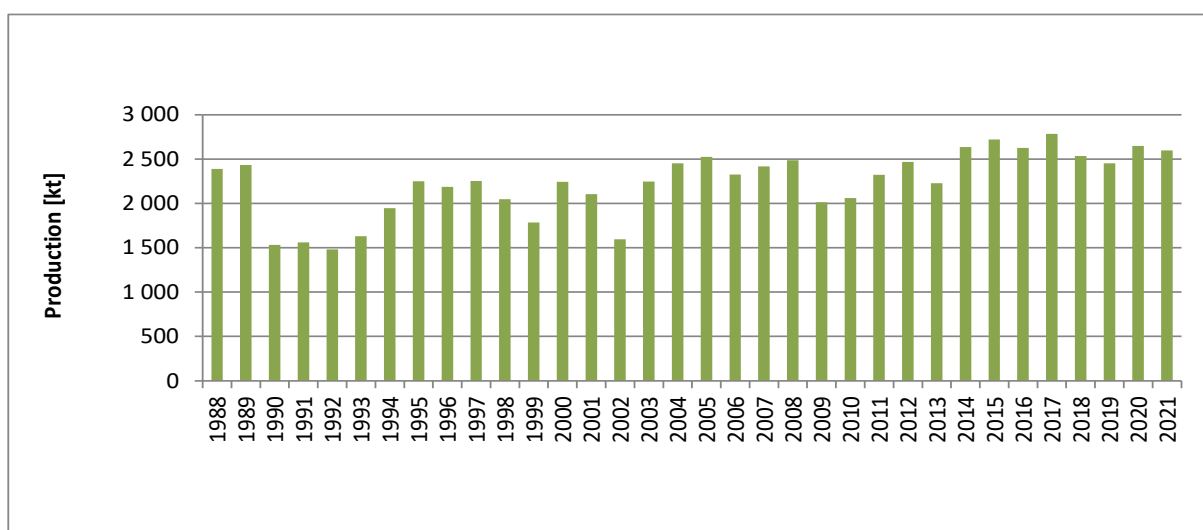


Figure 4.3.3. Production of ammonia in 1988-2021

4.3.2.2. Nitric acid production (CRF sector 2.B.2)

Estimation of N₂O emission from nitric acid production for 2021 was based on annual HNO₃ production data from [GUS 2022b]. The country specific emission factor of 0.65 kg N₂O/t nitric acid for 2021 was estimated based on the reports from all producers of HNO₃ [KOBiZE 2022]. The N₂O emission factors for years 2005-2021 (Table 4.3.1) were calculated also based on the reports provided by installations of nitric acid production.

Table 4.3.1. N₂O EFs in 2.B.2 subcategory for the years 2005-2021 [kg N₂O/t]

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
6.36	6.37	6.43	5.40	1.31	1.34	1.21	1.28	0.92	0.70	0.72
2016	2017	2018	2019	2020	2021					
0.87	0.66	0.74	0.66	0.54	0.65					

Emission factors mentioned above were estimated as weighted average of plant specific emission factors obtained from all nitric acid producers (from 5 installations located in 4 enterprises).

Drop of the N₂O EF value from nitric acid production in 2008 and its further decrease between 2009 - 2011 are the result of the implementation of the JI projects. N₂O catalytic decompose inside the oxidation ammonia reactor is the abatement technology applied in these installations.

Decline of emission factor value in 2012-2014 is mainly the result of change the catalyst for more effective one in the largest HNO₃ production installation.

The main reason for N₂O EF increase in 2016 is bypassing of nitrous gases outside the catalyst bed for reduction of nitrous oxide in one of the nitric acid production plants.

Individual data obtained from nitric acid producers is confidential, so was not published in the NIR (it could be available for ERT review purpose only).

For the period 1988-2004, N₂O EF amounted to 6.47 kg/t nitric acid was applied. This country specific emission factor was taken from [Kozłowski 2001].

Activity data (i.e. HNO₃ production) for estimation of nitrous oxide emissions in 2.B.2 subcategory was taken from [GUS 1989b-2022b] for the entire period 1988-2021. Since 2005, AD is cross-checked with the HNO₃ production reported by all nitric acid installations that are required to submit annual reports for emission database (KOBiZE 2022). A comparison of this data indicates only slight differences, ranging from -1.5% to 2.6% in individual years, what confirms that all nitric acid production is taken into account in AD applied in emission estimation.

The amount of production and N₂O emissions from nitric acid production are shown in figures 4.3.4 and 4.3.5, respectively.

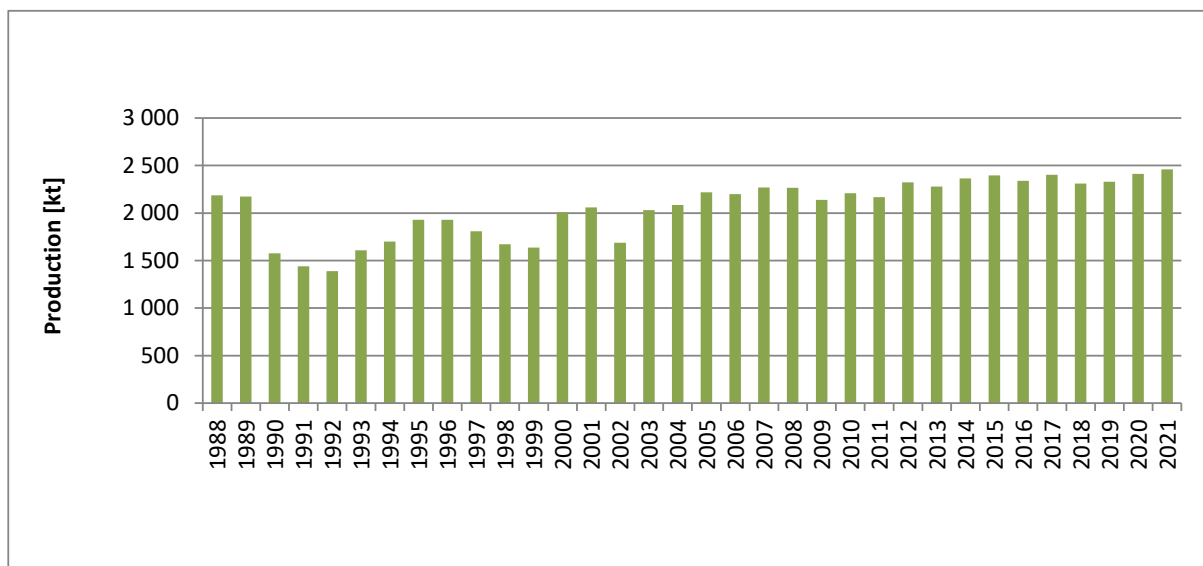
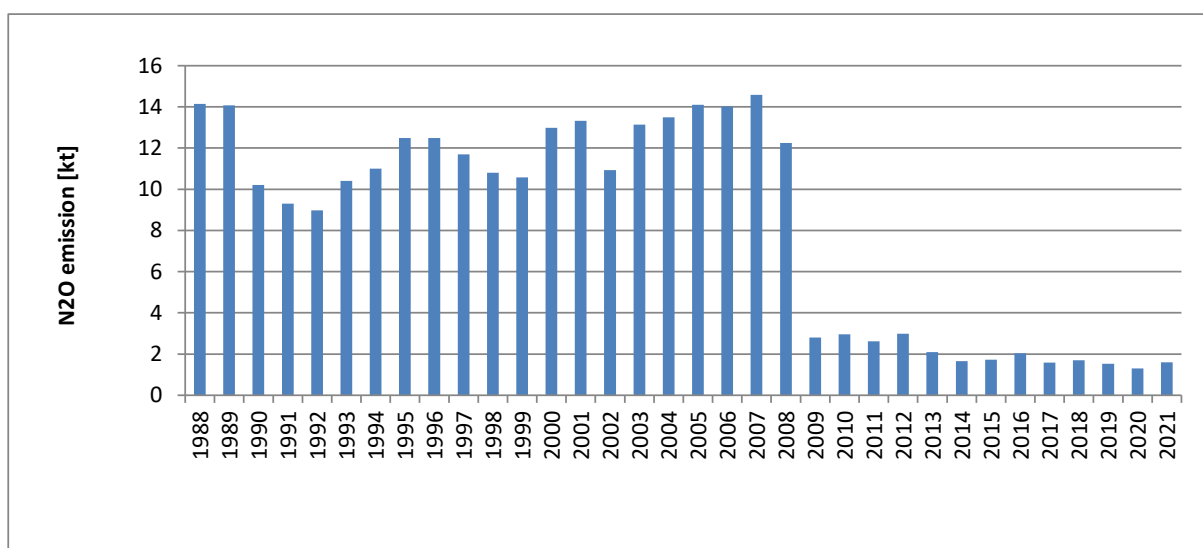


Figure 4.3.4. Production of nitric acid in 1988-2021

Figure 4.3.5. N₂O process emission for nitric acid production in 1988-2021

4.3.2.3. Adipic acid production (CRF sector 2.B.3)

Production of adipic acid was continued up to 1994. Activity data concerning adipic acid production was taken from the only adipic production plant.

N₂O emission factor for this category, which is equal 300 kg N₂O/t, was taken from table 3.4, p. 3.30, 2006 IPCC GLs [IPCC 2006].

4.3.2.4. Caprolactam, glyoxal and glyoxylic acid production (CRF sector 2.B.4)

Caprolactam Production

Data on annual caprolactam production for inventory calculation purpose, in entire time series, was taken from GUS publications [GUS 1989b-2022b]. From the base year up to 2014, the CS N₂O EF of 4.74 kg N₂O/t caprolactam produced was applied, based on the Polish study [Kozłowski 2001] containing an analysis of technologies in the existing caprolactam production installations in Poland and projection of N₂O emissions until 2020, taking into account the planned changes and shares of individual installations in domestic production.

Since 2015, N₂O emission factor is based on the data obtained from the caprolactam production installations. The emission factors for individual years from the 2015-2021 period are presented in the table 4.3.2.

Table 4.3.2. N₂O EFs for caprolactam production in the years 2015-2021 [kg N₂O/t]

2015	2016	2017	2018	2019	2020	2021
2.7	1.5	0.8	0.8	0.9	0.6	0.8

Values of EFs obtained from caprolactam producer for GHG inventory purpose is consistent with data submitted by installation to National Database managed by KOBIZE (National Centre for Emissions Management). The annual productions reported by the installations are fully in line with the amounts published in the statistical yearbook.

Such a significant decrease in N₂O emission from caprolactam production in recent years was possible due to the use of effective nitrous oxide reduction catalysts. The N₂O emission occurs at the stage of production of ammonium nitrite, which is an intermediate in the production of hydroxylamine sulphate in the caprolactam production process. Reduction in the N₂O EF value was achieved due to the development of more and more effective catalysts as a result of the cooperation of the caprolactam producers with the Łukasiewicz Research Network - Institute of New Chemical Syntheses in Puławy which included research and testing of new catalysts for the reduction of nitrous oxide.

Glyoxal and glyoxylic acid production

Glyoxal and glyoxylic acid have not been produced in Poland.

4.3.2.5. Carbide production (CRF sector 2.B.5)

CO₂ emission from calcium carbide category was estimated for years 1988-2007 based on annual production amounts taken from [GUS 1989b-2008b]. Starting from 2008 carbide is no longer produced in Poland.

EF equal 2190 kg CO₂/t of carbide (i.e.: 1090 kg CO₂/t carbide from production + 1100 kg CO₂/t carbide from use) was applied for CO₂ emission estimation in entire period 1988-2007. The factors given above were taken from tab. 3.8, 2006 IPCC GLs [IPCC 2006].

Silicon carbide has not been produced in Poland.

4.3.2.6. Titanium dioxide production (CRF sector 2.B.6)

Titanium dioxide is produced in Poland in sulphate route process, so it was assumed, that the GHG emission is insignificant from TiO₂ production (in accordance with 2006 IPCC GLs (Chapter 3.7, p. 3.47).

4.3.2.7. Soda ash production (CRF sector 2.B.7)

In Poland, soda ash is produced in the Solvay process. Emission of CO₂ from this process was assumed as 0 as coke consumption in soda ash production process is included in fuel use in *Final Energy Consumption - Chemical and Petrochemical* category in Polish energy balance and CO₂ emission is accounted in 1.A.2.c IPCC sector.

It is due to the amount of coke used for the production of soda ash is not separated in the national statistics. This consumption is aggregated with consumption in the production of other chemicals and given as final consumption (reported in category 1.A.2.c). It would therefore be difficult to distinguish emissions related to the consumption of coke in analyzed process.

An additional problem is the issue of transfer of CH₄ and N₂O emissions from coke from category 1.A.2.c to 2.B.7 within CRF. As the cells related to these gases in CRF Table for 2.B.7 are grayed out - no emissions of these gases are expected to be reported. Additionally when leaving the CH₄ and N₂O emissions in category 1.A.2.c, if the fuel was reallocated to 2.B.7, then IEFs for these gases would be not consistent.

The best option seems to be leaving emissions from coke used in the production of soda in category 1.A.2.c while in category 2.B.7 therefore notation key "IE" is reported (pointing to the 1.A.2.c).

4.3.2.8. Petrochemical and carbon black production (CRF sector 2.B.8)

a. Methanol production

According to the data contained in yearbook [GUS 2022b], in Poland in 2019-2021 methanol was not produced. Process emissions of CO₂ and CH₄ from methanol production for the period 1988-2018 were estimated based on data on annual production from [GUS 1989b-2020b]. CO₂ EF = 670 kg CO₂/t from tab. 3.12 of 2006 IPCC GLs [IPCC 2006] was applied. CH₄ emission values were calculated based on CH₄ EF = 2.3 kg CH₄/t [IPCC 2006].

b. Ethylene production

CO₂ and CH₄ process emissions related to ethylene production were estimated for the entire period 1988-2021 based on the data on annual production amounts taken from [GUS 1989b-2022b]. CO₂ EF = 1903 kg CO₂/t was applied. It is value of CO₂ EF (for default feedstock) given in tab. 3.14 of 2006 IPCC GLs adjusted by recommended regional factor (110% in case of Eastern Europe; tab. 3.15) [IPCC 2006]. CH₄ emission values were calculated based on CH₄ EF = 3.0 kg CH₄/t according to the table 3.16 [IPCC 2006].

c. Ethylene dichloride and vinyl chloride monomer production

CO₂ and CH₄ emission in this IPCC category was estimated based on vinyl chloride monomer production. Activity data for the years 2002-2021 was taken from Statistics Poland. Data for the years 1988-2001 come directly from VCM producer. CO₂ EF amounted to 294.3 kg CO₂/t VCM produced, recommended for balanced process (default process) in the table 3.17 of 2006 IPCC GLs [IPCC 2006], was applied for emission estimation in entire period. CH₄ emission was calculated using EF=0.0226 kg/t VCM produced (tab. 3.19, 2006 IPCC GLs).

d. Ethylene oxide production

Ethylene oxide production amounts from Statistics Poland were used for estimation of CO₂ and CH₄ emissions. Default EFs for both CO₂ and CH₄ were applied in order to calculation of emissions. Utilized EF values were as follow: CO₂ EF = 863 kg CO₂/tonne ethylene oxide (tab. 3.20, 2006 GLs), CH₄ EF = 1.79 kg CH₄/tonne ethylene oxide (tab. 3.21, 2006 GLs).

e. Acrylonitrile production

According to data from Statistics Poland production of acrylonitrile in Poland occurred only in the following years: 1988-1990 and 1996-2003. Emission of CO₂ and CH₄ from this production was estimated according to 2006 IPCC GLs. CO₂ EF = 1000 kg CO₂/tonne acrylonitrile produced (tab. 3.22, 2006 GLs) and CH₄ EF = 0.18 kg CH₄/tonne acrylonitrile produced (p. 3.79, 2006 GLs) were applied for GHG inventory purpose.

f. Carbon black production

CO₂ and CH₄ emissions from production of carbon black were estimated based on annual carbon black production taken from [GUS 1989b-2000b] and [GUS 2001e-2022e] respectively. CO₂ EF equal to 2620 kg CO₂/tonne carbon black produced (tab. 3.23, 2006 GLs) and CH₄ EF = 0.06 kg CH₄/tonne carbon black produced (tab. 3.24, 2006 GLs) were used.

g. Other - Styrene Production

Data on styrene production applied for emission estimation was obtained from [GUS 1996e-2022e] for the years 1995-2021 and directly from the only styrene producer for previous years (1988-1994). Methane emissions values for the entire period 1988-2021 were estimated by applying the same emission factor of 4 kg CH₄/t styrene produced [IPCC 1997].

4.3.3. Uncertainties and time-series consistency

See chapter 4.2.3

4.3.4. Source-specific QA/QC and verification

See chapter 4.2.4

4.3.5. Source-specific recalculations

- N₂O EFs for nitric acid production in the years 2018-2020 were slightly adjusted.

Table. 4.3.2. Changes of GHG emission values in 2.B. subcategory as a result of recalculations

Change	2013	2014	2015	2016	2017	2018	2019	2020
N₂O								
kt	0.000	0.000	0.000	0.000	0.000	-0.006	-0.005	-0.001
%	0.00	0.00	0.00	0.00	0.00	-0.31	-0.28	-0.07

4.3.6. Source-specific planned improvements

No improvements are planned at the moment.

4.4. Metal industry (CRF sector 2.C)

4.4.1. Source category description

Estimation of emissions in 2.C *Metal industry* are carried out in sub-categories listed below:

1. *Iron and steel production* (2.C.1):
 - a. *Steel* (2.C.1.a),
 - b. *Pig iron* (2.C.1.b),
 - c. *Direct reduced iron* (2.C.1.c),
 - d. *Sinter* (2.C.1.d),
 - e. *Pellet* (2.C.1.e),
 - f. *Other* (2.C.1.f).
2. *Ferroalloys production* (2.C.2);
3. *Aluminium production* (2.C.3);
4. *Magnesium production* (2.C.4);
5. *Lead production* (2.C.5);
6. *Zinc production* (2.C.6);
7. *Other* (2.C.7).

Subsector 2.C.1 *Iron and steel Production* is by far the largest contributor to emissions from this category (see figure 4.4.1) – over 75.6% in 2021.

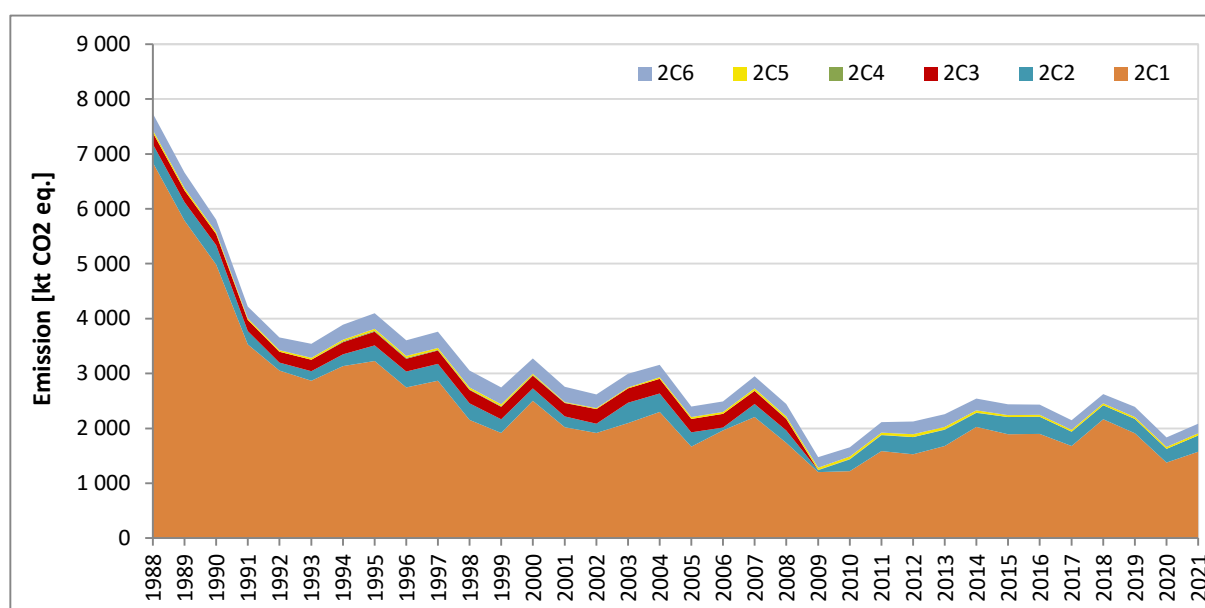


Figure 4.4.1. Emissions from *Metal industry* sector in years 1988-2021 according to subcategories

4.4.2. Methodological issues

4.4.2.1. Iron and steel production (CRF sector 2.C.1)

4.4.2.1.a. Steel (CRF sector 2.C.1.a)

Basic oxygen furnace steel production

Amount of CO₂ process emission from steel production in basic oxygen furnace was estimated based on the carbon balance in converter process (table 4.4.1). For the years 1988-2006 the Polish Steel Association (HIPH) study [HIPH 2007] was the main source of data for C balance purpose. The HIPH data was supplemented for the years 1988-2004 with the information from questionnaires collected by the National Centre for Emissions Management (KOBiZE) for installations covered by EU ETS and starting from 2005 with the data from verified reports concerning CO₂ emission, prepared as part of EU ETS. Based on mentioned verified reports, C balances for basic oxygen steel plants were prepared for the years not included in the HIPH study, it means for the period 2007-2021. Steel production amounts applied in the C balance were in accordance with data published in yearbook GUS [2005b-2022b].

Table 4.4.1. Carbon balance for steel production in basic oxygen process in years 1988-2021

	1988	1989	1990	1991	1992	1993	1994	1995	1996
CHARGE									
Pig iron [t]	6 437 194	6 274 714	6 212 430	4 835 755	5 279 309	5 205 226	5 873 001	6 440 439	5 669 525
Scrap [t]	1 895 954	1 841 725	1 840 367	1 468 313	1 595 404	1 573 016	1 796 072	1 962 554	1 725 579
Carbon pick-up agent [t]	0	0	0	0	0	0	0	0	0
Ferroalloys [t]	61 135	58 311	57 193	45 416	48 066	46 278	53 217	57 027	51 883
Dolomite [t]	187 960	182 054	189 020	144 459	155 741	144 853	163 776	177 073	156 867
Technological indicator [t/t of steel]									
Pig iron	0.867	0.870	0.862	0.841	0.845	0.845	0.835	0.838	0.839
Scrap	0.2554	0.2554	0.2554	0.2554	0.2554	0.2554	0.2554	0.2554	0.2554
Carbon pick-up agent	0	0	0	0	0	0	0	0	0
Ferroalloys	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.007	0.008
Dolomite	0.025	0.025	0.026	0.025	0.025	0.024	0.023	0.023	0.023
Material-specific carbon content									
Pig iron [t C/t]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Scrap [t C/t]	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Carbon pick-up agent [t C/TJ]	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Ferroalloys [t C/t]	0.033	0.033	0.033	0.033	0.032	0.033	0.033	0.033	0.032
Dolomite [t C/t]	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
Carbon contents in charge components [t C]									
Pig iron	257 488	250 989	248 497	193 430	211 172	208 209	234 920	257 618	226 781
Steel scrap	7 584	7 367	7 361	5 873	6 382	6 292	7 184	7 850	6 902
Carbon pick-up agent	0	0	0	0	0	0	0	0	0
Ferroalloys	2 019	1 936	1 868	1 481	1 557	1 518	1 741	1 862	1 686
Dolomite	24 435	23 667	24 573	18 780	20 246	18 831	21 291	23 019	20 393
Carbon contents in charge – SUM [t]	291 526	283 959	282 299	219 564	239 357	234 850	265 136	290 349	255 762
OUTPUT									
Steel [t]	7 424 676	7 212 315	7 206 995	5 750 006	6 247 703	6 160 031	7 033 534	7 685 488	6 757 479
Material-specific carbon content									
Steel [t C/t]	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Carbon content in products [t C]									
Steel	29 699	28 849	28 828	23 000	24 991	24 640	28 134	30 742	27 030
Carbon content in products – SUM [t]	29 699	28 849	28 828	23 000	24 991	24 640	28 134	30 742	27 030
C emission from steel production [t]	261 827	255 109	253 471	196 564	214 366	210 210	237 002	259 607	228 732
CO₂ process emission from steel production [kt]	960.033	935.401	929.394	720.734	786.009	770.769	869.006	951.893	838.684
CO₂ EMISSION FACTOR [kg CO₂/t of steel]	129.30	129.69	128.96	125.34	125.81	125.12	123.55	123.86	124.11

Table 4.4.1. Carbon balance (cont.) for steel production in basic oxygen process in years 1988-2021

	1997	1998	1999	2000	2001	2002	2003	2004	2005
CHARGE									
Pig iron [t]	6 311 208	5 233 149	4 640 291	6 491 867	5 440 047	5 296 410	5 629 786	6 304 253	4 538 670
Scrap [t]	1 923 174	1 588 976	1 303 910	1 657 053	1366064.9	1 360 557	1 424 125	1 608 909	1 147 906
Carbon pick-up agent [t]	0	0	0	0	1 201	2 645	4 286	1 689	1 205
Ferroalloys [t]	59 896	50 915	45 285	57 840	50 035	49 610	48 197	57 157	56 566
Dolomite [t]	188 810	157 145	141 317	174 301	156 426	161 404	127 127	162 673	191 374
Technological indicator [t/t of steel]									
Pig iron	0.838	0.841	0.851	1.047	1.070	1.095	1.078	1.088	1.078
Scrap	0.2554	0.2554	0.2391	0.2437	0.2346	0.2346	0.2346	0.2346	0.2346
Carbon pick-up agent	0	0	0	0	0.0002	0.0005	0.0007	0.0002	0.0002
Ferroalloys	0.008	0.008	0.008	0.009	0.009	0.009	0.008	0.008	0.012
Dolomite	0.025	0.025	0.026	0.026	0.027	0.028	0.021	0.024	0.039
Material-specific carbon content									
Pig iron [t C/t]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Scrap [t C/t]	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Carbon pick-up agent [t C/TJ]	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Ferroalloys [t C/t]	0.033	0.033	0.032	0.033	0.032	0.032	0.032	0.033	0.031
Dolomite [t C/t]	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
Carbon contents in charge components [t C]									
Pig iron	252 448	209 326	185 612	259 675	217 602	211 856	225 191	252 170	181 547
Steel scrap	7 693	6 356	5 216	6 628	5 464	5 442	5 696	6 436	4 592
Carbon pick-up agent	0	0	0	0	992	2 184	3 539	1 395	995
Ferroalloys	1 951	1 659	1 466	1 905	1 623	1 598	1 560	1 860	1 779
Dolomite	24 545	20 429	18 371	22 659	20 335	20 983	16 527	21 147	24 879
Carbon contents in charge – SUM [t]	286 637	237 769	210 665	290 867	246 016	242 063	252 514	283 008	213 791
OUTPUT									
Steel [t]	7 531 274	6 222 532	5 452 751	6 799 681	5 822 518	5 799 042	6 069 985	6 857 583	4 892 671
Material-specific carbon content									
Steel [t C/t]	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Carbon content in products [t C]									
Steel	30 125	24 890	21 811	27 199	23 290	23 196	24 280	27 430	19 571
Carbon content in products – SUM [t]	30 125	24 890	21 811	27 199	23 290	23 196	24 280	27 430	19 571
C emission from steel production [t]	256 512	212 879	188 854	263 668	222 726	218 867	228 234	255 578	194 220
CO₂ process emission from steel production [kt]	940.545	780.557	692.464	966.782	816.662	802.513	836.857	937.119	712.141
CO₂ EMISSION FACTOR [kg CO₂/t of steel]	124.89	125.44	126.99	142.18	140.26	138.39	137.87	136.65	145.55

Table 4.4.1. (cont.) Carbon balance for steel production in basic oxygen process in years 1988-2021

	2006	2007	2008	2009	2010	2011	2012	2013	2014
CHARGE									
Pig iron [t]	5 338 401	5 723 961	4 892 172	2 988 979	3 599 854	3 942 754	3 934 606	3 951 192	4 620 431
Scrap [t]	1 352 895	1 414 926	1 105 439	727 586	965 296	1 106 613	912 706	925 533	1 046 608
Carbon pick-up agent [t]	1 036	753	8 270	12 826	16 033	24 905	8 845	9 044	7 874
Ferroalloys [t]	68 765	71 480	65 149	40 273	53 926	59 738	53 477	57 253	66 718
Dolomite [t]	35 776	37 149	18 930	10 786	16 375	14 220	15 560	20 627	15 305
Technological indicator [t/t of steel]									
Pig iron	1.080	0.924	0.936	0.924	0.901	0.891	0.908	0.874	0.892
Scrap	0.2346	0.228	0.212	0.225	0.242	0.250	0.211	0.205	0.202
Carbon pick-up agent	0.0002	0.000	0.002	0.004	0.004	0.006	0.002	0.002	0.002
Ferroalloys	0.012	0.012	0.012	0.012	0.013	0.014	0.012	0.013	0.013
Dolomite	0.006	0.006	0.004	0.003	0.004	0.003	0.004	0.005	0.003
Material-specific carbon content									
Pig iron [t C/t]	0.04	0.042	0.042	0.043	0.042	0.042	0.043	0.043	0.043
Scrap [t C/t]	0.004	0.003	0.008	0.008	0.009	0.009	0.008	0.008	0.008
Carbon pick-up agent [t C/t]	0.826	0.899	0.820	0.845	0.823	0.806	0.823	0.833	0.853
Ferroalloys [t C/t]	0.029	0.032	0.035	0.035	0.033	0.028	0.031	0.031	0.033
Dolomite [t C/t]	0.130	0.130	0.124	0.125	0.125	0.125	0.126	0.125	0.126
Carbon contents in charge components [t C]									
Pig iron	213 536	239 730	207 333	127 337	150 438	165 971	167 334	168 816	197 002
Steel scrap	5 412	4 297	8 457	5 785	9 109	9 865	7 292	6 999	8 255
Carbon pick-up agent	855	677	6 783	10 839	13 198	20 075	7 277	7 538	6 714
Ferroalloys	2 021	2 288	2 249	1 427	1 761	1 673	1 681	1 769	2 222
Dolomite	4 649	4 829	2 341	1 345	2 047	1 780	1 960	2 586	1 924
Carbon contents in charge – SUM [t]	226 474	251 821	227 163	146 733	176 553	199 365	185 544	187 708	216 117
OUTPUT									
Steel [t]	5 766 375	6 197 910	5 225 075	3 235 666	3 994 650	4 423 604	4 333 168	4 520 358	5 182 371
Material-specific carbon content									
Steel [t C/t]	0.004	0.003	0.008	0.008	0.010	0.009	0.008	0.003	0.002
Carbon content in products [t C]									
Steel	23 066	18 304	41 662	25 760	38 441	40 780	34 990	11 919	8 579
Carbon content in products – SUM [t]	23 066	18 304	41 662	25 760	38 441	40 780	34 990	11 919	8 579
C emission from steel production [t]	203 408	233 516	185 501	120 974	138 111	158 585	150 554	175 789	207 538
CO₂ process emission from steel production [kt]	745.831	856.227	680.171	443.570	506.409	581.478	552.032	644 561	760 973
CO₂ EMISSION FACTOR [kg CO₂/t of steel]	129.34	138.15	130.17	137.09	126.77	131.45	127.40	142.59	146.84

Table 4.4.1. (cont.) Carbon balance for steel production in basic oxygen process in years 1988-2021

	2015	2016	2017	2018	2019	2020	2021
CHARGE							
Pig iron [t]	4 792 153	4 614 066	4 595 349	4 778 052	4 345 972	3 469 081	3 565 671
Scrap [t]	1 023 858	905 766	1 130 517	1 061 825	986 300	760 965	849 048
Carbon pick-up agent [t]	8 414	7 826	8 467	8 531	7 082	7 241	10 828
Ferroalloys [t]	71 598	64 505	76 167	74 275	64 748	52 773	59 714
Dolomite [t]	23 850	17 180	14 368	9 260	5 960	-	-
Technological indicator [t/t of steel]							
Pig iron	0.894	0.897	0.802	0.882	0.880	0.878	0.873
Scrap	0.191	0.176	0.197	0.196	0.200	0.193	0.208
Carbon pick-up agent	0.002	0.002	0.001	0.002	0.001	0.002	0.003
Ferroalloys	0.013	0.013	0.013	0.014	0.013	0.013	0.015
Dolomite	0.004	0.003	0.003	0.002	0.001	-	-
Material-specific carbon content							
Pig iron [t C/t]	0.043	0.042	0.042	0.043	0.043	0.041	0.041
Scrap [t C/t]	0.008	0.002	0.002	0.002	0.002	0.002	0.003
Carbon pick-up agent [t C/t]	0.859	0.872	0.872	0.865	0.875	0.864	0.873
Ferroalloys [t C/t]	0.029	0.027	0.028	0.027	0.028	0.023	0.023
Dolomite [t C/t]	0.126	0.125	0.127	0.127	0.127	-	-
Carbon contents in charge components [t C]							
Pig iron	203 829	194 579	193 994	206 006	185 957	141 885	145 836
Steel scrap	7 966	1 814	2 049	2 289	1 677	1 656	2 346
Carbon pick-up agent	7 229	6 824	7 379	7 381	6 196	6 255	9 457
Ferroalloys	2 067	1 766	2 150	1 971	1 811	1 220	1 399
Dolomite	3 003	2 152	1 821	1 175	756	-	-
Carbon contents in charge – SUM [t]	224 094	207 135	207 392	218 822	185 957	151 016	159 039
OUTPUT							
Steel [t]	5 358 991	5 145 076	5 728 091	5 418 381	4 937 654	3 950 813	4 083 338
Material-specific carbon content							
Steel [t C/t]	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Carbon content in products [t C]							
Steel	8 860	8 238	9 261	9 184	7 673	7 380	7 969
Carbon content in products – SUM [t]	8 860	8 238	9 261	9 184	7 673	7 380	7 969
C emission from steel production [t]	261 827	198 897	198 132	209 638	188 724	143 636	151 070
CO₂ process emission from steel production [kt]	789.194	729 290	726 484	768 673	691 988	526 665	553 924
CO₂ EMISSION FACTOR [kg CO₂/t of steel]	147.27	141.75	126.83	141.86	140.15	133.31	135.65

Electric furnace steel production

Process emissions of CO₂ from steel production in electric furnaces for particular years in the period 1988-2006 were estimated based on the data from Polish Steel Association study [HIPH 2007]. For the last years information from verified reports, prepared as part of EU ETS, was applied for emission calculation. Steel production amounts was taken from Statistics Poland yearbook [GUS 2008b-2022b]. Results of CO₂ emission estimation, AD and emission factors applied for calculation are presented in the table 4.4.2.

Table 4.4.2. Values of steel production in electric furnace [kt] as well as CO₂ emission factors [kg/t of steel] and CO₂ emission [kt] connected with that process for the years 1988-2021

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Production	2572.4	2264.3	2308.6	1950.9	1727.3	2044.2	2368.1	2581.9	2648.4	2906.3
CO ₂ emission factor	34.75	36.94	36.94	36.11	33.21	37.82	36.44	33.05	33.05	33.05
CO ₂ emission	89.38	83.63	85.27	70.45	57.36	77.32	86.29	85.34	87.54	96.07
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Production	3116.9	2825.1	3283.9	2809.1	2561.2	2916.6	3720.9	3443.2	4225.3	4432.8
CO ₂ emission factor	35.83	29.15	44.13	44.10	45.64	41.90	55.10	46.97	48.88	44.76
CO ₂ emission	111.66	82.35	144.91	123.89	116.90	122.20	205.00	161.74	206.53	198.41
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Production	4502.3	3892.8	4001.4	4352.9	4209.3	3679.0	3617.1	3977.5	4015.6	4812.3
CO ₂ emission factor	53.44	52.84	50.70	54.98	52.70	61.26	58.44	52.20	56.21	58.04
CO ₂ emission	240.58	205.68	202.88	239.30	221.84	225.38	211.40	207.63	225.72	279.30
	2018	2019	2020	2021						
Production	4913.9	4184.3	4007.4	4469.2						
CO ₂ emission factor	56.63	57.55	55.13	50.74						
CO ₂ emission	278.28	240.81	220.91	226.78						

Open-hearth furnace steel production

Steel production in open-hearth furnaces was continued up to 2002. CO₂ process emissions from this source was estimated according to case study prepared by the Polish Steel Association (HIPH) [HIPH 2007]. CO₂ emission was calculated based on carbon balance developed for steel production process in mentioned furnaces.

4.4.2.1.b. Pig iron (CRF sector 2.C.1.b)

CO₂ process emission from pig iron production for the years 1988-2021 was estimated based on carbon balance in blast furnace process. Balances for individual years were founded on the statistical data for main components of input and output. Pig iron production values for entire period were accepted according to G-03 questionnaires [GUS 1989e-2022e]. Output of blast furnace gas, input of coke and coal were taken from Eurostat database for the period 1990-2021. For the years 1988-1989 that data came from IEA database [IEA] due to data for mentioned years is not available in Eurostat database. Iron ore sinter consumption was applied in accordance with reports from steel plants. Amounts of other components in BF process were estimated according to technological factors taken from literature [Szargut J. 1983]. These applied coefficients, expressed in tonne per tonne of pig iron produced, were as follows: for dolomite – 0.0845, for limestone – 0.0974, for roasted ore 0.188 and 0.0716 for manganese ore. Carbon contents in components of charge and output were calculated based on C EFs from 2006 IPCC guidelines (for coke, limestone, dolomites) or based on country specific values (data for iron ore comes from [Szargut J. 1983] while for sinter, pig iron and BF gas – from steel plants). Carbon balance for blast furnace process for the years 1988-2021 and estimated emissions for entire period were presented in the table 4.4.3.

Table 4.4.3. Carbon balance for blast furnace process in years 1988-2021

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
CHARGE – amount used in process in given year										
Sinter [kt]	14 107.3	12 992.5	11 779.4	8 612.7	8 621.7	7 628.2	8 787.4	8 646.6	8 318.6	8 980.8
Roasted ore [kt]	1 929.3	1 783.7	1 627.5	1 222.3	1 214.9	1 183.1	1 331.3	1 399.4	1 233.6	1 394.6
Dolomite [kt]	867.2	801.7	731.5	549.4	546.0	531.7	598.4	629.0	554.5	626.8
Limestone [kt]	999.6	924.1	843.2	633.3	629.4	612.9	689.7	725.0	639.1	722.5
Manganese ore [kt]	734.8	679.3	619.8	465.5	462.7	450.6	507.0	533.0	469.8	531.1
Coke [TJ]	186 338	179 462	157 427	107 026	101 994	95 398	110 413	113 883	97 668	103 302
Coking coal [TJ]										
CHARGE – C content										
Sinter [kg/kg]	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Roasted ore [kg/kg]	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113
Dolomite [kg/kg]	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300
Limestone [kg/kg]	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200
Manganese ore [kg/kg]	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262
Coke [kg/GJ]	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
Coking coal [kg/GJ]										
CHARGE – total C content [kt]										
Sinter	17.1	15.8	14.2	10.3	10.3	9.2	10.5	10.3	9.9	10.7
Roasted ore	21.7	20.1	18.3	13.8	13.7	13.3	15.0	15.8	13.9	15.7
Dolomite	112.7	104.2	95.1	71.4	71.0	69.1	77.8	81.8	72.1	81.5
Limestone	119.9	110.9	101.2	76.0	75.5	73.6	82.8	87.0	76.7	86.7
Manganese ore	19.2	17.8	16.2	12.2	12.1	11.8	13.3	13.9	12.3	13.9
Coke	5 441.1	5 240.3	4 596.9	3 125.2	2 978.2	2 785.6	3 224.1	3 325.4	2 851.9	3 016.4
Coking coal										
C IN CHARGE – SUM	5 731.8	5 509.0	4 841.8	3 308.8	3 160.8	2 962.6	3 423.4	3 534.2	3 036.8	3 224.9
OUTPUT IN GIVEN YEAR										
Pig iron [kt]	10 262.4	9 487.6	8 656.7	6 501.5	6 462.0	6 292.9	7 081.2	7 443.5	6 561.9	7 418.0
Blast furnace gas [TJ]	74 521	71 771	62 970	42 811	40 802	38 157	44 162	45 545	39 062	41 319
OUTPUT – C content										
Pig iron [kg/kg]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Blast furnace gas [kg/GJ]	66.88	66.88	66.88	66.88	66.88	66.88	66.88	66.88	66.88	66.88
OUTPUT – total C content [kt]										
Pig iron	410.5	379.5	346.3	260.1	258.5	251.7	283.2	297.7	262.5	296.7
Blast furnace gas	4 983.7	4 799.8	4 211.2	2 863.0	2 728.7	2 551.8	2 953.4	3 045.9	2 612.3	2 763.3
C IN OUTPUT – SUM	5 394.2	5 179.3	4 557.5	3 123.1	2 987.2	2 803.5	3 236.6	3 343.6	2 874.8	3 060.0
DIFFERENCE BETWEEN C IN INPUT and C IN OUTPUT [kt]	337.6	329.8	284.4	185.7	173.7	159.1	186.8	190.6	162.0	165.0
CO₂ EMISSION [kt]	1 238	1 209	1 043	681	637	583	685	699	594	605
CO₂ EMISSION FACTOR [kg/t]	121	127	120	105	99	93	97	94	91	82

Table 4.4.3. (cont.) Carbon balance for blast furnace process in years 1988-2021

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CHARGE – amount used in process in given year										
Sinter [kt]	6 882.1	6 475.9	8 078.7	7 352.8	7 616.9	7 732.2	8 590.6	6 168.4	6 907.8	6 954.0
Roasted ore [kt]	1 180.5	993.1	1 223.0	1 023.3	995.7	1 061.4	1 208.3	841.6	1 042.1	1 091.2
Dolomite [kt]	530.6	446.4	549.7	459.9	447.5	477.1	543.1	378.3	468.4	490.5
Limestone [kt]	611.6	514.5	633.6	530.1	515.9	549.9	626.0	436.0	539.9	565.4
Manganese ore [kt]	449.6	378.2	465.8	389.7	379.2	404.2	460.2	320.5	396.9	415.6
Coke [TJ]	85 714	70 451	92 631	79 764	71 875	77 676	84 581	58 619	72 356	86 571
Coking coal [TJ]										
CHARGE – C content										
Sinter [kg/kg]	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Roasted ore [kg/kg]	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113
Dolomite [kg/kg]	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300
Limestone [kg/kg]	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200
Manganese ore [kg/kg]	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262
Coke [kg/ GJ]	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
Coking coal [kg/GJ]										
CHARGE – total C content [kt]										
Sinter	8.1	7.7	9.5	8.7	9.0	9.1	10.2	7.3	9.0	8.5
Roasted ore	13.3	11.2	13.8	11.5	11.2	12.0	13.6	9.5	11.7	12.3
Dolomite	69.0	58.0	71.5	59.8	58.2	62.0	70.6	49.2	60.9	63.8
Limestone	73.4	61.7	76.0	63.6	61.9	66.0	75.1	52.3	64.8	67.8
Manganese ore	11.8	9.9	12.2	10.2	9.9	10.6	12.0	8.4	10.4	10.9
Coke	2 502.8	2 057.2	2 704.8	2 329.1	2 098.7	2 268.1	2 469.8	1 711.7	2 112.8	2 527.9
Coking coal										
C IN CHARGE – SUM	2 678.4	2 205.7	2 887.8	2 482.9	2 248.9	2 427.8	2 651.3	1 838.4	2 269.6	2 691.2
OUTPUT IN GIVEN YEAR										
Pig iron [kt]	6 279.4	5 282.3	6 505.3	5 442.8	5 296.4	5 645.9	6 426.9	4 481.2	5 543.4	5 804.4
Blast furnace gas [TJ]	34 289	28 179	37 053	31 904	28 752	31 031	33 836	23 446	28 948	34 626
OUTPUT – C content										
Pig iron [kg/kg]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Blast furnace gas [kg/GJ]	66.88	66.88	66.88	66.88	66.88	66.88	66.88	66.88	66.88	66.88
OUTPUT – total C content [kt]										
Pig iron	251.2	211.3	260.2	217.7	211.9	225.8	257.1	179.2	221.7	232.2
Blast furnace gas	2 293.1	1 884.5	2 478.0	2 133.6	1 922.8	2 075.2	2 262.8	1 568.0	1 935.9	2 315.7
C IN OUTPUT – SUM	2 544.3	2 095.8	2 738.2	2 351.3	2 134.7	2 301.1	2 519.9	1 747.2	2 157.7	2 547.8
DIFFERENCE BETWEEN C IN INPUT and C IN OUTPUT [kt]	134.1	109.9	149.6	131.6	114.3	126.7	131.4	91.2	111.9	143.3
CO₂ EMISSION [kt]	492	403	549	482	419	465	482	335	410	526
CO₂ EMISSION FACTOR [kg/t]	78	76	84	89	79	82	75	75	74	91

Table 4.4.3. (cont.) Carbon balance for blast furnace process in years: 1988-2021

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CHARGE – amount used in process in given year										
Sinter [kt]	6 306	4 356.4	5 801.5	6 465.5	6 539.3	6 615.6	7 264.6	7 270.5	6 641.7	6 897.6
Roasted ore [kt]	927.6	560.9	683.9	747.3	741.0	754.2	871.8	1 056.7	878.7	977.4
Dolomite [kt]	416.9	252.1	307.4	335.9	333.1	339.0	391.9	475.0	394.9	439.3
Limestone [kt]	480.6	290.6	354.3	387.2	383.9	390.8	451.7	547.5	455.2	506.4
Manganese ore [kt]	353.3	213.6	260.5	284.6	282.2	287.3	332.0	402.5	334.6	372.3
Coke [TJ]	71 380	44 020	50 809	52 396	52 150	54 106	63 169	63 840	61 404	61 339
Coking coal [TJ]	0	0	948	2 338	5 980	4 191	5 454	7 992	8 377	10 870
CHARGE – C content										
Sinter [kg/kg]	0.0012	0.0016	0.0016	0.0017	0.0014	0.0012	0.0013	0.0013	0.0014	0.0014
Roasted ore [kg/kg]	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113
Dolomite [kg/kg]	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300
Limestone [kg/kg]	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200
Manganese ore [kg/kg]	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262
Coke [kg/ GJ]	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
Coking coal [kg/GJ]			26.02	26.03	25.97	26.01	26.02	26.02	26.02	26.01
CHARGE – total C content [kt]										
Sinter	7.6	7.1	9.1	11.0	9.1	7.7	9.2	9.7	9.0	9.5
Roasted ore	10.4	6.3	7.7	8.4	8.3	8.5	9.8	11.9	9.9	11.0
Dolomite	54.2	32.8	40.0	43.7	43.3	44.1	50.9	61.7	51.3	57.1
Limestone	57.7	34.9	42.5	46.5	46.1	46.9	54.2	65.7	54.6	60.8
Manganese ore	9.2	5.6	6.8	7.4	7.4	7.5	8.7	10.5	8.8	9.7
Coke	2 084.3	1 285.4	1 483.6	1 530.0	1 522.8	1 579.9	1 844.5	1 864.1	1 793.0	1 791.1
Coking coal			24.7	60.9	155.3	109.0	141.9	207.9	217.9	282.8
C IN CHARGE – SUM	2 223.4	1 372.1	1 614.4	1 707.8	1 792.3	1 803.6	2 119.2	2 231.6	2 144.6	2 222.0
OUTPUT IN GIVEN YEAR										
Pig iron [kt]	4 933.8	2 983.5	3 638.0	3 974.9	3 941.4	4 012.0	4 637.5	5 620.8	4 673.7	5 199.0
Blast furnace gas [TJ]	28 551	17 610	22 022	22 271	22 684	22 530	25 802	26 470	25 158	27 164
OUTPUT – C content										
Pig iron [kg/kg]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Blast furnace gas [kg/GJ]	68.37	67.85	65.67	65.51	66.97	67.12	67.31	69.90	70.58	70.20
OUTPUT – total C content [kt]										
Pig iron	209.1	127.1	152.0	167.3	167.6	171.4	197.7	239.1	197.1	219.5
Blast furnace gas	1 952.2	1 194.8	1 446.3	1 459.1	1 519.2	1 512.2	1 736.7	1 850.3	1 775.7	1 906.9
C IN OUTPUT – SUM	2 161.3	1 321.9	1 598.3	1 626.4	1 686.8	1 683.6	1 934.4	2 089.4	1 972.8	2 126.4
DIFFERENCE BETWEEN C IN INPUT and C IN OUTPUT [kt]	62.2	50.2	16.1	81.4	105.5	120.0	184.8	142.3	171.8	95.6
CO₂ EMISSION [kt]	228	184	59	299	387	440	678	522	630	351
CO₂ EMISSION FACTOR [kg/t]	46	62	16	75	98	110	146	93	135	67

Table 4.4.3. (cont.) Carbon balance for blast furnace process in years: 1988-2021

	2018	2019	2020	2021
CHARGE – amount used in process in given year				
Sinter [kt]	6 256.6	6 076.4	4 797.4	4 993.4
Roasted ore [kt]	900.1	797.5	652.3	674.3
Dolomite [kt]	404.6	42.4	104.1	101.2
Limestone [kt]	466.3	0.0	0.0	0.0
Manganese ore [kt]	342.8	303.7	248.4	256.8
Coke [TJ]	62 615	59 263	45 850	48 682
Coking coal [TJ]	8 990	11 036	7 873	7 244
CHARGE – C content				
Sinter [kg/kg]	0.0015	0.0015	0.0015	0.0014
Roasted ore [kg/kg]	0.0113	0.0113	0.0113	0.0113
Dolomite [kg/kg]	0.1300	0.1300	0.1300	0.1300
Limestone [kg/kg]	0.1200	0.1200	0.1200	0.1200
Manganese ore [kg/kg]	0.0262	0.0262	0.0262	0.0262
Coke [kg/GJ]	29.2	29.2	29.2	29.2
Coking coal [kg/GJ]	26.02	26.02	26.02	26.02
CHARGE – total C content [kt]				
Sinter	9.5	8.9	7.3	7.2
Roasted ore	10.1	9.0	7.3	7.6
Dolomite	52.6	5.5	13.5	13.1
Limestone	56.0	0.0	0.0	0.0
Manganese ore	9.0	7.9	6.5	6.7
Coke	1 828.4	1 730.5	1 338.8	1 421.5
Coking coal	233.9	287.1	204.8	188.5
C IN CHARGE – SUM	2 199.4	2 048.9	1 578.3	1 644.6
OUTPUT IN GIVEN YEAR				
Pig iron [kt]	4 787.7	4 241.9	3 469.8	3 586.9
Blast furnace gas [TJ]	26 377	24 327	19 443	20 336
OUTPUT – C content				
Pig iron [kg/kg]	0.04	0.04	0.04	0.04
Blast furnace gas [kg/GJ]	67.81	69.43	67.47	66.88
OUTPUT – total C content [kt]				
Pig iron	206.4	181.5	141.9	146.7
Blast furnace gas	1 788.6	1 688.9	1 311.7	1 360.1
C IN OUTPUT – SUM	1 995.0	1 870.4	1 453.6	1 506.9
DIFFERENCE BETWEEN C IN INPUT and C IN OUTPUT [kt]	204.4	178.5	124.7	137.8
CO₂ EMISSION [kt]	749	655	457	505
CO₂ EMISSION FACTOR [kg/t]	157	154	132	141

4.4.2.1.c. Direct reduced iron (CRF sector 2.C.1.c)

Direct reduced iron has not been produced in Poland (information confirmed by Polish Steel Association (HIPH)).

4.4.2.1.d. Sinter (2.C.1.d)

Estimation of carbon dioxide process emissions from iron ore sinter production for 2021 was based on the data from the EU ETS verified reports on annual emissions of CO₂ from iron ore sinter installations [KOBIZE 2022]. Sinter production (not published from 2000 in statistical materials) and data needed for estimation of country specific CO₂ EFs (i.a. amounts of components in input and output of the sintering process) were accepted according to mentioned EU ETS reports as well. Emissions for 2005-2020 were also estimated in accordance with EU ETS reports while for the years 1988-2004 according to data from questionnaires obtained by the National Centre for Emissions Management from installations entering the EU ETS [KOBIZE 2022]. The values of iron ore sinter production (AD), CO₂ EFs and CO₂ emissions were presented in the table 4.4.1. AD sources were as follows: G-03 reports for 1988-2000 [GUS 1989e-2002e], questionnaires from EU ETS installations collected by National Centre for Emissions Management for 2001-2004 and EU ETS verified reports for the years starting from 2005 [KOBIZE 2022].

For the entire period 1988-2021 emissions of CH₄ were also estimated from iron ore sinter production. The default emission factor for CH₄ (0.07 kg/t), was taken from tab. 4.2., 2006 GLs [IPCC 2006].

Table 4.4.4. Iron ore sinter production [kt], CO₂ emission factors [kg/t of sinter] and CO₂ emission values from sinter production in the years 1988-2021 [kt]

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Production	14107.3	12992.5	11779.4	8612.7	8621.7	7628.2	8787.4	8646.6	8318.6	8980.8
CO ₂ emission factor	78.05	56.72	71.41	79.08	72.97	75.70	73.10	79.77	79.81	74.89
CO ₂ emission	1101.14	736.98	841.16	681.13	629.08	577.45	642.35	689.76	663.94	672.58
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Production	6882.1	6475.9	8078.7	7352.8	7616.9	7732.2	8590.6	6168.4	6907.8	6954.0
CO ₂ emission factor	73.55	83.21	79.00	72.36	73.92	85.08	76.79	72.59	84.59	88.28
CO ₂ emission	506.20	538.89	638.21	532.01	563.07	657.86	659.70	447.73	584.31	613.91
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Production	6306.4	4362.6	5837.3	6512.8	6672.5	6854.2	7389.4	7429.9	6850.5	6992.2
CO ₂ emission factor	91.11	82.25	75.77	69.29	52.63	51.86	49.10	48.09	44.00	43.82
CO ₂ emission	574.59	358.80	442.32	451.29	351.14	355.48	362.79	357.28	301.43	306.40
	2018	2019	2020	2021						
Production	6738.5	6468.0	4890.0	5021.0						
CO ₂ emission factor	52.72	47.90	33.49	55.83						
CO ₂ emission	355.28	309.82	163.77	280.34						

4.4.2.1.e. Pellet (2.C.1.e)

Pellets have not been produced in Poland (information confirmed by Institute of Ferrous Metallurgy and by Polish Steel Association).

4.4.2.2. Ferroalloys production (CRF sector 2.C.2)

Emission of CO₂ concerning ferroalloys production was estimated based on annual ferrosilicon production taken from [GUS 2022b]. Applied emission factor of 4000 kg CO₂/t ferrosilicon, was taken from [IPCC 2006] – tab. 4.5 for ferrosilicon – 75% Si.

CH₄ emission was estimated based on emission factors from [IPCC 2006] – tab. 4.7 which is equal 1 kg CH₄/t ferrosilicon – 75% Si. In the period 1988-2021 CO₂ and CH₄ process emission from ferroalloys production was estimated also based on annual ferrosilicon production taken from [GUS 1989b-2022b] (figure 4.4.2) and emission factors as in 2021.

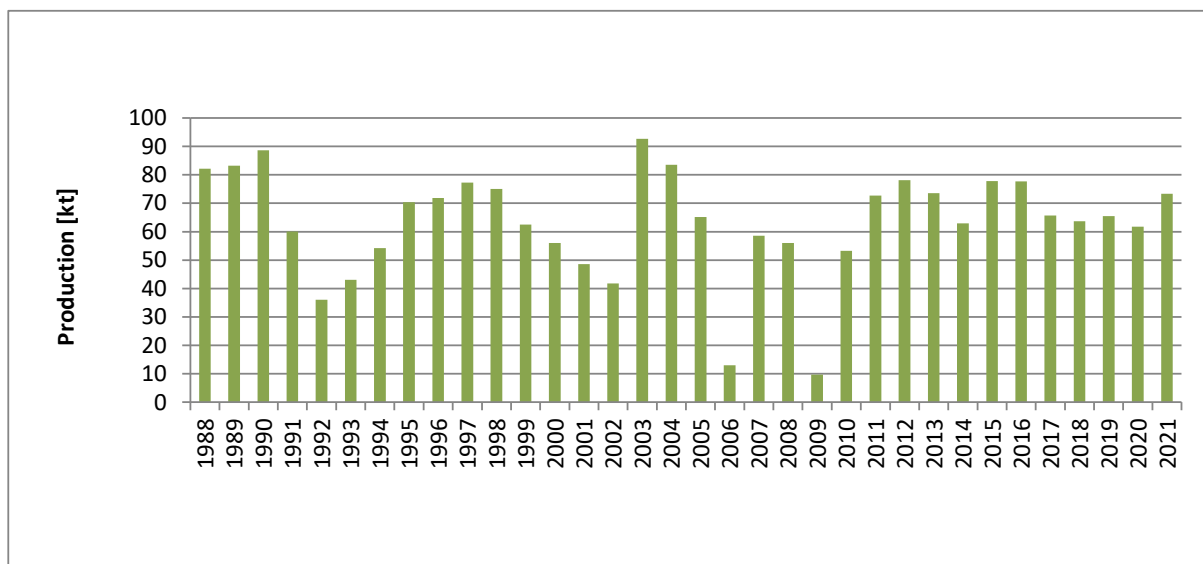


Figure 4.4.2. Production of ferrosilicon in 1988-2021

Coal consumption in ferroalloys production is submitted in national energy statistics as non-energy use of fuel. This means that coal consumed as reducer in mentioned process is not included in energy consumption of coal in 1.A.2 subsector, so double counting is avoided.

4.4.2.3. Aluminium production (CRF sector 2.C.3)

CO₂ emission from aluminium production was estimated for years 1988-2008 based on annual production amounts taken from [GUS 1989b-2009b]. Starting from 2009 primary aluminium is no longer produced in Poland.

The emission factor amounting to 1.7 t CO₂/t primary aluminium was applied in order to estimate CO₂ emission for entire period 1988-2008. Mentioned CO₂ EF is given in tab. 4.10. of 2006 IPCC GLs [IPCC 2006] as the value recommended for Soderberg process.

Emission of PFC gases from aluminium production is described in chapter 4.7.2.

4.4.2.4. Magnesium production (CRF sector 2.C.4)

Emission from use of SF₆ in magnesium foundries is described in chapter 4.7.2.

4.4.2.5. Lead production (CRF sector 2.C.5)

Process emissions of CO₂ from lead production for the years 1988-2021 were estimated based on annual lead productions taken from GUS yearbooks [GUS 1989b-2022b]. The default emission factor of 0.52 t CO₂/t lead produced, taken from the table 4.21 of 2006 GLs [IPCC 2006], was applied for the entire period.

The trend of process emissions from lead production is given in figure 4.4.3.

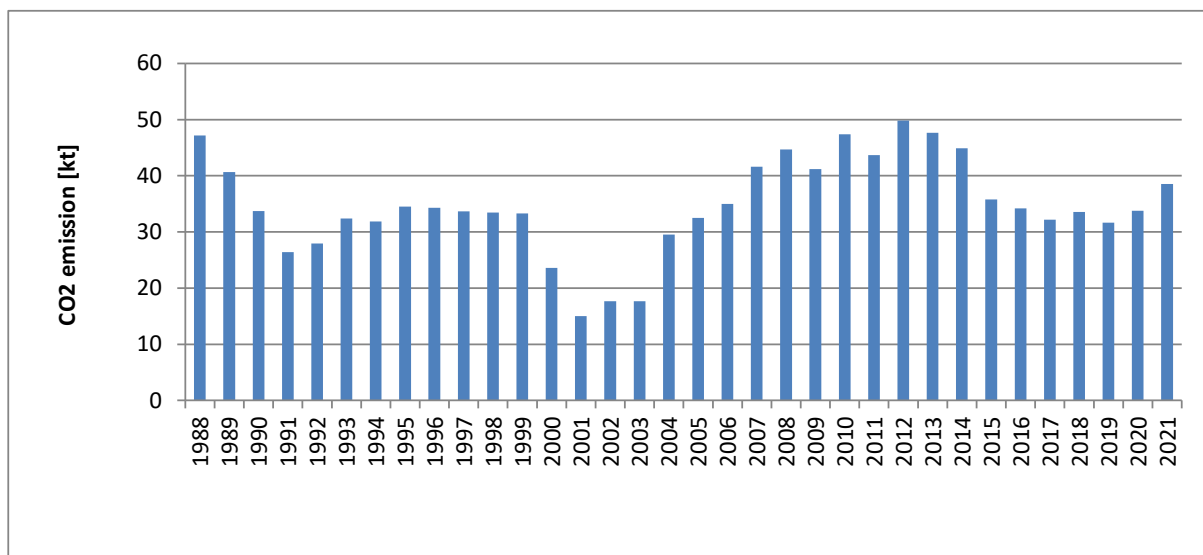


Figure 4.4.3. CO₂ process emission for lead production in 1988-2021

4.4.2.6. Zinc production (CRF sector 2.C.6)

CO₂ process emission from zinc production for the years 1988-2021 was estimated based on annual zinc production taken from GUS yearbooks [GUS 1989b-2022b]. The default emission factor amounting to 1.72 t CO₂/t zinc was used for entire reporting period. The factor comes from table 4.24 of 2006 GLs [IPCC 2006].

Process emission trend of CO₂ from zinc production is presented in figure 4.4.4.

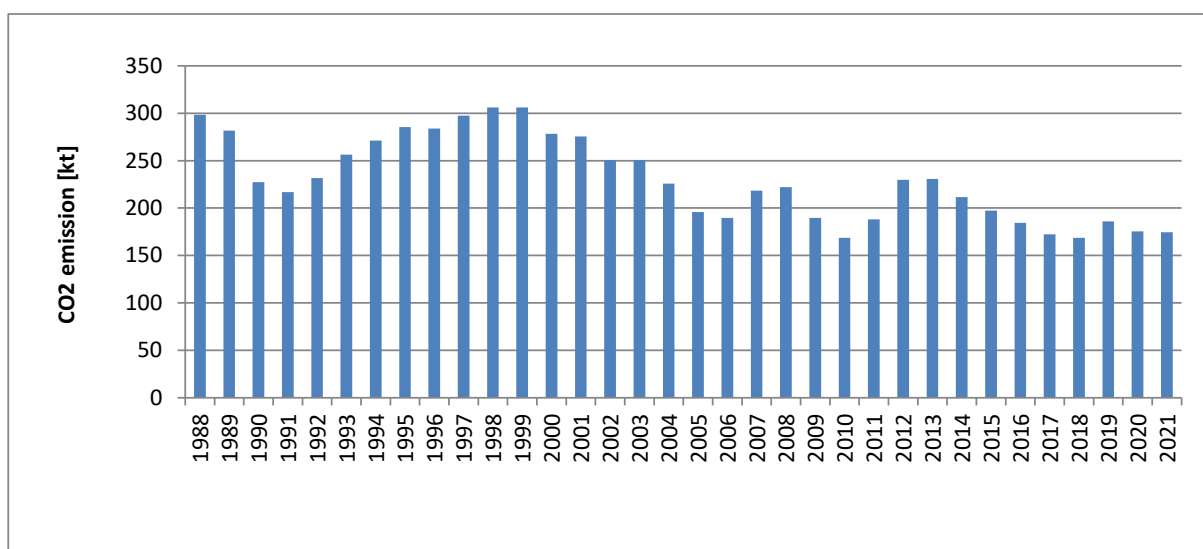


Figure 4.4.4. CO₂ process emission for zinc production in 1988-2021

4.4.3. Uncertainties and time-series consistency

See chapter 4.2.3

4.4.4. Source-specific QA/QC and verification

See chapter 4.2.4

4.4.5. Source-specific recalculations

No significant changes were introduced in 2.C category. The only insignificant adjustment (by 0.0014 kt CO₂ in emission from pig iron production in blast furnace for 2020) was made.

4.4.6. Source-specific planned improvements

No improvements are planned at the moment.

4.5. Non-energy Product from Fuels and Solvent Use (CRF sector 2.D)

4.5.1. Source category description

Estimation of emissions in 2.D *Non Energy Product from Fuels and Solvent Use* are performed in sub-categories listed below:

- Lubricant use* (2.D.1),
- Paraffin wax use* (2.D.2),
- Other* (2.D.3).

Subsector 2.D.3 *Other* is by far the largest contributor to emissions from this category (see figure 4.4.1) – responsible for about 27.5% in 2021.

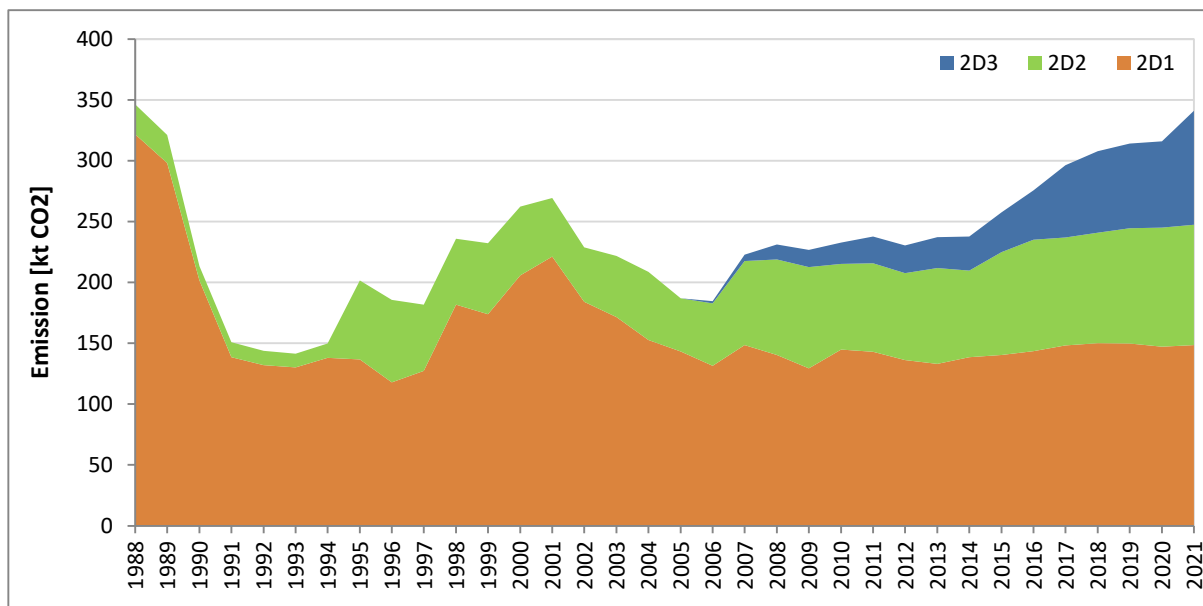


Figure 4.5.1. Emissions from *Non Energy Product from Fuels and Solvent Use* sector in years 1988-2021 according to subcategories

4.5.2. Methodological issues

4.5.2.1. Lubricant use (CRF sector 2.D.1)

This sector covers emissions from lubricants used in industry and transportation. The use of lubricants in engines is primarily for their lubricating properties and associated emissions are therefore considered as non-combustion emissions.

CO₂ emissions concerning non-energy use of lubricants were estimated based on Tier 1 method according to IPCC 2006 guidelines. Calculations were made in accordance with the following formula:

$$CO_2 \text{ emissions} = LC \times CC \times ODU \times 44/12$$

where:

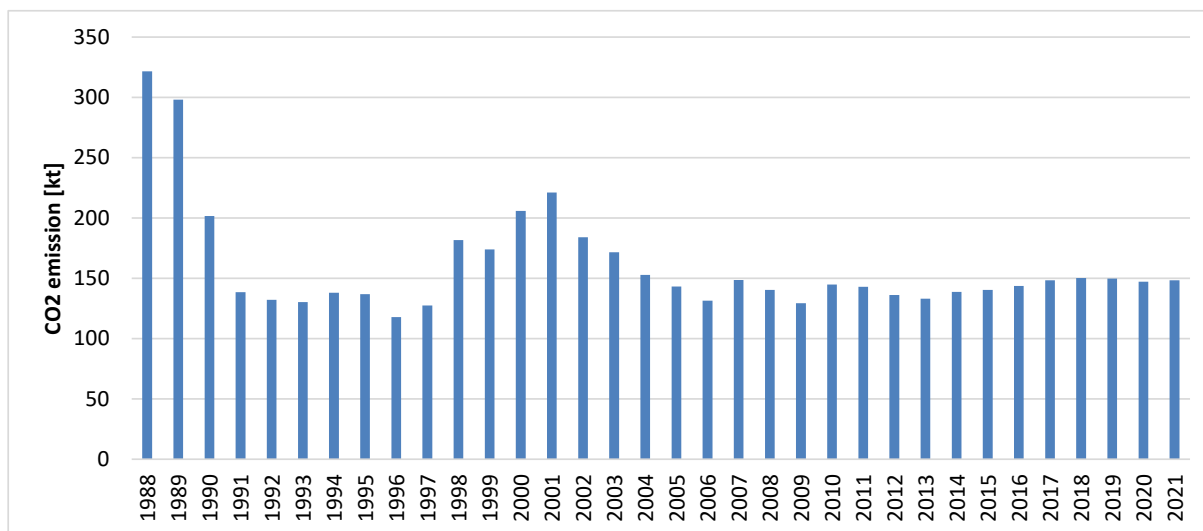
LC – non-energy use of lubricants, TJ

CC – carbon content of lubricants (carbon emission factor), t C/TJ

ODU – oxidised during use factor

44/12 – mass ratio of CO₂/C

Carbon content of lubricants is default value equal 20 t C/TJ. ODU factor for lubricant is country specific and is equal 0.5.

Figure 4.5.2. CO₂ emissions from non-energy use of lubricants in years 1988-2021

4.5.2.2. Paraffin wax use (CRF sector 2.D.2)

Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffins are combusted during use (e.g., candles). CO₂ emissions concerning non-energy use of paraffin wax were estimated based on Tier 1 method according to IPCC 2006 guidelines. Calculations were made in accordance with the following formula:

$$CO_2 \text{ emissions} = PW \times CC \times ODU \times 44/12$$

where:

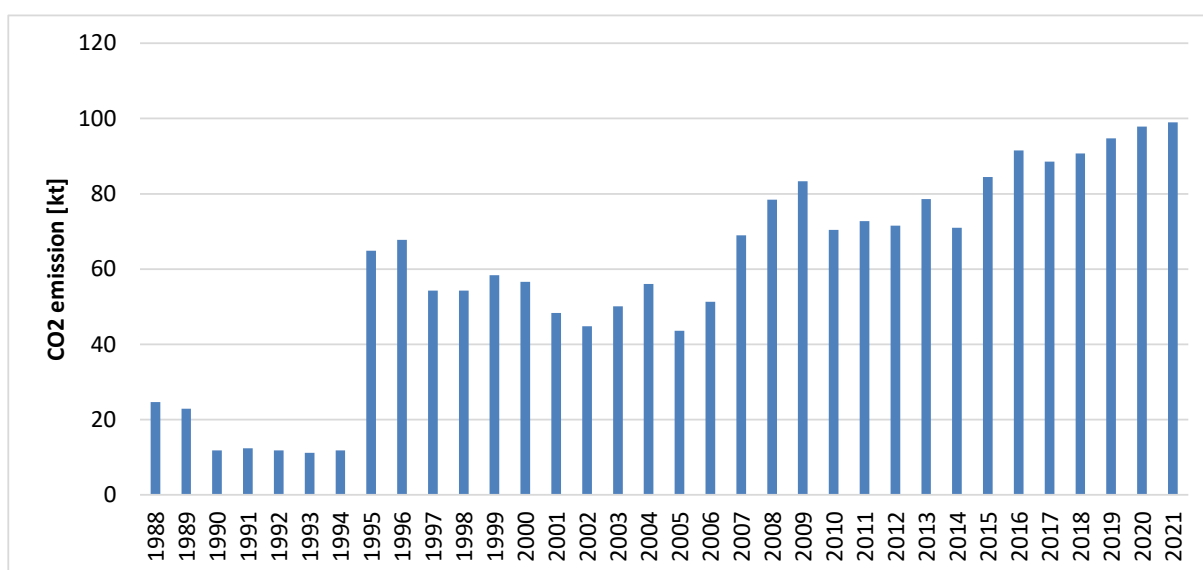
PW – non-energy use of paraffin wax, TJ

CC – carbon content of paraffin wax (carbon emission factor), t C/TJ

ODU – oxidised during use factor

44/12 – mass ratio of CO₂/C

Carbon content of paraffin wax is default value equal 20 t C/TJ. ODU factor for paraffin wax is default value equal 0.2.

Figure 4.5.3. CO₂ emissions from non-energy use of paraffin waxes in years 1988-2021

4.5.2.3. Other (CRF sector 2.D.3)

Category contain emission from solvent use and associated CO₂ emissions concerning non-energy use of fuels.

4.5.2.3.1. Solvent use

There are no sources from sub-category Solvent Use, which are identified as key sources.

The use of solvents is one of the main sources of NMVOC emissions and is associated with following processes:

- Paint application,
- Degreasing and dry cleaning,
- Chemical products, manufacture and processing,
- Other solvents use.

The GHG emission sources in Solvent and Other Product Use sector involve CO₂ emission from the following activities: Paint application, Degreasing and dry cleaning, Chemical Products, Manufacture and Processing and Other solvents use (Fat edible and non-edible oil extraction, Other non-specified).

Emission trend is consistent with the submission to the European Union in the framework of reporting to the Directive 2001/81/EC of European Parliament and the Council of 23 October 2001 on national emission ceilings for certain pollutants the Convention on Long-range Transboundary Air Pollution (LRTAP).

According to the new 2006 IPCC guidelines N₂O emissions from the use of N₂O for anesthesia and in food industry – to make whipped cream) is reported sub-category 2.G.3 (2.G.3.a and 2.G.3.b).

Total emission of GHG in this sector in 2021 was estimated to 500 kt CO₂. This emission decreased by 19.87% from year 1988 to 2021 (Figure 4.5.4 and 4.5.5).

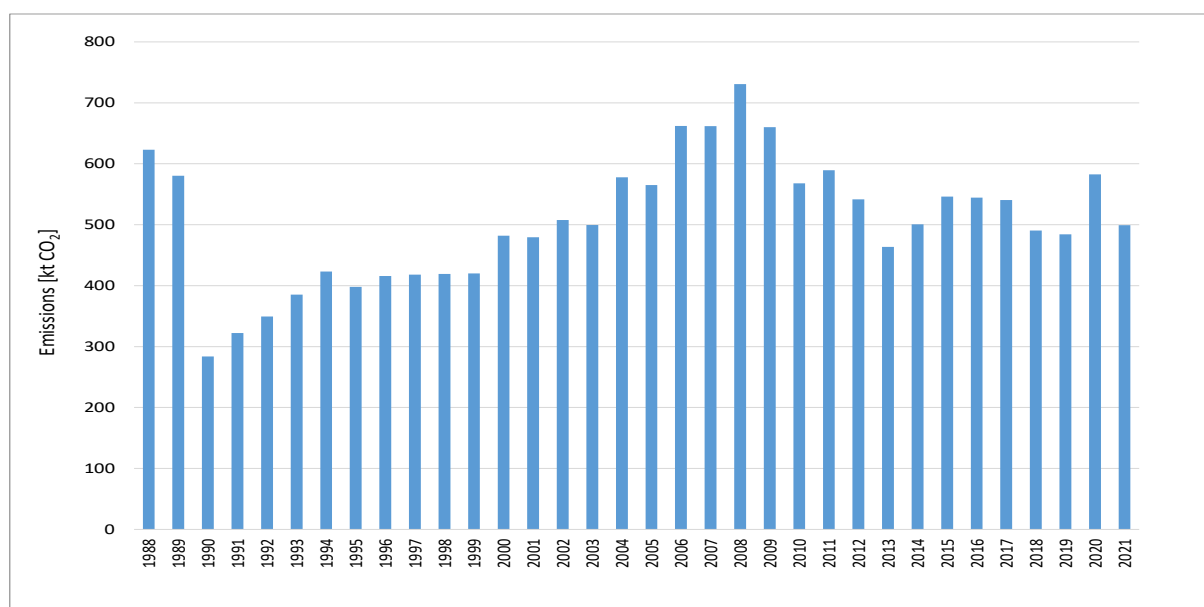


Figure 4.5.4. GHG emission from Solvent and Other Product Use sector in 1988-2021

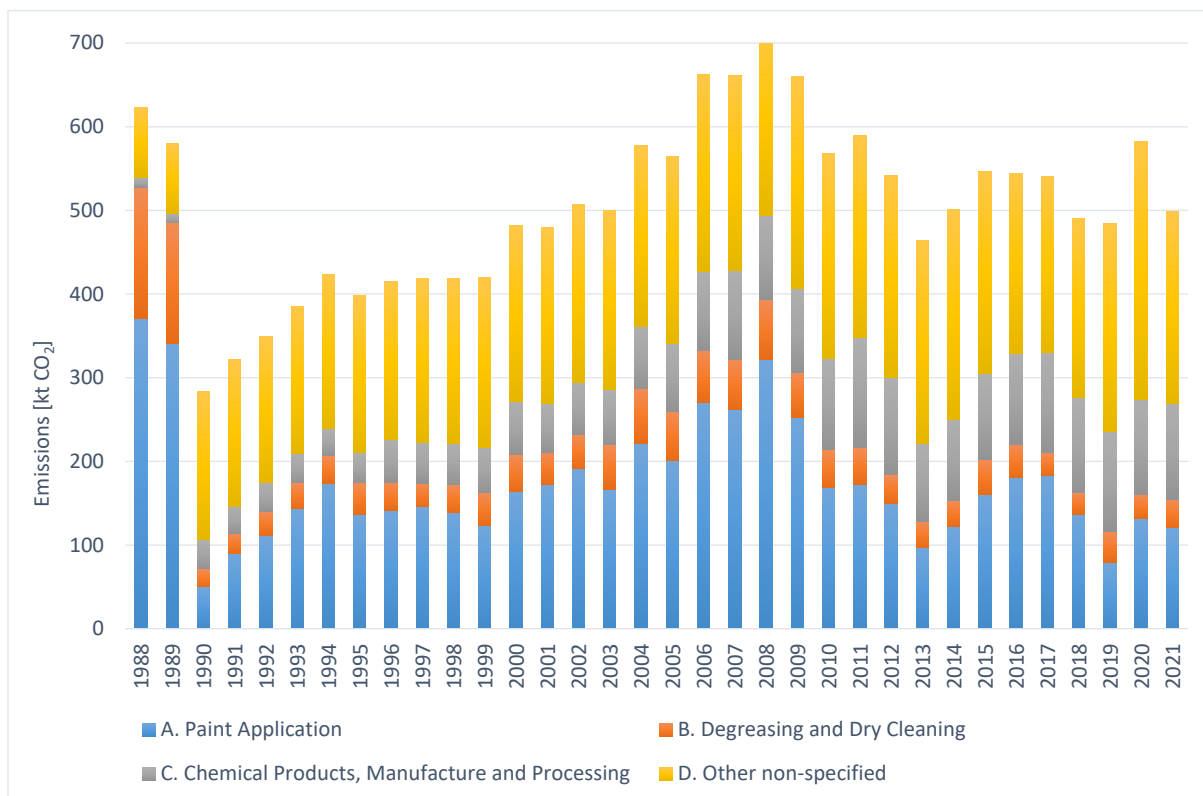


Figure 4.5.5. CO₂ emissions from Solvent and Other Product Use sector in 1988-2021

Calculations of CO₂ emissions within Sector Solvent Use, using the common methodology, were conducted on the basis of results of NMVOC emissions [EMEP 2019]. CO₂ emission factor was determined assuming, that carbon content in NMVOC is 60% [IPCC 2006, chapter 5.5.1., page 5.16.]. Then carbon content has been calculated in a stoichiometric way to CO₂. Calculations were made in accordance with the following formula:

$$\text{CO}_2 = 0.60 * 44/12 * \text{NMVOC}$$

where:

CO₂ – carbon dioxide emission from particular subsectors,
 NMVOC – NMVOC emission from particular subsectors.

Paint application

Paint application includes the following processes:

- cars production,
- car repair,
- use in households,
- coil coating,
- ship building,
- wood painting,
- other applications in industry,
- other non-manufacturing applications.

In the national inventory all of these processes are considered jointly with the division on the use of paints based on organic solvents and water-based paints.

Degreasing and dry cleaning

Degreasing and dry cleaning include:

- degreasing metals,
- chemical cleaning,
- production of electronic components,
- other industrial cleaning processes.

In the Polish national inventory the first two processes were considered. It was assumed that "degreasing metals" include also solvents used for other purposes in industrial processes, which were not included separately in the inventory report for NMVOC (eg., electronic industry, textile, leather, etc.).

Chemical products, manufacture and processing

The national inventory includes emissions from the following processes:

- polyvinylchloride processing,
- polystyrene foam processing,
- rubber processing,
- pharmaceutical products manufacturing,
- paints manufacturing,
- asphalt blowing.

Other solvents use

The category "Other use of solvents" includes following processes:

- solvents in the household use (except paint),
- oil extraction (production of fats and oils),
- printing industries,
- use of glues and adhesives.

4.5.2.3.2. CO₂ emissions from urea based catalyst

For estimating CO₂ emissions from urea-based catalyst additives in catalytic converters model COPERT 5 was used. The model assumed that consumption of urea is equal share of fuel consumption. For diesel passenger cars Euro 6/VI the consumption of urea is equal 2% of fuel consumption, the selective catalytic reduction (SCR) ratio being equal to 10%; for diesel heavy duty trucks and buses, the consumption of urea is assumed to be equal 6% of fuel consumption at Euro IV and V level (SCR ratio = 76.2%) and equal 3.5% at Euro VI level (SCR ratio = 100%). The purity (the mass fraction of urea in the urea-based additive), the default value of 32.5% has been used (IPCC 2006).

4.5.3. Uncertainties and time-series consistency

See chapter 4.2.3

4.5.4. Source-specific QA/QC and verification

See chapter 4.2.4

Calculations were examined with focus on formulas, units and trends consistency. Generally QC procedures follow QA/QC plan presented in Annex 7.

4.5.5. Source-specific recalculations

Recalculation for the years 1988-2020 was made as a result of:

- revision and updating of historical activities in subcategory Other solvent use. Poland has updated activity for years 1994-2001 for printing processes according to the Industrial Commodity Statistics Database and the Commodity Trade Statistics Database;
- correction of emissions factors in subcategory Degreasing and dry Cleaning starting from 2005. The emissions factors have been obtained from IIASA;
- correction of emissions factors in subcategory Other solvent use. The emissions factors for solvents in the household use was received from ESIG. Also Poland corrected the number of inhabitants according to the official statistical data of Statistics Poland.

In table 4.5.1. are shown emission recalculations for category Solvent Use (2.D.3).

Table 4.5.1. GHG emission recalculations for category Solvent Use

Difference	1988	1989	1990	1991	1992	1993	1994	1995
kt CO ₂ eq.	0.00	0.00	119.57	119.82	120.01	120.13	127.35	127.99
%	0.00	0.00	42.11	37.19	34.34	31.17	30.09	32.17
	1996	1997	1998	1999	2000	2001	2002	2003
kt CO ₂ eq.	130.55	135.24	137.85	141.28	144.75	145.21	120.02	119.94
%	31.41	32.35	32.89	33.65	30.04	30.28	23.64	24.01
	2004	2005	2006	2007	2008	2009	2010	2011
kt CO ₂ eq.	119.90	116.70	115.85	115.48	113.72	115.22	116.81	116.42
%	20.75	20.66	17.50	17.45	15.56	17.46	20.57	19.75
	2012	2013	2014	2015	2016	2017	2018	2019
kt CO ₂ eq.	117.24	120.35	116.76	110.55	82.44	77.61	89.03	119.13
%	21.65	25.96	23.33	20.24	15.14	14.36	18.15	24.60
	2020							
kt CO ₂ eq.	180.59							
%	31.00							

4.5.6. Source-specific planned improvements

Any possible improvements will be related to further development of NMVOCs emissions methodology.

4.6. Electronic industry (CRF sector 2.E)

No sources of f-gases were identified for that sector for whole time series, thus activity data and emission were reported as not occurring.

4.7. Product uses as substitutes for ODS (CRF sector 2.F) and other minor sources of f-gases emissions

4.7.1. Source category description

Data used to estimate emissions in preparation of the greenhouse gas inventories is based on aggregated data collected by operators under Regulation (EC) 517/2014/EU. Use of the same data source for both obligations results in full consistency between datasets. Data consistency checks are performed on yearly basis for the whole reported time series.

In case of refrigeration and air-conditioning equipment containing HFCs, some information concerning e.g. amounts of gas used, are collected by experts among main domestic producers and importers/exporters [Mąkosa 2012, Popławska-Jach 2022].

To assure transparency and completeness of the description in the NIR it was decided to group description of all f-gases emission in this chapter. Methodologies described here were divided into 3 groups referring to the substance: HFCs, PFCs and SF₆.

Besides dominating category in terms of f-gases emission 2.F *Product uses as substitutes for ODS* – this chapter also includes description of **PFC emission** from IPCC category **2.C.3 Aluminium production** described under PFC section below.

This chapter also includes description of **SF₆ emissions** from IPCC categories **2.C.4 Magnesium production** and **2.G.1 Electrical equipment**.

Since submission 2023 f-gases are recalculated to CO₂ equivalent using updated global warming potentials (GWPs) from the IPCC 5th Assessment Report,

4.7.2. Methodological issues

Nitrogen trifluoride (NF₃)

Since 2015 mandatory reporting was extended to include NF₃, which is used in the manufacture of semiconductors, liquid crystal display (LCD) panels and photovoltaics. Other application of NF₃ are hydrogen fluoride and deuterium fluoride lasers.

During preparation of submission 2015 Polish market was investigated to identify potential sources of NF₃ emission. During this process **no activity resulting in NF₃ emission was identified** and all potential sources are not occurring in Poland. During preparation of f-gases inventory for submission 2023 this information was verified and confirmed by information reported by producers and suppliers of f-gases in Poland. Therefore, NF₃ emission from all potential categories was reported as not occurring.

Hydrofluorocarbons (HFC)

The national GHG inventory covers the following emission sources for HFCs:

- 2.F.1 *Refrigeration and air-conditioning equipment* (dominating category in terms of emission volume),
- 2.F.2 *Foam blowing agents*,

- 2.F.3 *Fire protection,*
- 2.F.4 *Aerosols (technical and medical),*
- 2.F.5 *Solvents.*

In response to annual review process NIR structure was updated to include description of reaction to most important issues raised by Expert Review Team. To ensure transparency of compilation process additional information for few selected aspects of f-gases that need clarification were provided below. At the moment of the finalization of this report latest published review report is available for submission 2018.

Party comment on no use of HFC-23 and limited use of HFC-152a (I.5, ARR 2018)

Law restricting use of R508A and 508B blends came into force in Poland on 1 January 2016, however since 2013 was visible that operators are aware that restrictions will be applied to the f-gases market. In scope of forthcoming restrictions and relatively high price of the blends there was no demand on the market for HFC-23 and very limited for HFC-152a. This information was confirmed by users and operators of the blends reporting under EU f-gases regulation. During this verification we confirmed that HFC-23 import or production was never identified in Poland. Import of HFC-152a was identified, but 100% of it was used in closed foam blowing installations. Also during EU review this issue was not identified as problem, despite the fact that at EU level is available border custom information, not available for Member States, allowing to track and identify missing substances.

Party comment on fluctuation of emission trends and increasing activities related to decommissioning of the equipment (I.12, ARR 2018)

Origin of this increase is fact that in year 2000 significant number of passenger cars containing f-gases were imported into the national market, phasing out older equipment without AC. Taking into account that assumed life time of mobile AC equipment is 15 years then this import is reflected in significant relative emission increase for year 2014/2015, when oldest equipment is reaching its life time. Passenger cars fleet was 291 551 cars in 1999 and 537 060 cars in 2000. Such significant change was result of legislation change and opening national market for used cars from western Europe.

Party comment on the 15-year lifetime used for transport refrigeration (I.7, ARR 2018)

Analysis of the available fleet data showed that IPCC default 10 years life time is not accurately reflecting situation in Poland. Due to economic reasons equipment used in transport refrigeration is operating for much longer than 10 years – reaching average 15 years. This effect is based on two main economic drivers – maintenance and repairing of older equipment is significantly cheaper in Poland (and other Eastern European countries) than in Western Europe due to lower work cost and spare part prices.

During review 2018 (Issue I.7, AR 2018) Expert Review Team agreed with Poland confirming that statistical data from the United Nations Economic Commission for Europe demonstrate that the lorry fleet in Poland is older than 10 years.

Party comment on sources for information and assumptions used in HFCs calculations (I.11, ARR 2018)

Main data source of information about f-gases on Polish market are two national f-gases register and aggregated reports available on the basis of data reported by installation operators, distributors and importers of f-gases. Those two national registers are:

- Central Register of Operators, and
- Database of Reports.

Both databases were set up during implementation of EU F-gas regulation in 2017 and contain verified reports of different types.

In case of years from the beginning of the time series there is no direct information on f-gases emission available thus assumptions on percent of refrigeration equipment are based on expert's opinion – which taken into account:

- 1) Information provided in 2006 GLs,
- 2) analysis of the available national data from questionnaires send by installations and operators,
- 3) working knowledge of experts involved in f-gases data collection,
- 4) direct contact with f-gases operators,
- 5) analysis of the parameters applied by other countries with comparable national circumstances (EU members from eastern Europe),
- 6) analysis of phasing out effect and conversion to equipment not containing f-gases due to legislation.

2.F.1 Refrigeration and air-conditioning equipment

For transparency reasons and due to importance of the emissions from the refrigeration and air-conditioning equipment (2.F.1) – the main assumptions for estimates were described with more details below. Amount of f-gases input in each equipment type was given in table 4.7.1 below.

Methodology used for estimates of f-gases is based on IPCC 2006 Guidelines, which is mandatory for submission 2023. Applying new guidelines did not affect estimated emission values directly, because this methodology was used before, however some emissions were allocated differently than in submission 2014 to reflect new classification of categories (electrical equipment, etc).

Table 4.7.1. Amount of input in each equipment type

Equipment type	F-gas input per piece of equipment [kg]
Domestic refrigerators	0.285
Domestic freezers	0.285
Commercial refrigeration (small hermetic MT)	0.24
Commercial refrigeration (small hermetic LT)	0.24
Commercial refrigeration (single condensing units MT)	3.60
Commercial refrigeration (single condensing units LT)	2.70
Commercial refrigeration (large multipack MT)	100.00
Commercial refrigeration (large multipack LT)	50.00
Stationary air-conditioning (small split)	0.90
Stationary air-conditioning (medium split)	2.25
Stationary air-conditioning (large split)	5.60
Stationary air-conditioning (packaged systems)	20.0
Stationary air-conditioning (VRF systems)	25.0
Stationary air-conditioning (small chillers)	30.0
Stationary air-conditioning (medium chillers)	150.0
Stationary air-conditioning (large chillers)	500.0
Passenger cars with air-conditioning	1.20
Public transport	1.50
Trucks	1.50
Trailers	5.50
Wagon, tank, cold rooms	5.50
Cargo railway cars	5.50
Tram cars	5.50
Equipment used for refrigeration	5.50

Estimates of the amount of each gas in selected equipment type assumption on shares of gases (or their mixes) were applied (see table 4.7.2. and 4.7.3 below).

Table 4.7.2. Share of gases and mixes for commercial refrigerators

Gas or mix	Share in market	HFC-125 amount	HFC-134a amount	HFC-143a amount	HFC-32 amount
407c	10	25%	52%	0%	23%
410a	70	50%	0%	0%	50%
HFC-134a	20	0%	100%	0%	0%
Amount of gas applied to estimates		38%	25%	2%	35%

Table 4.7.3. Share of gases and mixes for stationary air-conditioning

Gas or mix	Share in market	HFC-125 amount	HFC-134a amount	HFC-143a amount	HFC-32 amount
404a	30	44%	4%	52%	0
507a	40	50%	0%	50%	0%
HFC-134a	30	0%	100%	0%	0%
Amount of gas applied to estimates		35%	30%	35%	0%

The final assumptions on percent of substances used for refrigeration and air conditioning equipment were shown in tables 4.7.4-4.7.7 below.

Table 4.7.4. Shares of different substances used in air conditioning equipment

Year	Type of AC equipment	HFC-32	HFC-125	HFC-134a
1995	Average systems (due to lack of available data)	0	0	0
1996		0	0	0
1997		0	0	0
1998		0	0	0
1999		0	0	0
2000		29	28	12
2001		29	28	12
2002		32	31	18
2003		35	34	18
2004		35	34	23
2005		35	35	25
2006		35	35	25
2007		35	35	25
2008		35	35	25
2009		38	37	25
2010		38	37	25
2011		38	37	25
2012		38	37	25
2013		38	37	25
2014		38	34	23
2015		38	34	23
2016		38	34	23
2017*	Small split systems	45	29	21
	Medium split systems	45	29	21
	Large split systems	40	29	21
	Packaged Systems	45	29	21
	VRF Systems	45	29	21
	Small Chillers	36	27	21
	Medium Chillers	36	27	21
	Large Chilers	11	5	66
2018*	Small split systems	70	16	7
	Medium split systems	70	16	7
	Large split systems	37	27	19
	Packaged Systems	47	27	19
	VRF Systems	47	27	19
	Small Chillers	26	20	31
	Medium Chillers	26	20	31
	Large Chilers	11	5	66

Year	Type of AC equipment	HFC-32	HFC-125	HFC-134a
2019*	Small split systems	70	16	7
	Medium split systems	70	16	7
	Large split systems	37	27	19
	Packaged Systems	47	27	19
	VRF Systems	47	27	19
	Small Chillers	26	20	31
	Medium Chillers	26	20	31
	Large Chillers	11	5	66
2020*	Small split systems	79	8	6
	Medium split systems	79	8	6
	Large split systems	40	24	19
	Packaged Systems	50	24	19
	VRF Systems	50	24	19
	Small Chillers	29	18	31
	Medium Chillers	29	18	31
	Large Chillers	11	5	66
2021*	Small split systems	70	16	7
	Medium split systems	70	16	7
	Large split systems	40	24	19
	Packaged Systems	50	24	19
	VRF Systems	50	24	19
	Small Chillers	29	18	31
	Medium Chillers	29	18	31
	Large Chillers	11	5	66

*- since 2017 data on equipment split becomes available from installation reports

Table 4.7.5. Shares of different substances used in refrigeration equipment

Year	Type of refrigeration equipment	HFC-143a	HFC-125	HFC-134a	HFC-32
1995	Average systems (due to lack of available data)	0	0	0	0
1996		0	0	0	0
1997		12	11	11	0
1998		12	11	11	0
1999		12	11	11	0
2000		17	16	16	0
2001		17	16	16	0
2002		22	21	21	0
2003		22	21	21	0
2004		28	26	26	0
2005		28	26	26	0
2006		35	33	32	0
2007		35	33	32	0
2008		35	33	32	0
2009		34	32	31	0
2010		34	31	31	0
2011		30	28	30	0
2012		29	27	30	0
2013		28	26	30	0
2014		28	26	29	0
2015		26	24	29	0
2016		25	24	27	1
2017*	Small Hermetic MT	17	16	21	0
	Small Hermetic LT	17	16	21	0
	Single condensing units MT	22	28	33	8
	Single condensing units LT	28	33	18	8
	Large Multipack, MT	22	21	11	0
	Large Multipack, LT	22	27	32	7

Year	Type of refrigeration equipment	HFC-143a	HFC-125	HFC-134a	HFC-32
2018*	Small Hermetic MT	10	9	11	0
	Small Hermetic LT	10	9	11	0
	Single condensing units MT	17	26	35	10
	Single condensing units LT	28	33	18	8
	Large Multipack, MT	17	16	11	0
	Large Multipack, LT	20	27	29	9
2019*	Small Hermetic MT	2	4	6	33
	Small Hermetic LT	2	4	6	33
	Single condensing units MT	10	31	18	33
	Single condensing units LT	7	32	13	36
	Large Multipack, MT	5	14	11	10
	Large Multipack, LT	5	28	34	24
2020*	Small Hermetic MT	0	0	5	0
	Small Hermetic LT	0	0	5	0
	Single condensing units MT	0	20	19	21
	Single condensing units LT	28	33	18	8
	Large Multipack, MT	10	9	6	0
	Large Multipack, LT	10	23	34	14
2021*	Small Hermetic MT	0	0	5	0
	Small Hermetic LT	0	0	5	0
	Single condensing units MT	0	20	19	21
	Single condensing units LT	28	33	18	8
	Large Multipack, MT	0	0	0	0
	Large Multipack, LT	0	17	37	18

*- since 2017 data on equipment split becomes available from installation reports

Table 4.7.6. Shares of different substances used in transport refrigeration equipment

Year	HFC-143a	HFC-125	HFC-134a	HFC-32
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	13	11	2	0
2001	13	11	2	0
2002	13	11	2	0
2003	13	11	2	0
2004	13	11	2	0
2005	13	11	2	0
2006	26	22	4	0
2007	26	22	4	0
2008	26	22	4	0
2009	26	22	4	0
2010	38	33	5	0
2011	38	33	5	0
2012	48	42	9	1
2013	48	42	9	1
2014	48	42	9	1
2015	48	42	9	1
2016	48	42	9	1
2017	43	44	9	3
2018	36	46	8	5
2019	28	45	8	6
2020	20	47	12	10
2021	13	49	11	12

Table 4.7.7. Shares of HFC-134a used in different types of mobile air-conditioning (MAC)

Year	Passanger cars with AC	Public transportation	Trucks
1995	15	10	0
1996	20	10	0
1997	25	20	15
1998	30	25	20
1999	40	30	25
2000	50	30	25
2001	60	30	25
2002	60	30	30
2003	70	40	30
2004	70	40	30
2005	80	40	40
2006	80	50	40
2007	90	50	40
2008	90	50	50
2009	100	60	50
2010	100	60	50
2011	100	60	50
2012	100	60	50
2013	98	60	50
2014	95	58	50
2015	90	58	50
2016	60	50	50
2017	5	45	45
2018	0	40	40
2019	0	40	40
2020	0	40	40
2021	0	35	35

Table 4.7.8 shows aggregated national total HFCs emissions over 1995-2021 expressed in CO₂ equivalents and HFCs emission in sub-sector: 2.F.1 *Refrigeration and Air Conditioning*. Prior to 1995, HFCs were not used in Poland.

Table 4.7.8. HFCs emissions in 2.F.1 *Refrigeration and Air Conditioning* and in Total

Year	HFCs emissions in 2.F.1 <i>Refrigeration and Air Conditioning</i> [t CO ₂ eq.]	Total HFCs emissions [t CO ₂ eq.]
1995	150.66	166.58
1996	183.88	259.00
1997	232.22	346.42
1998	308.32	417.65
1999	466.30	581.29
2000	916.06	1 022.57
2001	1 340.98	1 504.78
2002	1 866.86	2 048.48
2003	2 522.63	2 617.09
2004	2 780.72	3 150.17
2005	3 188.60	3 761.45
2006	3 675.61	4 440.19
2007	4 167.65	4 888.19
2008	4 845.00	5 364.00
2009	5 244.70	5 653.31

Year	HFCs emissions in 2.F.1 Refrigeration and Air Conditioning [t CO ₂ eq.]	Total HFCs emissions [t CO ₂ eq.]
2010	5 298.34	5 598.16
2011	5 781.69	6 104.97
2012	6 010.54	6 344.77
2013	5 595.01	5 965.81
2014	6 112.21	6 501.19
2015	5 317.66	5 583.52
2016	5 432.10	5 689.62
2017	5 493.26	5 772.79
2018	5 290.16	5 579.88
2019	5 012.40	5 304.57
2020	4 843.80	5 114.48
2021	4 771.17	4 937.26

2.F.2 Foam blowing agents

Activity data for this application was collected during the questionnaire survey of importers, suppliers and end users of HFCs. Analysis of the Polish market allowed to identify use of HFC-134a, HFC-227ea, HFC-365mfc, HFC-245ca and HFC-152a as foam blowing agents. Following IPCC 2006 GLs it was assumed that HFCs applied to open cells foam are released in first year of use.

Results of the emission estimates for foam blowing agents were presented in table 4.6.9 below.

Table 4.7.9. HFCs emissions for categories: 2.F.2 *Foam blowing agents*, 2.F.3 *Fire protection*, 2.F.4 *Aerosols* and 2.F.5 *Solvents* [kt CO₂ eq.]

Year	HFCs emissions [kt CO ₂ eq.]			
	2.F.2 <i>Foam blowing agents</i>	2.F.3 <i>Fire protection</i>	2.F.4 <i>Aerosols</i>	2.F.5 <i>Solvents</i>
1995	NO	NO	15.93	NO
1996	NO	0.04	75.08	NO
1997	NO	0.13	114.08	NO
1998	NO	0.24	109.09	NO
1999	15.60	1.47	97.92	NO
2000	15.73	1.64	89.13	NO
2001	15.86	3.66	144.29	NO
2002	0.81	3.13	177.67	NO
2003	3.23	9.46	81.78	NO
2004	12.40	8.28	348.78	NO
2005	214.08	12.13	346.11	0.53
2006	230.69	15.09	517.78	1.01
2007	258.67	20.42	440.80	0.65
2008	206.16	23.69	288.82	0.33
2009	133.69	28.80	245.12	0.99
2010	146.61	38.70	112.26	2.25
2011	161.37	45.37	113.74	2.80
2012	165.19	52.62	114.79	1.63
2013	197.42	59.37	113.60	0.41
2014	205.66	68.87	114.04	0.41
2015	74.44	76.04	114.93	0.45
2016	61.86	79.56	115.58	0.53
2017	71.17	91.18	116.60	0.57
2018	76.83	96.10	116.25	0.55
2019	75.41	100.32	115.84	0.61
2020	71.52	94.71	104.03	0.42
2021	75.01	90.69	0.08	0.30

NO – emission not occurring

2.F.3 Fire protection

Activity data for this application was collected during the same questionnaire survey of importers, suppliers and end users of HFCs as for categories 2.F.1 and 2.F.2. Analysis of the Polish market allowed to identify use of HFC-227ea and HFC-236fa (since 1996). Regarding release ratio from fire protection equipment it was assumed as follows:

- EF for HFC-227ea: new product = 1% manufacturing factor; 5% product life factor,
- EF for HFC-236fa: new product = 1% manufacturing factor; 5% product life factor.

Results of the emission estimates for foam blowing agents were presented in table 4.7.9 above.

2.F.4 Aerosols

As mentioned in description of categories above activity data for this application of technical and medical aerosols was collected during the questionnaire survey of importers, suppliers and end users of HFCs. Analysis of the Polish market allowed to identify use of HFC-134a (since 1995). Release ratio for technical and medical aerosols was assumed as follows:

- EF for HFC-134a: import for production of technical aerosols = 50% first year; 50% next year,
- EF for HFC-134a: import of technical aerosols = 50% first year; 50% next year,
- EF for HFC-134a: import for production of medical aerosols = 100% first year,
- EF for HFC-134a: import of medical aerosols = 100% first year.

Results of the emission estimates for foam blowing agents were presented in table 4.6.9 above.

2.F.5 Solvents

As mentioned in description of categories above activity data for this application of technical and medical aerosols was collected during the questionnaire survey of importers, suppliers and end users of HFCs. Analysis of the Polish market allowed to identify use of HFC-365mfc and HFC-43-10mee (since 2005). Release ratio for solvents category was assumed as follows:

- EF for HFC-365mfc: 100% first year,
- EF for HFC-43-10mee: 100% first year.

Results of the emission estimates for foam blowing agents were presented in table 4.7.9 above.

Perfluorocarbons (PFC)

The national GHG inventory covers the following emission sources for PFCs: fire extinguishers (C₄F₁₀) and primary aluminium production (CF₄, C₂F₆).

2.C.3 Aluminium production

The dominating source of emission of PFC gases in Poland is IPCC sector 2.C.3 *Aluminium production*. Activities on aluminium production were taken from [GUS 2010b]. *Tier 1* method and the country specific emission factors were used for estimation of PFC emissions:

- for CF₄ EF = 0.373 kg/Mg aluminium produced,
- for C₂F₆ EF = 0.027 kg/Mg aluminium produced.

Country specific emission factors given above are based on plant specific reporting of installations under EU ETS.

Table 4.7.10 shows aggregated national total PFCs emissions over 1988-2018 expressed in CO₂ equivalents and PFCs emission in sub-sector: 2.C.3 *Aluminium Production*. More details on activity in this category was provided in chapter describing CO₂ emission from aluminium production. Aluminium production in Poland stopped in 2008 and is not occurring since then.

2.F.3 Fire protection

According to historical data obtained from producers and importers/exporters first use of PFCs (C₄F₁₀) in fire extinguishers began in 1996. Prior to 1996, the only known source of PFCs was primary aluminium production. On basis of IPCC 2006 GL applied emission factors for C₄F₁₀ for import and use of equipment were 1% and 5% respectively. Formula used for estimating amount of substance in use in current year (n+1) is presented below:

$$\text{in use } n+1 = \text{in use } n - \text{emission from in use } n + (\text{import } n+1 - \text{emission from import } n+1)$$

where: n - year

Table 4.7.10. PFCs emissions in 2.C.3 *Aluminium production* and 2.F.3 *Fire protection* compared to national total PFCs emission [kt CO₂ eq.]

Year	PFCs emissions in 2.C.3 <i>Aluminium Production</i>	PFCs emissions in 2.F.3 <i>Fire protection</i>	Total PFCs emissions
1988	132.31	NO	132.31
1989	132.54	NO	132.54
1990	127.47	NO	127.47
1991	126.97	NO	126.97
1992	120.97	NO	120.97
1993	130.16	NO	130.16
1994	137.27	NO	137.27
1995	154.52	NO	154.52
1996	143.97	0.88	144.84
1997	148.66	8.22	156.87
1998	150.19	8.00	158.19
1999	141.34	11.85	153.19
2000	145.11	15.76	160.87
2001	151.39	29.96	181.35
2002	163.03	26.87	189.91
2003	158.71	25.38	184.09
2004	163.40	24.11	187.51
2005	148.57	22.91	171.47
2006	155.10	21.76	176.86
2007	148.00	20.67	168.68
2008	129.57	19.64	149.21
2009	NO	18.66	18.66
2010	NO	17.72	17.72
2011	NO	16.84	16.84
2012	NO	16.00	16.00
2013	NO	15.20	15.20
2014	NO	14.44	14.44
2015	NO	13.71	13.71
2016	NO	13.03	13.03
2017	NO	12.38	12.38
2018	NO	11.76	11.76
2019	NO	11.17	11.17
2020	NO	10.61	10.61
2021	NO	10.08	10.08

NO – emission not occurring

Sulfur hexafluoride (SF₆)

As concerns SF₆ the national GHG inventory covers the following emission sources: electrical equipment and magnesium foundries.

2.C.4 Magnesium casting

One of the results of f-gas monitoring and reduction policy was introducing law prohibiting use of SF₆ for magnesium casting since the beginning of 2018. Since 2018 emission is reported as not occurring.

Data on Mg casting were obtained from yearbooks of *Modern Casting*. The first use of SF₆ in magnesium foundries was identified in 1994. Due to unavailability of the data on magnesium in national statistics and other external data sources for recent years it was decided to use last verified activity data available (2007). Emission factors referring to amount of cast per year was used for calculation of SF₆ emission:

Mg casting EF = 1 kg SF₆ / Mg of the amount of alloy used to produce casting

Amount of alloy used to produce casting is based on amount of magnesium production per year taking into account yield factor 55%.

Table 4.7.11 below includes the activity data used for estimation SF₆ emissions over the period: 1988-2021.

2.G.1 Electrical equipment

Applied emissions factors were based on methodology provided in IPCC 2006 GL. Amounts of equipment on the market was assessed on the basis of data provided by producers and importers/exporters.

Electrical equipment manufacturing EF = 0.06 Mg/Mg of SF₆ used

Electrical equipment use EF = 0.05 Mg/Mg SF₆ in use (1995), EF = 0.02 Mg/Mg (since 1996)

Table 4.7.11 presented below includes the activity data used for estimation SF₆ emissions over the period: 1994-2021.

Table 4.7.11. Activity data used for estimation of SF₆ emissions in 2.C.4 *Magnesium production* and 2.G.1 *Electrical equipment* [Mg]

Activity data	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2.C Metal industry														
4. Magnesium production – amount of alloy used to produce casting	320	400	400	345	291	236	181	127	72	46	20	30	65	100
2.G Other product manufacture and use														
1. Electrical equipment – amount of SF ₆ in use	NO	11.00	14.02	17.05	20.07	23.10	26.12	28.70	32.04	33.75	36.45	40.57	46.23	48.63
1. Electrical equipment – amount of SF ₆ filled into new manufactured products	NO	NO	0.60	0.60	2.00	2.33	2.66	3.30	4.16	2.50	3.59	5.16	6.89	3.54

Activity data	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
<i>2.C Metal industry</i>														
<i>4. Magnesium production – amount of alloy used to produce casting</i>	100	100	100	100	100	100	100	100	100	100	NO	NO	NO	NO
<i>2.G Other product manufacture and use</i>														
<i>1. Electrical equipment – amount of SF₆ in use</i>	51.32	55.80	57.97	61.50	65.66	71.70	78.95	97.04	111.25	123.97	148.69	158.43	165.07	170.17
<i>1. Electrical equipment – amount of SF₆ filled into new manufactured products</i>	3.89	5.86	3.50	4.99	5.73	7.82	9.24	20.93	17.18	15.90	28.93	13.53	10.43	8.95

Table 4.7.12 below shows aggregated national total SF₆ emissions over 1994-2021 in tones compared to SF₆ emission in most important sub-sector: 2.G.1 *Electrical Equipment*.

Table 4.7.12. SF₆ emissions in 2.C.4 *Magnesium production* and 2.G.1 *Electrical equipment* compared to national total emission [t]

Year	SF ₆ emissions in 2.C.4 <i>Magnesium production</i>	SF ₆ emissions in 2.G.1 <i>Electrical equipment</i>	Total SF ₆ emissions
1994	0.58	NO	0.58
1995	0.73	0.55	1.28
1996	0.73	0.32	1.04
1997	0.63	0.38	1.00
1998	0.53	0.52	1.05
1999	0.43	0.60	1.03
2000	0.33	0.68	1.01
2001	0.23	0.77	1.00
2002	0.13	0.89	1.02
2003	0.08	0.82	0.91
2004	0.04	0.94	0.98
2005	0.05	1.12	1.18
2006	0.12	1.34	1.46
2007	0.18	1.18	1.37
2008	0.18	1.26	1.44
2009	0.18	1.47	1.65
2010	0.18	1.37	1.55
2011	0.18	1.53	1.71
2012	0.18	1.66	1.84
2013	0.18	1.90	2.08
2014	0.18	2.13	2.32
2015	0.18	3.20	3.38
2016	0.18	3.26	3.44
2017	0.18	3.43	3.62
2018	NO	4.71	4.71
2019	NO	3.98	3.98
2020	NO	3.93	3.93
2021	NO	3.94	3.94

NO – emission not occurring

4.7.3. Uncertainties and time-series consistency

Uncertainty analysis made for industrial gases HFC, PFC and SF₆ was significantly improved since submission 2018, as response to recommendations of the previous UNFCCC reviews. Previously uncertainty assumptions were applied directly to emission values of each pollutant due to lack of available information. In submissions 2018, 2019 and 2020 some of the applied assumptions were revised to better reflect national circumstances and in result some of the uncertainties decreased.

Present calculation model was revised and extended to include uncertainties applied to activity data and emission factors. Uncertainty assessment is now performed taking into account information given on for different subcategories and single f-gases. Uncertainty is also assessed separately for manufacture, operating and decommissioning of f-gases containing equipment.

Overall results are estimated using GWP potential from IPCC 4AR. To ensure consistency with the approach taken in the NIR uncertainty assessment model for f-gases covers complete set of categories resulting in emission of gases (2.C *Metal production*, 2.F *Product uses as substitutes for ODS* and 2.G. *Other product manufacture and use*). More details on assumed input uncertainties for each of the subcategories and gases are given in annex 8 describing uncertainty assessment for whole inventory.

Uncertainty of f-gases by categories	From manufacturing	From stocks	From disposal	Total	Contributing f-gases
TOTAL	2.68%	13.40%	15.80%	13.31%	HFC, PFC, SF₆
C. Metal production	-	-	-	-	SF ₆
F. Product uses as substitutes for ODS	2.79%	13.42%	15.80%	13.33%	HFC, PFC
G. Other product manufacture and use	5.39%	7.07%	-	6.15%	SF ₆

4.7.4. Source-specific QA/QC and verification

Main verification exercise is comparing amounts of HFCs, PFC and SF₆ with data available in f-gases registries (users and importers). Amount of import/export of f-gases is compared with amount recovered from decommissioned equipment and refilled during the maintenance activities. In case of potential inconsistencies direct contact with installation or operator is established. Additional second level QA/QC procedures are applied by inventory team during compiling the final all GHG inventory. Then the time series consistency and completeness are checked as priority. Results are also compared to previous submission and verified in case of outlying results. Last third level QA/QC is applied at EU level, where f-gases are reviewed in a process similar to UNFCCC review. For more information see chapter 4.2.4.

4.7.5. Source-specific recalculations

No recalculations were made in f-gases historical emissions, however since submission 2023 all reported years of the time series are calculated using GWP published in IPCC Fifth Assessment Report (AR5).

Example results of the recalculations for 2020 were presented in table below:

kt of CO ₂ eq.	HFCs	PFCs	SF ₆
Previous submission	5 220.97	10.22	89.54
Latest submission	5 114.48	10.61	92.29
Difference	-106.49	0.39	2.75
%	-2.04 %	3.48%	3.07%

4.7.6. Source-specific planned improvements

Continuing ongoing project on revision and extending dataset for f-gases. Further analysis of filling amounts in equipment containing HFCs, PFCs and SF₆.

4.8. Other product manufacture and use (CRF sector 2.G)

SF₆ emissions from sector 2.G.1 *Electrical equipment* is described in chapter 4.7.2.

The N₂O use in medical applications and as propellant in whipped-cream aerosol cans are covered in this subsector.

2.G.3.a. Other Product Manufacture and Use – Medical applications (Anaesthesia)

N₂O emission from anaesthesiology was estimated based on country study: “Strategy of reduction of GHG emission until 2020 in the division into separate gases (N₂O, HFCs, PFCs and SF₆) and sectors” elaborated by the Institute of Environmental Protection [IOŚ 2001]. Due to lack of available data the value established in 2001 amounting to 0.4 kt is annually applied for entire series. Steps are undertaken to confirm or update this emission but data on N₂O medical use is scattered.

2.G.3.b. Propellant for pressure and aerosol products

The country study has been performed to develop methodology of estimating domestic N₂O emission from use as a propellant in aerosol products, primarily in food industry (2.G.3.b): “The methodology for estimating N₂O emissions in food industry (primarily as a propellant in aerosol products) for reporting to the national inventory of emissions and removals of greenhouse gases” (National Centre for Emission Management 2017, in Polish) [KOBIZE 2017]. Based on this analysis it was assumed that the main product taken into consideration in emission calculations is wheapped cream where entire propellant is released from container. The emission values related to this subcategory range from 0 kt N₂O in 1988 up to 0.05 kt N₂O in 2021.

5. AGRICULTURE (CRF SECTOR 3)

5.1. Overview of sector

The GHG emission sources in agricultural sector involve: enteric fermentation from domestic livestock (CH₄), manure related to livestock management (CH₄ and N₂O), agricultural soils (N₂O), liming and urea application (CO₂) and agricultural residue burning (CH₄ and N₂O). Emission categories like: rice cultivation and prescribed burning of savannas do not occur in Poland and are therefore not reported.

Following subcategories from sector 3 have been identified as key source (excluding LULUCF):

IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)		
		Level	Trend	Qualitative
3.A Enteric Fermentation	CH ₄	L	T	
3.B Manure Management	N ₂ O	L		
3.D.1 Direct N ₂ O Emissions From Managed Soils	N ₂ O	L	T	
3.D.2 Indirect N ₂ O Emissions From Managed Soils	N ₂ O	L		

Share of these subcategories in total Poland's GHG emissions amounts ca. 7.80%.

Total emissions of GHG in Agriculture sector presented as carbon dioxide equivalent amounted to 34.04 Mt in 2021 and decreased since 1988 by about 32.0%. Strong decrease in emissions in Poland occurred after 1989 when economic transformation began shifting from centrally planned economy to the market one (Fig. 5.1.1). The cost-effectiveness of agricultural production deeply changed then – up to 1989 agricultural production was generally subsidised on the state level. Since 1990 the prices for agricultural products as well as for agricultural means of production (like mineral fertilisers or machines) became the market ones and the subsidies were cut off. Deterioration of macroeconomic conditions for agricultural production in early 1990-ties during the restructuring of the state economy triggered changes in structure of agricultural farms since 1989. The big state agricultural farms became economically ineffective in a new market conditions so they were constantly eliminated. Also production of many small family farms became cost-ineffective so for instance the process of leaving the animal production by small farms started. On the other hand - gradual development of private and collective farms breeding large livestock herds begun. In the total number of farms conducting agricultural activity in Poland maintains the dominance of small farms up to 5 ha of agricultural land [GUS R 2021].

Significant decrease of livestock population was observed after 1989 – the cattle population dropped almost by half – from over 10 million in 1988 to about 6 million presently. Since 2002, just before accessing Poland to the European Union (in 2004), population of dairy cattle stabilized when the limits of milk production were known in advance what stabilized the milk market. In the same time sheep population drop by 94% (from over 4 million in 1988 up to 0.29 million in 2021). Especially sheep breeding became unprofitable – the wool up to 1989 was highly subsidised so sheep farming was related mostly to wool production and over 70% of sheep farms' income was related to wool sale. Small domestic demand for sheep meat also caused retreat from sheep breeding.

Additional reasons for decreasing the agricultural production in 1990-ties were export limitation for Eastern markets, deterioration of relationship between prices for agricultural products and prices for means of production as well as increased competition of imported food from Western Europe. Since 2004, when Poland joined the European Union, the key factor influencing the Polish agriculture and rural areas is the EU Common Agricultural Policy aiming at improvement of productivity through introducing technical progress and stabilisation of agricultural market.

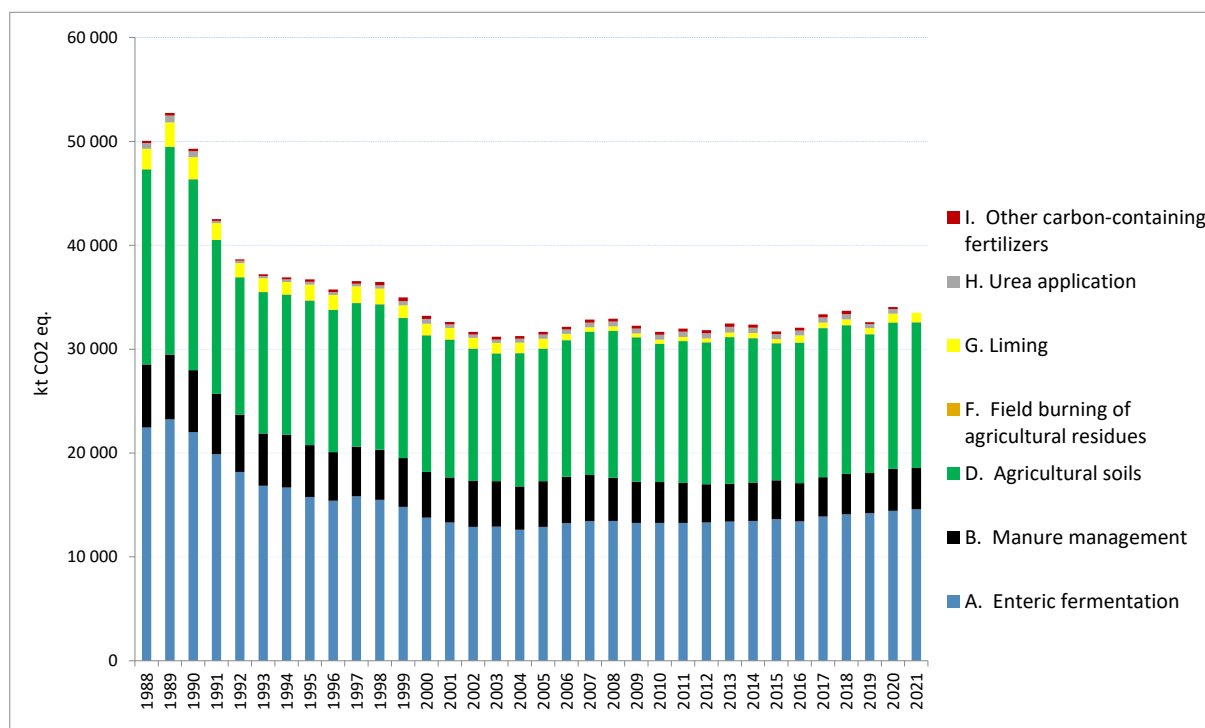


Figure 5.1.1. Total greenhouse gas emissions related to the Polish agriculture according to main source categories

The value of global agricultural production in Poland in current prices increased compared to 2020 by 6.5% as a result of an increase in crop production by 8.3% and animal production by 4.6%. In addition to changes in the volume of products of plant and animal origin, the volume of global agricultural production was affected by changes in prices of agricultural products correlated with domestic supply and changes in prices occurring on foreign, primarily EU agricultural markets.

The sown area in 2021 was 10.9 million ha, which means a slightly decrease compared to the previous year (by 0.6%). The sowing structure was dominated by cereals (68.4% of the total sown area), followed by industrial crops (12.1%) and fodder crops (11.5%). Harvests and yields of major agricultural crops in 2021 were lower than in previous year. Harvest of cereals, field vegetables and fruit from berry plantations and fruit bushes in orchards were lower than in 2020. Less favorable agrometeorological conditions during the growing season, as well as the reduction of the area of some crops, contributed to the decline in production and yielding.

The total cattle population amounted 6.4 million heads and was by 1.6% higher than in the previous year. The increase in the number of cattle herd occurred in the group of calves (by 3.9%), and young cattle aged 1 – 2 years (by 6.4%), with a simultaneous decrease in the number of cattle aged 2 years and more (by 3.0%), including cows (by 4.3%).

The pig population amounted 11.0 million heads and was 3.5% lower than a year ago. The number of all utility groups decreased throughout the year. The number of covered sows (by 20.6%) and pigs for rearing in the group of pigs weighing 50 kg and more (by 19.8%) decreased the most. With livestock price falling, profitability of pigs' fattening worsened compared to the previous year. In addition further infections with African Swine Fever disease (ASF) were recorded in 2021.

Year-over-year purchase prices for cereals, potatoes, sugar beet, rape and turnip rape, most vegetables and fruit, livestock except of pork, chicken eggs and cow's milk increased. On the other hand, the prices of apples and cherries decreased. In 2021 there was a decrease in global agricultural production calculated in constant prices (compared to 2020 by 4.5%). The decrease was due to the decrease in the value of animal production (by 8.3%) and crop production (by 0.8%) [GUS R4 2022].

Contribution of Agriculture in national emissions excluding LULUCF is 8.5% in 2021. Among GHGs the highest contribution Agriculture has in national totals in N_2O – 80.6%, then in CH_4 – 37.4% and insignificant share in CO_2 – 0.4%. The biggest share in GHG Agricultural emissions have 2 sectors: Enteric fermentation – 42.9% and Agricultural soils – 41.2% while Manure management is responsible for about 11.6% of GHG emissions. Liming, urea and other carbon containing fertilizers application are responsible respectively for: 2.6%, 1.2% and 0.4%. Share of CH_4 and N_2O emissions from Field burning of agricultural residues are minor – only about 0.1%.

The review of agricultural emission trends by gases and subsectors are given in Figures 5.1.2–5.1.4.

Carbon dioxide emissions in Agriculture sector come from liming, urea application as well as from other carbon containing fertilizers (i.e. calcium ammonium nitrate) and were responsible for 62%, 28% and 10% respectively in 2021 (Fig. 5.1.2).

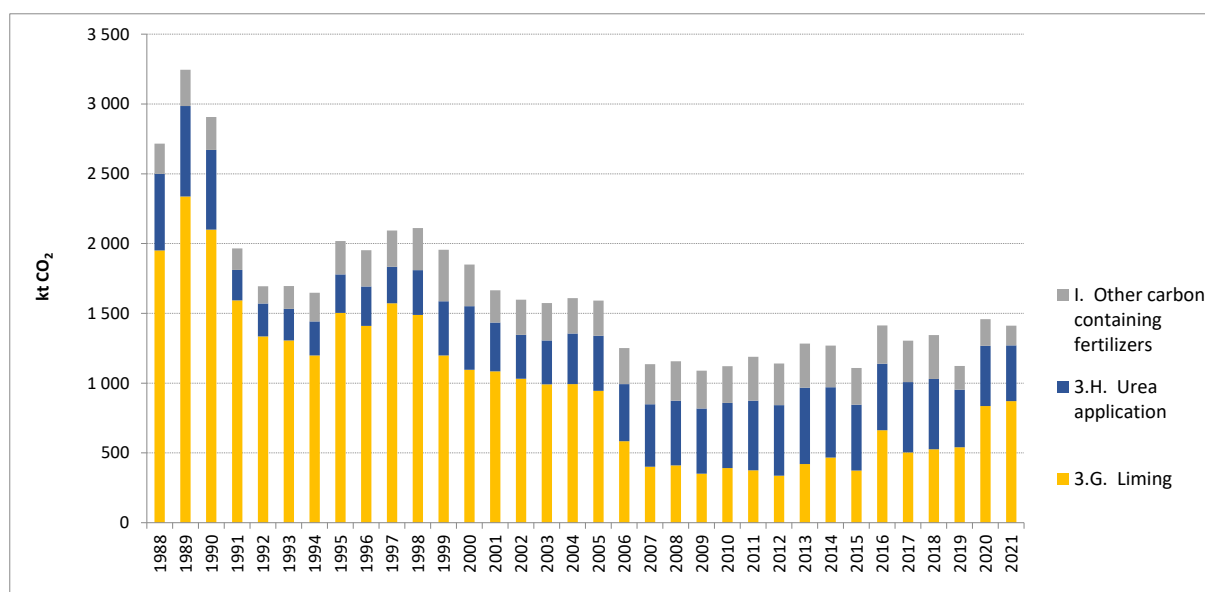


Figure 5.1.2. Carbon dioxide emissions from the Polish agriculture according to subcategories

As relates to methane emissions most of them originated from enteric fermentation (91.1%) and about 8.7% was related to manure management in 2021. Share of field burning of agricultural residues represent only 0.2% of emissions (Fig. 5.1.3).

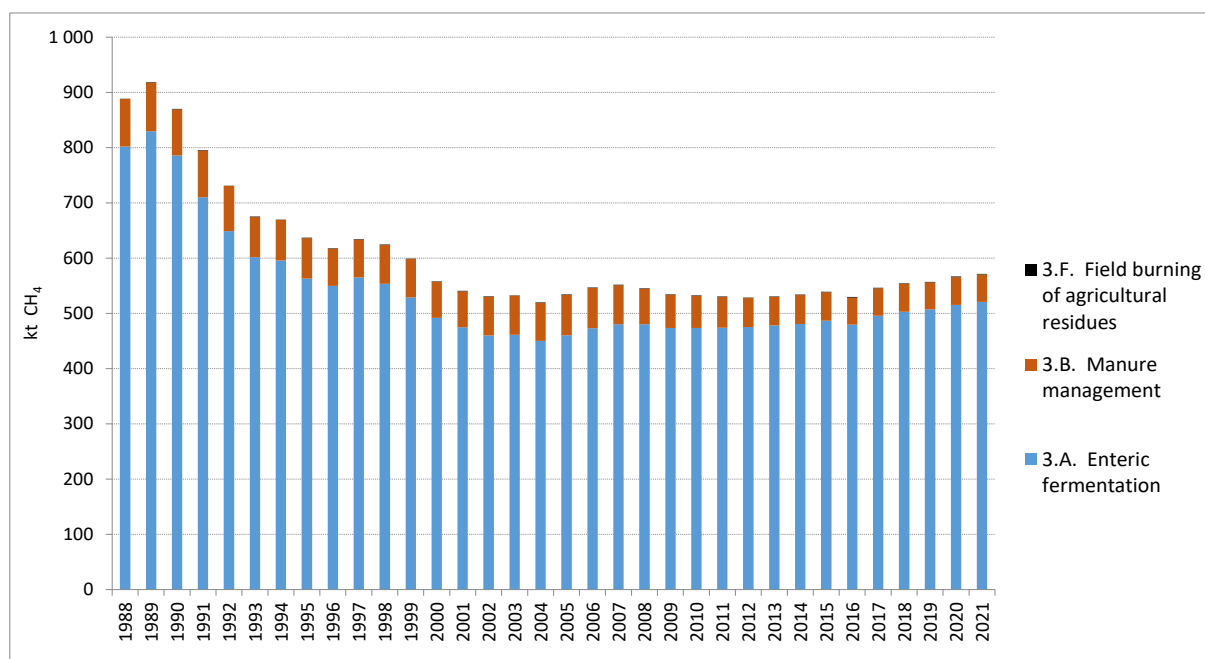


Figure 5.1.3. Methane emissions from the Polish agriculture according to subcategories

As concerns the nitrous oxide emissions, the main source of emissions in 2021 was agricultural soils responsible for 84.4% while manure management – for 15.5%. Emissions from field burning of agricultural residues are negligible (0.07%) (Fig. 5.1.4).

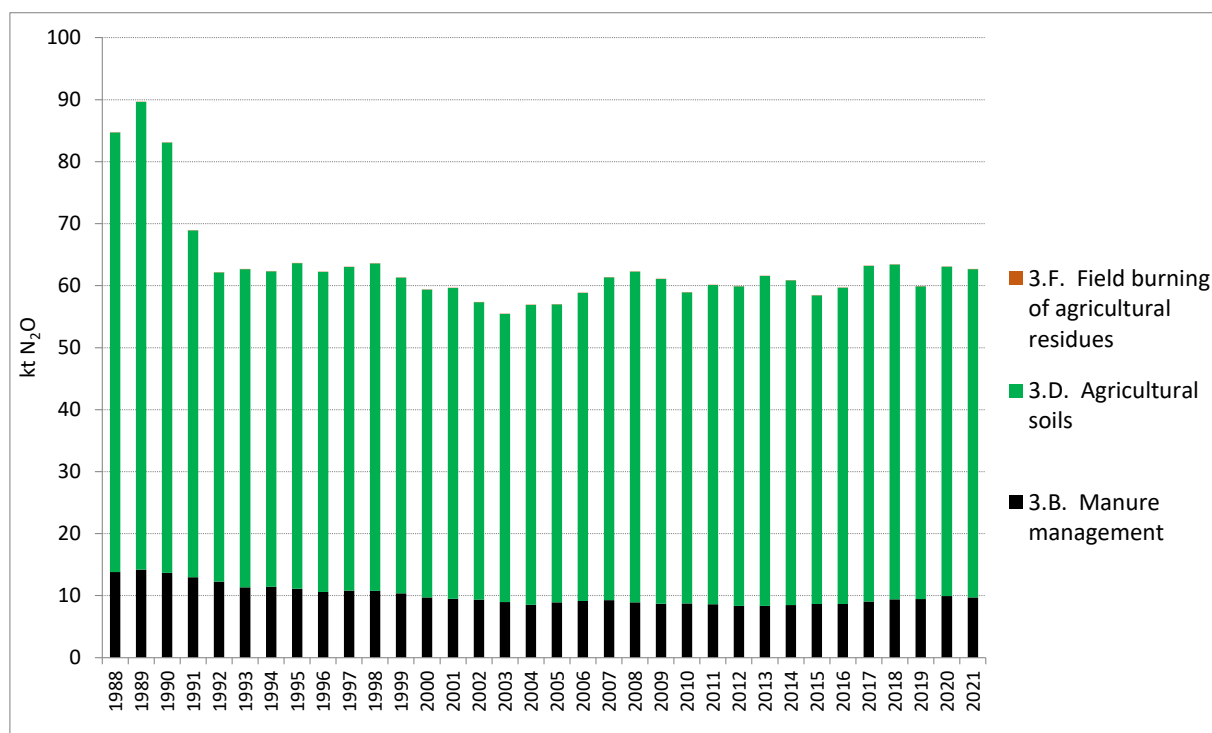


Figure 5.1.4. Nitrous oxide emissions from the Polish agriculture according to subcategories

5.2. Enteric Fermentation (CRF sector 3.A)

5.2.1. Source category description

CH₄ emissions from animals' enteric fermentation in 2021 amounted to almost 521 kt CH₄ and decreased since 1988 by 35.1%. Majority of CH₄ emissions in this subcategory, almost 96%, are related to cattle breeding. The main driver influencing CH₄ emissions decline from enteric fermentation is the decrease of livestock population since 1988. The biggest change over time relates to the sheep breeding where cut of emissions amounts to 93% in 1988-2021. At the same time CH₄ emission reduction for dairy cattle amounts to 36% (table 5.2.1).

Table 5.2.1. Trends in CH₄ emissions from enteric fermentation kt CH₄

Year	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Swine	Total
1988	462.28	255.64	35.02	0.90	18.92	29.41	802.16
1989	485.34	262.61	35.27	0.90	17.51	28.25	829.89
1990	471.20	234.49	33.27	0.90	16.94	29.20	786.00
1991	434.39	199.26	25.87	0.90	16.90	32.80	710.13
1992	400.56	183.23	14.96	0.90	16.20	33.13	648.97
1993	376.53	170.75	10.14	0.90	15.14	28.29	601.75
1994	367.76	179.57	6.96	0.90	11.20	29.20	595.59
1995	340.93	173.56	5.70	0.90	11.45	30.63	563.17
1996	334.80	172.55	4.42	0.90	10.24	26.95	549.85
1997	342.54	180.51	3.93	0.91	10.04	27.20	565.14
1998	349.42	160.76	3.62	0.93	10.10	28.75	553.58
1999	337.95	149.04	3.14	0.91	9.92	27.81	528.76
2000	309.96	142.41	2.90	0.88	9.89	25.68	491.73
2001	306.12	129.86	2.74	0.86	9.83	25.66	475.08
2002	294.47	127.86	2.76	0.97	5.94	27.94	459.94
2003	299.52	124.26	2.70	0.96	5.99	27.91	461.35
2004	292.64	123.06	2.54	0.88	5.78	25.48	450.39
2005	295.30	129.24	2.53	0.71	5.62	27.17	460.56
2006	300.24	135.97	2.41	0.65	5.53	28.32	473.12
2007	300.76	143.01	2.66	0.72	5.92	27.19	480.26
2008	303.25	145.02	2.59	0.68	5.86	23.14	480.54
2009	293.23	150.64	2.29	0.59	5.36	21.42	473.54
2010	290.25	153.62	2.06	0.54	4.75	22.30	473.53
2011	289.01	157.70	2.01	0.56	4.58	20.26	474.12
2012	289.33	162.17	2.13	0.45	4.00	17.37	475.46
2013	287.18	168.22	1.78	0.43	3.86	16.74	478.22
2014	284.60	172.97	1.61	0.41	3.73	17.59	480.90
2015	286.74	176.42	1.82	0.31	3.86	17.46	486.61
2016	276.86	180.39	1.91	0.27	3.73	16.30	479.46
2017	283.15	189.72	2.09	0.22	3.34	17.03	495.55
2018	288.92	190.83	2.21	0.24	3.17	17.74	503.10
2019	292.38	193.29	2.18	0.25	2.99	16.17	507.27
2020	296.90	195.72	2.30	0.27	2.82	17.15	515.16
2021	296.90	202.10	2.31	0.27	2.82	16.55	520.95
share [%] in 2021	56.99	38.79	0.44	0.05	0.54	3.18	100.00
change [%] 1988-2021	-35.78	-20.94	-93.40	-69.83	-85.11	-43.72	-35.06

5.2.2. Methodological issues

Generally data on animal population is collected by Statistics Poland and is published on an annual basis in Statistical Yearbook of the Republic of Poland [GUS (1989-2022)] but also in other agricultural statistical publications and the Local Bank Data in the Statistics Poland [GUS R1 2022]. Annual average population (AAP), as it is described in the [IPCC 2006, in Chapter 10.2.2 page 10.8], can be obtained as one-time animal inventory data, especially for static animal populations (like dairy cattle or breeding swine). It should be noted that in Poland the June sample survey is a common date for collecting data by national statistics on all main livestock numbers and covers entire trend since the base year 1988.

The exception here is swine population for which data in 1998-2013 were collected also in summer but in July. It should be mentioned that for the last years sample surveys for cattle, sheep and poultry are performed twice a year (June, December) while for swine - three times a year (March, June and December) but the dates for additional sampling are not consistent and use to change since 1988. On the other hand population of horses and goats is collected once a year, in June, only. Additionally, for the first years of the inventoried series, only one annual number of livestock is available (June) for all main animal categories. In conclusion, application of the June survey results is justified and in fact the only one available to ensure timeseries consistency.

Even more - comparison of differences in livestock population in the surveyed months performed for the same year indicated that summer populations are the highest in most of cases of the given year, thus use of summer statistical data should not lead to underestimation of the emission. The population data on livestock applied for GHG inventory correlates also with the numbers available in the FAO database what can be checked for consistency. Detail methodological information related to collecting data on livestock population by Statistics Poland is given in Annex 5.

Trend of animal population (excluding cattle) in 1988-2021 is given in table 5.2.2. As relates to goats population some lack of data is noticed for 1988-1995 and 1997, so data for 1996 was taken for the period 1988-1995 and for 1997 the average value for 1996 and 1998 was calculated. Since 1998 up to 2013 goats population is available on an annual basis.

The goats and horses population, since 2013, has been collected every 3 years. Therefore repeated data for 2013-2015 were used only for the middle year like 2014 and the same data for 2016-2018 were used for 2017. For the years between interpolation was used (2015, 2016). In 2022 the results of Agricultural Census 2020 on livestock population were published so those data for goats and horses were employed for both years 2020 and 2021 (as no new data for horses and goats for 2021 in the national statistics appeared) so the interpolation was made for 2018 and 2019. Interpolated data for livestock population are shown in *Italics* in table 5.2.2.

Table 5.2.2. Trends of selected livestock population

Years	Livestock population [thousands]						
	Sheep	Goats	Horses	Swine	Poultry	Rabbits	Fur-bearing animals
1988	4 377	179	1 051	19 605	241 518	1 091	483
1989	4 409	179	973	18 835	263 135	1 091	441
1990	4 159	179	941	19 464	224 866	1 091	399
1991	3 234	179	939	21 868	216 093	1 091	357
1992	1 870	179	900	22 086	199 135	1 091	314
1993	1 268	179	841	18 860	194 705	1 091	272
1994	870	179	622	19 466	201 396	1 091	230
1995	713	179	636	20 418	189 984	1 091	187
1996	552	179	569	17 964	207 480	1 091	145
1997	491	182	558	18 135	201 240	<i>1 054</i>	<i>164</i>
1998	453	186	561	19 168	201 363	<i>1 017</i>	<i>183</i>
1999	392	181	551	18 538	202 507	<i>981</i>	<i>201</i>
2000	362	177	550	17 122	198 337	<i>944</i>	<i>220</i>
2001	343	172	546	17 105	206 209	<i>907</i>	<i>239</i>
2002	345	193	330	18 629	198 783	870	257
2003	338	192	333	18 605	146 321	<i>840</i>	<i>281</i>
2004	318	176	321	16 988	131 142	<i>811</i>	<i>305</i>
2005	316	142	312	18 112	152 799	<i>781</i>	<i>329</i>
2006	301	130	307	18 881	141 808	<i>751</i>	<i>353</i>
2007	332	144	329	18 129	150 620	<i>721</i>	<i>377</i>
2008	324	136	325	15 425	145 496	<i>691</i>	<i>401</i>
2009	286	119	298	14 279	140 826	<i>661</i>	<i>425</i>
2010	258	108	264	14 865	132 196	632	449
2011	251	112	254	13 509	143 557	550	427
2012	267	90	222	11 581	130 596	<i>468</i>	<i>404</i>
2013	223	86	215	11 162	140 691	386	382
2014	201	82	207	11 724	146 770	<i>374</i>	<i>601</i>
2015	228	63	215	11 640	163 426	362	820

Years	Livestock population [thousands]						
	Sheep	Goats	Horses	Swine	Poultry	Rabbits	Fur-bearing animals
2016	239	54	207	10 865	187 775	350	1 039
2017	261	44	185	11 353	197 537	426	1 707
2018	277	47	176	11 828	206 228	52	2 375
2019	273	51	166	10 781	210 364	578	3 044
2020	288	54	157	11 433	214 987	654	3 712
2021	289	54	157	11 033	190 264	730	4 380

Data on rabbits and fur animals population is available in public statistics only for selected years like: 1983 [GUS R5 1987] and 1996 [GUS R6 1996], 2002 [GUS R7 2002], 2010 [GUS R8 2010], 2013 [GUS R9 2014] and 2016 [GUS R12 2017] as well as for 2021 [GUS R3 2022] when Agricultural Censuses were performed or other periodic studies were published containing required data. Interpolation was used for in-between years (presented in *Italic* in table 7). Statistical data as referenced above related to rabbits covers female rabbits capable for reproduction. Fur-bearing animals include also female animals of: foxes, minks, polecats, nutrias, polecat-ferrets, chinchilla and yenots. No statistical information on deer population is available.

Trends of cattle population presented for specific subcategories is given in Table 5.2.3. In 1998 Statistics Poland introduced methodological changes in collecting statistical data on cattle population (apart from dairy cattle). This change triggered some inconsistency in population trend of other cattle. So in response to recommendations of the Expert Review Team (ERT 2013) the non-dairy cattle trend for 1988-1997 was unified based on average share in 1998-2007 of specific age groups in relation to all non-dairy cattle population.

Table 5.2.3. Trends of cattle population [thousands]

Years	Dairy cattle	Non-dairy cattle			
		young cattle <1 year	young cattle 1-2 years	heifers >2 years	bulls >2 years
1988	4 806	2 879	2 025	401	211
1989	4 994	2 996	2 107	417	219
1990	4 919	2 678	1 883	373	196
1991	4 577	2 227	1 567	310	163
1992	4 257	2 069	1 456	288	151
1993	3 983	1 910	1 344	266	140
1994	3 863	2 001	1 407	279	146
1995	3 579	1 946	1 368	271	142
1996	3 461	1 919	1 349	267	140
1997	3 490	1 992	1 401	278	146
1998	3 542	1 799	1 235	280	99
1999	3 418	1 647	1 108	283	99
2000	3 098	1 572	1 101	231	81
2001	3 005	1 472	973	210	74
2002	2 873	1 384	1 084	142	50
2003	2 898	1 349	932	229	81
2004	2 796	1 309	916	246	86
2005	2 795	1 425	978	209	76
2006	2 824	1 428	1 040	224	90
2007	2 787	1 473	1 072	265	99
2008	2 806	1 502	1 102	263	83
2009	2 688	1 472	1 204	238	99
2010	2 656	1 457	1 244	276	92
2011	2 626	1 481	1 300	242	113
2012	2 578	1 469	1 344	239	147
2013	2 531	1 586	1 422	178	144
2014	2 479	1 609	1 433	259	141
2015	2 444	1 669	1 529	222	97

Years	Dairy cattle	Non-dairy cattle			
		young cattle <1 year	young cattle 1-2 years	heifers >2 years	bulls >2 years
2016	2 332	1 728	1 576	215	87
2017	2 374	1 721	1 701	231	116
2018	2 429	1 686	1 734	228	124
2019	2 461	1 710	1 768	244	115
2020	2 468	1 709	1 812	241	113
2021	2 388	1 789	1 856	255	113

In the estimation of CH₄ emissions from enteric fermentation two types of approaches were applied – in case of horses, sheep, goats and swine, the IPCC *Tier 1* method was applied using default CH₄ Emission Factors [IPCC 2006, table 10.10] as given in table 5.2.4.

Table 5.2.4. Methane emission factors related to enteric fermentation for horses, sheep, goats and swine

Animal	Emission Factors [kg CH ₄ /head/year] IPCC 2006 default vales for developed countries
Horses	18.0
Sheep	8.0
Goats	5.0
Swine	1.5

Emissions from enteric fermentation of poultry and fur animals were not estimated as the IPCC do not provide the guidelines.

More detailed, IPCC *Tier 2* method, was applied in calculation of methane emissions from enteric fermentation from cattle being the key category. Here country specific emission factors were calculated based on specific gross energy intake (GE) values estimated for selected cattle sub-categories [IPCC 2006, equation 10.21]:

$$EF = \left(GE * \frac{Y_m}{100} * 365 \frac{days}{yr} \right) / \left(55.65 \frac{MJ}{kg CH_4} \right)$$

where:

EF – emission factor, kg CH₄/head/yr

GE – gross energy intake, MJ/head/day

Y_m – methane conversion rate which is the fraction of gross energy in feed converted to methane, %.

Gross energy intake (GE) was calculated separately for dairy cattle and for and non-dairy cattle disaggregated for: calves under 1 year, young cattle 1-2 years and other mature cattle (divided for heifers and bulls over 2 years) using the equation 10.16 from [IPCC 2006]:

$$GE = \left[\frac{(NE_m + NE_a + NE_l + NE_{work} + NE_p)}{REM} + \frac{NE_g}{REG} \right] / \frac{DE\%}{100}$$

where:

GE – gross energy, MJ/day

NE_m – net energy required by the animal for maintenance, MJ/day

NE_a – net energy for animal activity, MJ/day

NE_l – net energy for lactation, MJ/day

NE_{work} = net energy for work, MJ/day (assumed zero)

NE_p – net energy required for pregnancy, MJ/day

REM = ratio of net energy available in a diet for maintenance to digestible energy consumed

NE_g – net energy needed for growth, MJ/day

REG – ratio of net energy available for growth in a diet to digestible energy consumed

DE% – digestible energy expressed as a percentage of gross energy

Detail information on cattle parameters taken and/or calculated GE are given in tables 5.2.5–5.2.6. Parameters required for estimation of GE factor for dairy cattle like dairy cattle pregnancy [GUS R1 2022], milk production [GUS M 2022], percent of fat in milk [GUS R 2022] come from national statistics. Digestible energy (DE – expressed as a percent of gross energy) as well as mean mass and daily weight gain for cattle was updated by the National Research Institute of Animal Production [Walczak 2020, 2022] and relates to genetic as well as feeding improvements of cattle breeding throughout inventoried period. More detail parameters for cattle is given in Tables 5.2.7 – 5.2.9.

Table 5.2.5. Parameters and equations used to estimate GE and EF for mature dairy cattle

Parameters/unit	Source/reference	Values/comments
Body weight [kg]	National Research Institute of Animal Production [Walczak 2020]	Table 5.2.7
$C_{pregnancy}$	Table 10.7 in 2006 IPCC GLs	0.1
C_{fi} [MJ/day/kg]	Table 10.4 in 2006 IPCC GLs	0.386
NE_m = net energy required by the animal for maintenance [MJ/day]	Equation 10.3 in 2006 IPCC GLs	Dependent on body weight
C_a	Table 10.5 of 2006 IPCC GLs	0 for stall 0.17 for pasture
NE_a – net energy for animal activity [MJ/day]	Equation 10.4 in 2006 IPCC GLs	Calculated using share of grazing animals (table 5.3.2) and C_a parameters
NE_l – net energy for lactation [MJ/day]	Equation 10.8 in 2006 IPCC GLs	Amount of milk produced and fat content of milk from national statistics
NE_{work} = net energy for work [MJ/day]	Equation 10.11 in 2006 IPCC GLs	Time spend for work assumed as zero
NE_p – net energy required for pregnancy [MJ/day]	Equation 10.13	calculated
Digestible energy (DE) expressed as a percentage of gross energy [%]	National Research Institute of Animal Production [Walczak 2006, 2013, 2020, 2022]	Country Specific, see table 5.2.7
REM – ratio of net energy available in a diet for maintenance to digestible energy consumed	Equation 10.14 in 2006 IPCC GLs	calculated
NE_g – net energy needed for growth [MJ/day]	Equation 10.6 in 2006 IPCC GLs	0
REG – ratio of net energy available for growth in a diet to digestible energy consumed	Equation 10.15 in 2006 IPCC GLs	calculated
Y_m – CH_4 conversion factor [%]	Table 10.12 of 2006 IPCC GLs	6.5

Table 5.2.6. Parameters and equations used to estimate GE and EF for other cattle

Parameters/unit	Source	Values/comments
Body weight [kg]	National Research Institute of Animal Production [Walczak 2006]	Table 5.2.8
$C_{pregnancy}$	Table 10.7 in IPCC 2006 GLs	0
C_{fi} [MJ/day/kg]	Table 10.4 in IPCC 2006 GLs	0.322
NE_m = net energy required by the animal for maintenance [MJ/day]	Equation 10.3 in IPCC 2006 GLs	Dependent on body weight
C_a	Table 10.5 of IPCC 2006 GLs	0 for stall 0.17 for pasture
NE_a – net energy for animal activity [MJ/day]	Equation 10.4 in IPCC 2006 GLs	Calculated using share of grazing animals (table 5.3.2) and C_a parameters
NE_l – net energy for lactation [MJ/day]	Equation 10.8 in IPCC 2006 GLs	0
NE_{work} = net energy for work [MJ/day]	Equation 10.11 in IPCC 2006 GLs	Time spend for work assumed as zero
NE_p – net energy required for pregnancy [MJ/day]	Equation 10.13	0
Digestible energy (DE) expressed as a percentage of gross energy [%]	National Research Institute of Animal Production	Country Specific, see table 5.2.9

Parameters/unit	Source	Values/comments
REM – ratio of net energy available in a diet for maintenance to digestible energy consumed	Equation 10.14 in IPCC 2006 GLs	calculated
NEg – net energy needed for growth [MJ/day]	Equation 10.6 in IPCC 2006 GLs	Calculated for cattle < 2 years based on daily weight gain in Table 5.2.8, 0 for heifers and bulls > 2 years
REG – ratio of net energy available for growth in a diet to digestible energy consumed	Equation 10.15 in IPCC 2006 GLs	calculated
Y _m – CH ₄ conversion factor [%]	Table 10.12 of IPCC 2006 GLs	6.5

Methane emission factor for dairy cattle, established based on the above described methodology, vary from 96.2 CH₄/animal/year in 1988 up to 124.3 kg CH₄/animal/year in 2021, following GE changes (tab. 5.2.7). Specific methane emission factors for entire trend for non-dairy cattle are presented in table 5.2.10. Here the CS weighted mean values EFs for non-dairy cattle vary from 46.3 kg CH₄/animal/year in 1988 up to 50.4 kg CH₄/animal/year in 2021.

Table 5.2.7. Body mass, digestible energy, milk yield and fat contain, gross energy intake and emission factors for dairy cattle

Years	Body mass	Digestible Energy	Average milk production	Fat content of milk	GE (gross energy intake)	Emission Factor
	[kg/head]	[%]	[litres/cow/yr]	[%]	[MJ/cow/day]	[kg CH ₄ /animal/year]
1988	500	63.8	3 165	3.99	225.62	96.19
1989	500	63.8	3 260	3.98	227.96	97.18
1990	500	64.0	3 151	4.04	224.69	95.79
1991	503	64.1	3 082	4.03	222.62	94.91
1992	505	64.2	3 015	4.01	220.71	94.09
1993	508	64.3	3 075	3.99	221.74	94.53
1994	510	64.4	3 121	4.02	223.31	95.20
1995	512	64.5	3 136	4.03	223.44	95.26
1996	515	64.6	3 249	4.07	226.90	96.73
1997	517	64.7	3 370	4.11	230.22	98.15
1998	520	64.8	3 491	4.12	231.40	98.65
1999	523	64.9	3 510	4.12	231.92	98.87
2000	526	65.2	3 668	4.12	234.69	100.05
2001	528	65.4	3 828	4.19	238.95	101.87
2002	531	65.6	3 902	4.19	240.41	102.49
2003	533	65.8	3 969	4.23	242.43	103.35
2004	540	66.0	4 082	4.22	245.50	104.66
2005	550	66.2	4 147	4.21	247.82	105.65
2006	560	66.4	4 200	4.18	249.38	106.32
2007	565	66.6	4 292	4.22	253.13	107.92
2008	570	66.8	4 351	4.14	253.50	108.07
2009	575	67.0	4 455	4.17	255.89	109.09
2010	580	67.2	4 487	4.18	256.36	109.29
2011	583	67.4	4 618	4.13	258.15	110.06
2012	585	67.6	4 845	4.15	263.25	112.23
2013	588	67.8	4 978	4.16	266.19	113.48
2014	590	68.0	5 164	4.08	269.28	114.80
2015	593	68.2	5 395	4.08	275.14	117.30
2016	595	68.6	5 563	4.09	278.46	118.71
2017	598	69.0	5 687	4.11	279.72	119.25
2018	600	69.4	5 747	4.08	278.98	118.93
2019	600	69.4	5 803	4.03	278.67	118.80
2020	600	69.5	5 946	4.07	282.17	120.30
2021	600	69.5	6 136	4.07	291.57	124.30

Table 5.2.8. Body mass (BM), daily weight gain (DWG) and crude protein in diet (CP%) for non-dairy cattle

Years	Young cattle <1 year			Young cattle 1-2 years			Heifers >2 years		Bulls >2 years	
	BM [kg]	DWG [kg/day]	CP%	BM [kg]	DWG [kg/day]	CP%	BM [kg]	CP%	BM [kg]	CP%
1988	245	0.60	17.50	365	0.51	16.80	500	18.0	700	15.6
1989	245	0.61	17.50	345	0.52	16.80	500	18.0	700	15.6
1990	235	0.62	17.50	355	0.53	16.80	500	18.0	710	15.6
1991	245	0.63	17.50	360	0.54	16.80	503	18.0	720	15.6
1992	250	0.64	17.50	365	0.55	16.80	505	18.0	730	15.6
1993	255	0.65	17.50	367	0.56	16.80	508	18.0	740	15.6
1994	257	0.66	17.50	369	0.57	16.80	510	18.0	750	15.6
1995	250	0.67	17.50	371	0.58	16.60	512	18.0	760	15.6
1996	253	0.68	17.50	375	0.59	16.40	515	17.9	770	15.6
1997	255	0.69	17.50	378	0.60	16.20	517	17.8	780	15.6
1998	257	0.70	17.50	380	0.61	16.00	520	17.5	790	15.6
1999	259	0.72	17.50	382	0.62	15.80	523	17.4	800	15.6
2000	261	0.73	17.50	385	0.63	15.60	526	17.3	810	15.6
2001	263	0.73	17.50	387	0.64	15.40	528	17.2	820	15.6
2002	265	0.74	17.40	390	0.64	15.20	531	17.1	830	15.5
2003	267	0.74	17.30	392	0.65	15.00	533	17.0	840	15.4
2004	269	0.74	17.20	395	0.65	14.90	540	16.9	850	15.3
2005	271	0.75	17.10	400	0.66	14.80	550	16.8	860	15.2
2006	274	0.75	17.00	410	0.67	14.70	560	16.7	870	15.1
2007	276	0.76	16.90	420	0.67	14.60	565	16.6	880	15
2008	279	0.76	16.80	425	0.68	14.50	570	16.5	890	14.9
2009	282	0.77	16.70	430	0.68	14.40	575	16.4	900	14.8
2010	284	0.77	16.60	433	0.69	14.30	580	16.3	910	14.7
2011	287	0.78	16.50	435	0.69	14.20	583	16.2	920	14.6
2012	290	0.78	16.40	437	0.70	14.10	585	16.1	930	14.5
2013	293	0.79	16.30	438	0.70	14.00	588	16.0	940	14.4
2014	295	0.79	16.20	440	0.70	13.90	590	16.0	950	14.3
2015	297	0.80	16.10	450	0.71	13.80	593	16.0	960	14.2
2016	299	0.80	16.00	450	0.71	13.80	595	16.0	970	14.1
2017	300	0.81	15.90	450	0.72	13.80	598	16.0	980	14.0
2018	305	0.83	15.80	450	0.72	13.80	600	16.0	990	13.9
2019	305	0.83	15.80	450	0.72	13.80	600	16.0	990	13.9
2020	305	0.83	15.80	450	0.72	13.80	600	16.0	990	13.9
2021	305	0.83	15.80	450	0.72	13.80	600	16.0	990	13.9

Table 5.2.9. Parameters DE and GE for non-dairy cattle

Years	Young cattle <1 year		Young cattle 1-2 years		Heifers >2 years		Bulls >2 years	
	DE	GE	DE	GE	DE	GE	DE	GE
1988	68.60	88.10	62.40	130.84	63.80	107.92	59.10	178.94
1989	68.60	88.67	62.40	126.31	63.80	107.92	59.10	178.94
1990	68.70	86.06	62.40	129.62	64.00	107.36	59.10	180.73
1991	68.70	89.06	62.40	131.49	64.10	107.53	59.20	182.04
1992	68.70	88.21	62.50	129.56	64.20	107.53	59.30	183.34
1993	68.80	89.57	62.60	130.17	64.30	107.70	59.40	184.61
1994	69.00	89.94	62.70	130.81	64.40	107.70	59.50	185.88
1995	69.10	88.15	62.80	131.44	64.50	107.71	59.60	187.13
1996	69.20	88.97	62.90	132.56	64.60	107.87	59.70	188.36
1997	69.20	89.75	63.00	133.44	64.70	107.87	59.80	189.58
1998	69.30	90.30	63.10	134.03	64.80	108.03	59.90	190.79
1999	69.30	91.56	63.20	134.61	64.90	108.19	60.00	191.98
2000	69.40	91.85	63.30	135.44	65.20	107.87	60.20	192.67
2001	69.60	91.96	63.40	136.03	65.40	107.63	60.40	193.34
2002	69.80	92.04	63.50	136.14	65.60	107.55	60.60	194.01
2003	70.00	92.09	63.60	136.24	65.80	107.32	60.90	194.18
2004	70.20	91.96	63.70	136.57	66.00	107.46	61.20	194.50
2005	70.40	92.23	63.80	137.60	66.20	106.89	61.50	194.79
2006	70.60	92.38	64.00	139.33	66.40	109.43	61.70	195.54
2007	70.80	92.33	64.30	140.78	66.60	109.79	61.90	196.27

Years	Young cattle <1 year		Young cattle 1-2 years		Heifers >2 years		Bulls >2 years	
	DE	GE	DE	GE	DE	GE	DE	GE
2008	71.00	92.65	64.50	141.31	66.80	110.04	62.10	197.00
2009	71.20	92.99	64.70	141.84	67.00	110.31	62.30	197.71
2010	71.40	93.09	65.00	141.50	67.20	110.56	62.50	198.42
2011	71.60	93.41	65.50	140.28	67.40	110.55	62.70	199.12
2012	72.00	93.41	65.90	139.45	67.60	110.38	62.90	199.80
2013	72.30	93.56	66.10	139.07	67.80	110.35	63.00	200.94
2014	72.50	93.69	66.50	138.19	68.00	110.18	63.10	202.07
2015	72.70	93.80	66.80	139.44	68.20	110.15	63.20	203.20
2016	72.80	94.12	67.00	138.72	68.60	109.55	62.30	209.14
2017	73.00	94.22	67.50	137.14	69.00	109.09	62.40	210.26
2018	73.20	95.50	67.80	136.27	69.40	108.50	63.50	206.51
2019	73.30	95.30	67.90	135.95	69.40	108.50	63.50	206.51
2020	73.20	95.50	67.90	135.95	69.50	108.29	63.50	206.51
2021	73.20	95.50	67.90	135.95	69.50	108.29	63.50	206.51

Table 5.2.10. Trends of emission factors from enteric fermentation for non-dairy cattle

Years	Non-dairy cattle weighted mean EF	Non-dairy cattle EF [kg CH ₄ /head/yr]			
		Young cattle <1 year	Young cattle 1-2 years	Heifers >2 years	Bulls >2 years
1988	46.35	37.56	55.78	46.01	76.29
1989	45.76	37.80	53.85	46.01	76.29
1990	45.71	36.69	55.26	45.77	77.05
1991	46.70	37.97	56.06	45.84	77.61
1992	46.22	37.60	55.23	45.84	78.16
1993	46.65	38.18	55.50	45.91	78.71
1994	46.85	38.34	55.77	45.92	79.24
1995	46.57	37.58	56.03	45.92	79.78
1996	46.95	37.93	56.51	45.99	80.30
1997	47.29	38.26	56.89	45.99	80.82
1998	47.10	38.50	57.14	46.06	81.34
1999	47.51	39.04	57.39	46.12	81.84
2000	47.71	39.16	57.74	45.99	82.14
2001	47.59	39.20	57.99	45.89	82.43
2002	48.07	39.24	58.04	45.85	82.71
2003	47.96	39.26	58.08	45.75	82.78
2004	48.13	39.21	58.22	45.81	82.92
2005	48.08	39.32	58.66	45.57	83.04
2006	48.88	39.39	59.40	46.65	83.36
2007	49.16	39.36	60.02	46.81	83.68
2008	49.16	39.50	60.25	46.91	83.99
2009	50.01	39.65	60.47	47.03	84.29
2010	50.07	39.69	60.33	47.14	84.59
2011	50.29	39.82	59.80	47.13	84.89
2012	50.70	39.82	59.45	47.06	85.18
2013	50.53	39.89	59.29	47.04	85.67
2014	50.26	39.94	58.92	46.97	86.15
2015	50.17	39.99	59.45	46.96	86.63
2016	50.01	40.12	59.14	46.70	89.16
2017	50.34	40.17	58.47	46.51	89.64
2018	50.59	40.71	58.09	46.26	88.04
2019	50.39	40.71	57.96	46.26	88.04
2020	50.50	40.71	57.96	46.17	88.04
2021	50.37	40.71	57.96	46.17	88.04

As relates to dairy cattle breeding and impact on milk productivity, three main factors influence the most: feeding, genetic and environmental. Observed in Poland increased milk productivity, especially after joining the EU in 2004, is related to all three factors, but genetic progress (mostly selection and increasing share of HF cattle) influences here the littlest. Still mean milk production in Poland is about 30% lower than, for instance, in Germany. The feeding factor has the highest impact on milk productivity improvement for country specific dairy cattle population based on research made by the National Research Institute of Animal Production. The feeding model reshaped into good quality maize

silage used for forage at the milk market. Significant investments were made on farms with changing from tied to free-stall maintenance systems in parallel with modernisation of cowsheds for semi-open buildings with curtain ventilation. Also thermal stress has been eliminated in herds with increasing milk productivity for both: high and low temperatures (elimination of pasturage during heat waves and thermal modernisation of barns).

Genetic progress still remains the most expensive way of increasing milk productivity. As the income of milk farms is relatively low most of them decides to cross/mix existing cattle with Holstein- Friesian (KF) breed than to purchase pure breed cattle. Mean share of HF mix within these herds is about 70%. However the remaining 70% of domestic dairy cows population is based on the Polish Black-White breed, Simental and Jersey characterised with lower body mass than HF. In Poland small milky farms still dominate having 15-30 dairy cattle for which genetic progress is too expensive. Moreover Simental breed is maintained at the mountainous areas where fodder is much worse taking into account climatic conditions.

5.2.3. Uncertainties and time-series consistency

Uncertainty analysis for the year 2021 for IPCC sector 3. *Agriculture* was estimated with use of approach 1 described in IPCC 2006 Guidelines for National Greenhouse Gas Inventories. This approach is based on the assumptions that every value is independent and probability distribution is symmetric. Results of the sectoral uncertainty analysis are given below. More details on uncertainty assessment of whole inventory are given in annex 8.

Recalculation of data for years 1988-2020 ensured consistency for whole time-series.

Detailed table with assumptions for the uncertainty of activity data and emission factors is presented below. Combined uncertainty estimated using error propagation formulas (approach 1) are also presented in the table.

2021	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ Emission uncertainty [%]	CH ₄ Emission uncertainty [%]	N ₂ O Emission uncertainty [%]
3. Agriculture	1 412.12	571.58	62.71	16.1%	28.9%	56.2%
A. Enteric fermentation		520.95			31.3%	
B. Manure management		49.50	9.73		51.3%	33.9%
D. Agricultural soils			52.94			66.3%
F. Field burning of agricultural residues		1.13	0.04		22.0%	118.2%
G. Liming	871.08			21.5%		
H. Urea application	399.14			30.4%		
I. Other carbon-containing fertilizers	141.90			30.4%		

Complementing data presented in Annex 8 on AD, EFs and combined uncertainty assessment for Agricultural sector some additional information is given below.

The primary source of activity data used for GHG emission calculation, relating number of livestock and corresponding parameters as well as crop production and nitrogen fertilizers use, is the national statistical office – Statistics Poland (GUS) which is also a substantial data provider to the Eurostat and other international bodies. The main rural publications are prepared by the GUS's Agricultural Department and cover yearbooks on:

- Farm animals,
- Production of agricultural and horticultural crops,
- Means of production in agriculture,
- Agricultural Statistical Yearbooks.

Yearly data published by GUS are based on representative samples and verified with data collected during the General Agricultural Censuses performed every 10 years on average (the last ones occurred in 2011 and 2020). Therefore relatively low uncertainty (5%) is attributed to AD in agricultural sector as relates to livestock population or crop production. The electronic database is also developed by GUS allowing to import and cross-check data in trends back to 1999 or 2004 depending on range of data. Detail method of elaboration of livestock population on a yearly basis is presented in Annex 5. Higher uncertainty (30%) relates to AD for field burning of agricultural residues where amount of crop waste is assessed based on case study. The same range of uncertainty covers urea application where data come from international database on fertilizers (IFASTAT).

Uncertainties related to emission factors are noticeably higher than those for the activity data. Application of Tier 2 methodologies involving country specific parameters instead of IPCC default EFs, also diminishes the uncertainty EFs ranges. Uncertainty accompanying CH₄ implied emission factors reaches 50% as they rely partially on experts analysis covering animal waste management systems. Even higher uncertainty concerns the EFs for nitrous oxide, reaching 100–150%, what influence the combined uncertainty as % of particular GHG emissions. The highest combined uncertainties characterise soil related N₂O emissions (reaching 70%), especially indirect ones, what is caused among others by natural variability, spatial data aggregation as well as rare measurements.

5.2.4. Source-specific QA/QC and verification

Activity data related to livestock population and any additional parameters like milk productivity or cattle pregnancy come from national statistics prepared by the Statistics Poland. Data like livestock population, crop production, nitrogen fertilizers use and others are available in several publications as well as electronic database that were cross-checked. Emphasis was put on data consistency between sub-categories and between sectors using agricultural data. Also emphasis on comparison and consistency is checked with the input data applied in the UNECE CLRTAP and NECD reporting in Agriculture sector. Emission factors and methodology is compared with international literature and other countries methods/EF applied. Calculations were examined with focus on formulas, units and trends consistency.

In 2019 additional cross check for emission calculation was done by the modelling team working in frames of the EU project CAKE (Centre for Climate and Energy Analyses – <http://climatecake.pl/?lang=en>) elaborating, among others, model for policy assessment of mitigation actions undertaken in agriculture. All major GHG emission agricultural sources reported under UNFCCC following IPCC methodology were considered. Generally QC procedures follow QA/QC plan presented in Annex 7.

As a part of verification specific data related to livestock breeding are compared with other European countries (tab. 5.2.11). As the National Inventory Reports are elaborated by Parties in the same time, only data related to emission factors and other characteristics can be compared from previous reporting year. Cross-check for dairy cattle generally indicates that Polish characteristics does not deviate from neighbouring countries – although milk production is in lower range but GE and IEF are in the middle of the range due to specific dairy cattle breeding conditions described in Chapter 5.2.2.

When comparing to IPCC default CH₄ emission factor for dairy cattle the country specific one is higher (89 kg CH₄/animal/year for Eastern Europe with average milk production 2550 kg/head/yr) due to increasing intensification of dairy cattle production, characterised among others, with growing milk production (tab. 5.2.7).

Non-dairy IEF for Poland is lower than the IPCC default (58 kg CH₄/animal/year for Eastern Europe) what relates to high share of youngest cattle (< 1 year) among this category (53% in 1998 and 44% in 2020) (table 5.2.3). Also the Polish CH₄ CS EF for non-dairy cattle is at lower level of the EFs reported by other European countries (tab. 5.2.11).

Table 5.2.11. Comparison of parameters and Implied Emission Factors related to methane emissions from enteric fermentation for cattle in 2020

Country	Dairy cattle			Non-dairy cattle
	Milk yield [kg/head/yr]	GE intake [MJ/day]	IEF [kg CH ₄ /head/yr]	IEF [kg CH ₄ /head/yr]
Austria	20.0	315	130	54
Czechia	25.0	374	159	59
Germany	23.2	343	141	48
France	20.3	315	127	53
Hungary	23.1	322	125	56
Lithuania	17.1	307	131	59
Poland	16.8	283	121	51
Romania	9.8	293	125	65
Slovakia	20.4	287	122	61
Ireland	16.0	273	122	48
IPCC default value	–	–	109 (Western Eurpe) 89 (Eastern Europe)	57 (Western Eurpe) 58 (Eastern Europe)

5.2.5. Source-specific recalculations

- Correction of population has been made for goats and horses for the following years: 2015-2016 and 2018–2020, as well as for poultry for 2020;
- Update of DE parameters for cattle for 2018-2020 influencing GEs and thus Nex;

Table 5.2.12. Changes in CH₄ emissions from manure management due to recalculations

Change	1988	1989	1990	1991	1992	1993	1994
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	1995	1996	1997	1998	1999	2000	2001
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	2002	2003	2004	2005	2006	2007	2008
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	2009	2010	2011	2012	2013	2014	2015
kt	0.00	0.00	0.00	0.00	0.16	0.00	0.33
%	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%	0.07%
Change	2016	2017	2018	2019	2020		
kt	0.29	0.00	-0.18	-0.74	-1.50		
%	0.06%	0.00%	-0.04%	-0.15%	-0.29%		

5.2.6. Source-specific planned improvements

Presently no further improvements are planned.

5.3. Manure Management (CRF sector 3.B)

5.3.1. Source category description

CH₄ emissions related to animal manure management in 2021 amounted to 49.5 kt and decreased since 1988 by about 42.4%. Most of CH₄ emissions come from manure generated by cattle (53%) and swine (30%).

Table 5.3.1. Trends in CH₄ emissions from manure management according to livestock categories [kt CH₄]

Year	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Swine	Poultry	Fur animals	Total
1988	28.028	12.207	0.832	0.023	1.640	36.657	6.076	0.416	85.878
1989	29.506	13.899	0.838	0.023	1.518	35.271	6.853	0.387	88.296
1990	28.316	10.048	0.790	0.023	1.468	36.504	5.995	0.359	83.503
1991	26.170	9.609	0.614	0.023	1.465	41.075	5.712	0.330	84.998
1992	23.896	8.792	0.355	0.023	1.404	41.547	5.374	0.301	81.692
1993	22.133	7.909	0.241	0.023	1.312	35.532	5.321	0.272	72.745
1994	21.674	8.203	0.165	0.023	0.970	36.729	5.673	0.243	73.681
1995	20.143	7.719	0.135	0.023	0.992	38.583	5.256	0.215	73.067
1996	19.504	7.483	0.105	0.023	0.888	33.997	5.195	0.186	67.381
1997	20.367	7.640	0.093	0.024	0.870	34.372	5.072	0.196	68.635
1998	20.389	6.934	0.086	0.024	0.875	36.573	5.272	0.205	70.358
1999	21.374	6.583	0.074	0.024	0.860	35.335	5.338	0.215	69.803
2000	19.965	6.394	0.069	0.023	0.858	32.632	5.340	0.225	65.505
2001	19.693	5.884	0.065	0.022	0.852	32.745	5.502	0.235	64.997
2002	22.540	5.839	0.066	0.025	0.515	35.720	5.300	0.245	70.250
2003	25.021	5.690	0.064	0.025	0.519	35.652	3.680	0.259	70.910
2004	26.471	5.457	0.060	0.023	0.501	32.544	3.365	0.272	68.694
2005	26.710	5.735	0.060	0.018	0.487	35.529	4.104	0.286	72.929
2006	26.232	5.802	0.057	0.017	0.479	35.977	3.881	0.300	72.745
2007	26.102	6.090	0.063	0.019	0.513	33.665	4.069	0.314	70.835
2008	25.839	6.029	0.061	0.018	0.507	27.395	3.959	0.328	64.137
2009	24.249	6.138	0.054	0.015	0.465	24.928	3.875	0.342	60.068
2010	22.775	6.194	0.049	0.014	0.412	25.018	3.649	0.356	58.467
2011	22.939	6.297	0.048	0.015	0.397	21.790	3.934	0.334	55.752
2012	22.784	6.352	0.051	0.012	0.347	18.653	3.834	0.312	52.344
2013	22.473	6.487	0.042	0.011	0.335	17.850	3.876	0.290	51.365
2014	22.131	6.647	0.038	0.011	0.323	18.618	4.015	0.438	52.221
2015	21.600	6.621	0.043	0.008	0.335	17.977	4.447	0.587	51.618
2016	20.075	6.615	0.045	0.007	0.323	16.321	5.046	0.735	49.166
2017	19.746	6.785	0.050	0.006	0.289	16.604	5.308	1.195	49.983
2018	19.359	6.645	0.053	0.006	0.274	16.796	5.656	1.655	50.444
2019	19.026	6.600	0.052	0.007	0.259	14.857	5.845	2.116	48.761
2020	19.264	6.695	0.055	0.007	0.244	15.751	6.002	2.576	50.594
2021	19.264	6.907	0.055	0.007	0.244	14.646	5.341	3.037	49.500
<i>share [%] in 2021</i>	38.92	13.95	0.11	0.01	0.49	29.59	10.79	6.13	100.00
<i>change [%] 1988-2021</i>	-31.27	-43.42	-93.40	-69.83	-85.11	-60.05	-12.11	629.93	-42.36

Generally decreasing trend is observed in CH₄ emissions from manure management for all livestock sub-categories, where the biggest drop over time occurred to sheep breeding where CH₄ emissions

dropped by 93% in 1988-2021 (tab. 5.3.1). The main reason for decreasing emissions are diminishing livestock populations, implemented abatement measures and conditions described in previous chapter.

N₂O emissions from manure management amounted to 9.7 kt in 2021 and drop since 1988 by 29.6% what is associated mostly with the diminishing livestock population. Direct emissions are responsible for about 49% and indirect for 51% of N₂O emissions in this category in 2021 (fig. 5.3.1).

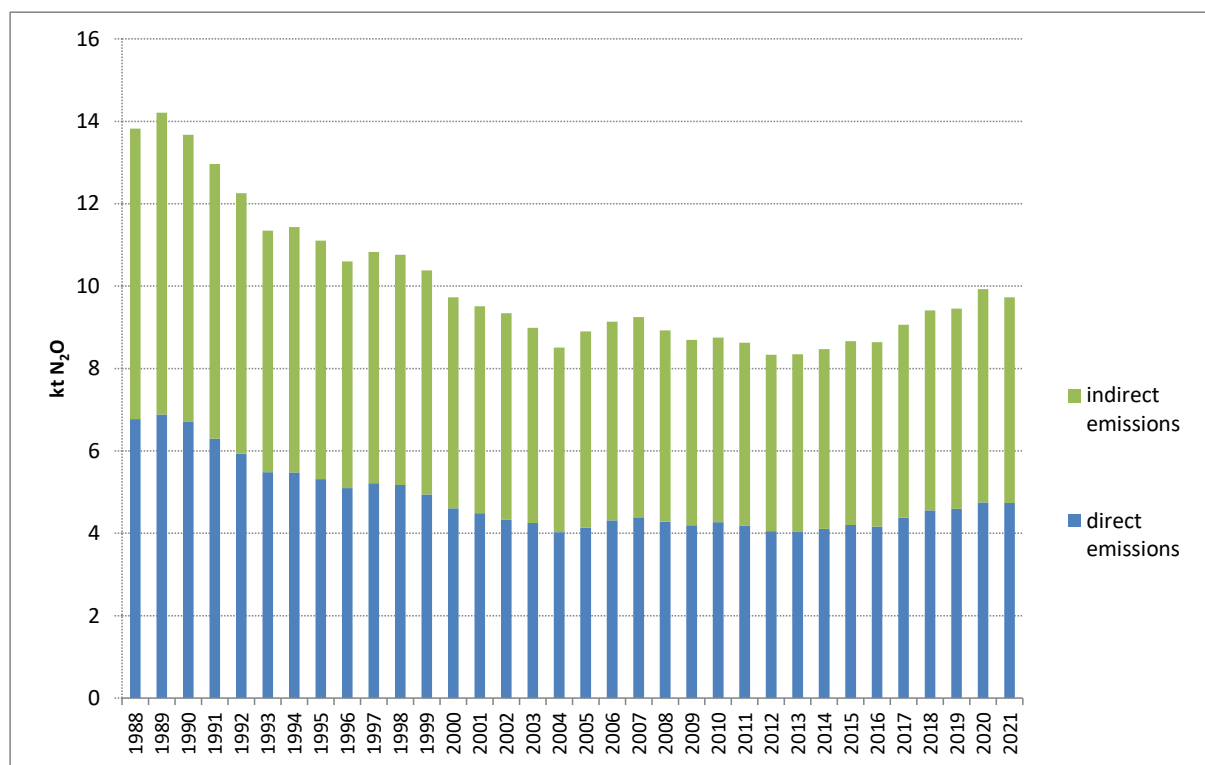


Figure 5.3.1. Trend of N₂O emissions (in division for direct and indirect) from manure management

5.3.2. Methodological issues

The source of activity data i.e. animal population was taken from the public statistics as described in chapter 5.2.2 (tab. 5.2.2, 5.2.3).

Country specific data on the animal waste management systems (AWMS) come from [Walczak 2006, 2009, 2011, 2012, 2013]. The fractions of manure managed in given AWMS for cattle were assessed on an annual basis for periods 1988-2002 and 2004-2012, data for 2003 was interpolated between 2002 and 2004. The share of pastures and solid storage were assessed for the key years: 1988-1989 and for 2004-2012 and the values in-between were interpolated (tab. 5.3.2). As concerns swine manure management systems the share of liquid and solid storage was estimated based on AWMS shares and pigs population for age categories for 1988 [Walczak 2006]. Data for 2004-2012 was taken from [Walczak 2011, 2012, 2013]. Data for years between 1988 and 2004 interpolation was made. Data for 2012 were used for 2013-2021.

For other animals permanent shares of AWMS for entire inventoried period were assumed based on data assessed for 2004-2012: for sheep - 40% on pastures and 60% solid storage, for goats: 44% on pastures and 56% on solid storage and for horses: 22% and 78% respectively. For poultry the following AWMS shares were established: 11% on litter-free systems and 89% on solid storage [Walczak 2011, 2012, 2013].

According to the results of the Agricultural Census (PSR 2020), published in late 2022, the number of farms in June 2020 was 1,317.4 thousand. Out of this number, 99.4% (1,309.9 thousand) were

individual farms, which owned 91.3% of the total agricultural land and 90.8% of the total conversion units of large livestock on farms. In 2020, the trend of a decrease in the number of farms with a simultaneous increase in their average area, recorded for many years, continued. Compared to Agricultural Census results from 2010, the number of farms decreased by approx. 192 thousand. (by 12.7%). This was caused by a decrease in the number of farms in the area groups of agricultural land (AL) from 1 to 20 ha. The deepest decrease concerned the area group of 1–2 ha of AL (by over ¼) and 5–10 ha of AL (by over 16%). The smallest number of farms decreased in the group of 2–3 ha of agricultural land. It should be noted that generally in Poland prevail small farms where 52% farms have up to 5 ha and 74% below 10 ha, and only 3% above 50 ha in 2020.

In the 2010-2020 decade, the number of the smallest farms with an area of up to 1 ha of agricultural land increased (by 1.6%) and the largest farms belonging to the area groups of 20 ha and more of agricultural land. The largest number of farms was added in the area group of 50 ha and more AL (over 50%). The observed trend of a decrease in the number of farms was reflected in an increase in the average area of agricultural land per farm - from 9.85 ha in 2010 to 11.35 ha in 2020. This increase was mainly due to the increase in the average area in farms with an area of 20–50 ha of agricultural land.

Among all farms, 1,311.9 thous. (99.6%) had agricultural land and 582.1 thous. (approx. 44%) kept livestock. On average in the country, one farm keeping livestock had: 23 head of cattle, 131 head of swine, 4.4 head of horses, 7.2 head of goats, 30.9 head of sheep and 615.5 poultry birds.

Solid manure was used by 482.8 thous. farms, slurry – 139.4 thousand as well as 110.6 thous. farms used poultry manure for fertilization. Natural fertilization was used mainly by farms specializing in field crops, while and slurry was used by farms specializing in rearing animals fed with roughage. It follows the proportion of solid and liquid systems of livestock maintenance where solid one prevail [GUS R3 2022].

Such fragmentation of agricultural farms causes that solid systems for animal management are commonly used due to lower investment costs. Liquid systems are applied mostly at big farms, for instance having more than 120 dairy cattle or above 500 pigs. Development of such big milk farms in early years of 2000 influenced significant increase of CH₄ emissions from manure management for dairy cattle since 2002. As relates to AWMS for pigs data established by the National Research Institute of Animal Production can be supported by expertise [Winnicki et al, 2009] where analysis was made for 2004-2009 which concluded that most of farms in Poland apply solid systems with bedding reaching even 80%. When modernizing, adapting or revitalizing piggeries up to 50–60 sows or 300 fattening pigs bedding systems were introduced.

The data on AWMS shares for livestock has been prepared by the Institute of Animal Production where the database has been established. The database covers livestock population together with their waste management systems (solid, liquid) to determine impact of animal production on natural environment. This database covers animal breeding according to groups (technological and age) for Poland and has been constructed based on livestock monitoring on farms across country in frames of Multiannual Program: "Protection and management of national genetic resources of livestock in the sustainable use conditions" in 2011-2015. Data related to AWMS share will be cross-checked and updated based on results of the Agricultural Census (2020) performed by the Statistics Poland.

Table 5.3.2. Fractions of manure managed in given AWMS for cattle and swine for selected years [%]

	Dairy cattle			Other cattle			swine		
	liquid	solid	pasture	liquid	solid	pasture	liquid	solid	pasture
1988	2.8	75.2	22.0	4.9	77.1	18.0	22.3	77.7	0.0
1990	2.7	76.1	21.2	3.2	79.2	17.6	22.4	77.6	0.0
1995	2.3	80.4	17.2	3.8	80.6	15.6	22.7	77.3	0.0
2000	3.7	83.1	13.2	4.0	82.4	13.6	23.0	77.0	0.0
2005	10.6	79.4	10.0	5.2	82.8	12.0	24.0	76.0	0.0
2010	10.1	79.6	10.3	5.1	82.9	12.1	25.5	74.5	0.0
since 2012	10.5	79.2	10.3	5.1	82.9	12.0	24.3	75.7	0.0

5.3.2.1. Estimation of CH₄ emissions from manure management

The *Tier 1* methodology was used for estimation of CH₄ emissions from manure management of horses, sheep, goats, swine, poultry, rabbits and fur animals [IPCC 2006] (tab. 5.3.3).

Table 5.3.3. CH₄ Emission factors applied for selected livestock where Tier 1 methodology was used based on IPCC 2006 GLs

Livestock	EF Emission Factors [kg CH ₄ /animal/year]
Sheep	0.19
Goats	0.13
Horses	1.56
Poultry:	
Layers (dry)	0.03
Broilers	0.02
Turkeys	0.09
Ducks	0.02
Rabbits	0.08
Fur-bearing animals	0.68

The *Tier 2* methodology was used to establish domestic CH₄ emission factors for cattle applying equation 10.23 from [IPCC 2006]:

$$EF = Vs * 365 \frac{\text{days}}{\text{year}} * B_o * 0.67 \frac{\text{kg}}{\text{m}^3} * \sum MCF * MS$$

where:

EF – emission factor (kg CH₄/animal/year),

Vs – average daily volatile excreted solids,

B_o – maximum CH₄ production capacity for manure produced by animal,

MCF – methane conversion factors for each manure management system for cool climate [IPCC 2006, tab. 10.17],

MS – fraction of livestock category manure in given AWMS (table 5.3.2).

Detail information on parameters used in methane emissions estimation from manure management for cattle is given in table 5.3.4. The CS methane EFs for dairy cattle range from above 6 kg CH₄/animal/year in early 1990. to 10 kg CH₄/animal/year in 2005 (tab. 5.3.5) and slowly decreasing to 8 after 2005 where cover of tanks with slurry were used following legal obligations (table 5.3.12). EFs for years for mid 2000 are close to the IPCC default ones (11 kg CH₄/animal/year for cool climate ≤10°C). More data on comparison of CH₄ EFs from manure management with other countries is presented in chapter 5.3.4.

Table 5.3.4. Parameters used for calculation of CH₄ emissions from manure management for cattle

Parameters/unit	Source/reference	Values/comments
Volatile solids (Vs) [kg DM/head/day]	equation 10.24 in IPCC 2006 GLs	Calculated with the use of specific GE and DE parameters
Urinary energy expressed as fraction of GE	IPCC 2006 GLs	0.04
ASH content	IPCC 2006 GLs	0.08
Maximum CH ₄ producing capacity (B _o) [m ³ CH ₄ /kg Vs]	IPCC 2006 GLs	0.24 for dairy cattle 0.17 for non-dairy cattle

Table 5.3.5. Volatile excreted solids and CS CH₄ EFs for cattle

Years	Dairy cattle		Non-dairy cattle	
	Vs [kg DM/head/day]	CH ₄ EF [kg/head/yr]	Vs [kg DM/head/day]	CH ₄ EF [kg/head/yr]
1988	4.52	5.83	2.08	2.21
1989	4.57	5.91	2.05	2.42
1990	4.48	5.76	2.05	1.96

Years	Dairy cattle		Non-dairy cattle	
	Vs [kg DM/head/day]	CH ₄ EF [kg/head/yr]	Vs [kg DM/head/day]	CH ₄ EF [kg/head/yr]
1991	4.43	5.72	2.09	2.25
1992	4.38	5.61	2.07	2.22
1993	4.39	5.56	2.08	2.16
1994	4.41	5.61	2.08	2.14
1995	4.40	5.63	2.06	2.07
1996	4.46	5.64	2.08	2.04
1997	4.51	5.84	2.09	2.00
1998	4.52	5.76	2.07	2.03
1999	4.52	6.25	2.09	2.10
2000	4.54	6.44	2.09	2.14
2001	4.60	6.55	2.07	2.16
2002	4.60	7.85	2.09	2.20
2003	4.62	8.63	2.07	2.20
2004	4.65	9.47	1.89	2.13
2005	4.67	9.56	1.87	2.13
2006	4.68	9.29	1.90	2.09
2007	4.72	9.37	1.90	2.09
2008	4.70	9.21	1.88	2.04
2009	4.72	9.02	1.92	2.04
2010	4.70	8.58	1.91	2.02
2011	4.71	8.74	1.90	2.01
2012	4.78	8.84	1.90	1.99
2013	4.81	8.88	1.87	1.95
2014	4.83	8.93	1.85	1.93
2015	4.91	8.84	1.82	1.88
2016	4.92	8.61	1.81	1.83
2017	4.88	8.32	1.81	1.80
2018	4.81	7.97	1.80	1.76
2019	4.81	7.73	1.79	1.72
2020	4.85	7.81	1.79	1.73
2021	5.02	8.07	1.79	1.72

The rising trend of Polish EFs for dairy cattle is mostly related to increasing share of liquid systems since 1988. On the other hand the methane CS EFs for non-dairy cattle is less than 2 kg CH₄/animal/year in entire period and is lower than the IPCC default EF (6 kg CH₄/animal/year) due to relatively small share of liquid systems applied and moderate level of GE (see also table 5.3.2).

For calculation of methane emissions from manure management from swine bred also the equation 10.23 from [IPCC 2006] was used but the default values for Vs, B₀ and MCF were applied [IPCC 2006]. The weighted mean CH₄ EF calculated for 2021 as described above for market swine is 1.3 kg CH₄/animal/year and for breeding swine 2.2 kg CH₄/animal/year and both EFs are lower than the IPCC default EFs (3 kg CH₄/animal/year for market swine and 4 kg CH₄/animal/year for breeding swine). These EFs decrease after 2005 when abatement measures are gradually endorsed with slurry tanks covering (table 5.3.11).

Table 5.3.6. Methane-producing potential (B₀), volatile solids excreted (Vs) and CH₄ emission factors for manure management for swine

Livestock	EF Emission Factor [kg CH ₄ /animal/year]	Vs Volatile Solids Excreted [kg d.m./animal/day]	B ₀ Methane-producing potential [m ³ CH ₄ /kg Vs]
Market swine	1.33	Market swine: 0.30	0.45
Breeding swine	2.15	Breeding swine: 0.50	

Methane conversion factors (MFCs) for all systems were taken from the table 10.17 of the IPCC 2006 Guidelines for cool climate ≤ 10°C (see table 5.3.5). As relates to liquid/slurry animal manure storage the reduction measures are taken since 2006 directed to cover slurry tanks (tab 5.3.11). The same reduction measures are taken into account for estimation of NH₃ and NO_x emissions under NECD and UNECE CLRTAP reporting based on case study (Walczak 2016). Therefore CH₄ MCF values characterised

as “with natural crust cover” for the part of slurry under cover were applied and the ones “without natural crust cover” (tab. 5.3.7) for the rest of slurry and period before 2006 (Chapter 5.3.2.2). Data between years 2005–2010–2014–2019 were interpolated. Since 2019 100% of tanks with liquid slurry need to be covered.

Table 5.3.7. MCF values for manure management applied in CH₄ emissions [IPCC 2006 GLs table 10.17]

System	MCF for cool climate ≤ 10°C
pasture/range/paddock	1%
solid storage	2%
liquid/slurry systems with cover	10%
liquid/slurry systems without cover	17%

Methane combusted in biogas plants, including agriculture biogas plants, is included in energy sector. As relates to separation of methane emissions from anaerobic digesters in manure management category (recommendation A.4 from FCCC/ARR/2020/POL) – this work is still under development due to specific data needed available only from satellite studies and agricultural census made by national statistics.

Data on inputs (including manure) used in agricultural biogas plants so far collected for 2011–2017 and updated up to 2020 from the National Centre for Agricultural Support (KOWR) is not sufficient for incorporating into emission calculations. So additional information was gained from the national statistics which started to publish data on manure applied on soils for the last years. Here the share of manure used in biogas plants could be assessed. As the IPCC 2006 GLs do not provide MCFs for anaerobic digester therefore the new IPCC 2019 Refinement GLs are going to be employed presented in Table 10-17 where MCFs for anaerobic digesters are divided for groups depending on leakage and digestate management. Based on information from the National Centre for Agricultural Support it is assumed that only low leakage installations are operating in Poland but digestate is stored both in gastight tanks or in the open air. Information on types of agricultural biogas plants operating in Poland was seek through questionnaire sent in January 2022. Data collected from the query covered about 30% biogas installations. Here weighted mean MCF was assigned. Shortage in the data still exists and relates to differentiation of manure used in anaerobic digesters in relation to livestock so the simplified method was used to assign the same share of liquid or solid manure used in biogas from cattle or swine.

Initial calculations made for 2020 indicate that methane emissions savings due to using some part of manure in agricultural biogas plants, instead of application on soils, can reach about –0,7 kt CH₄ what constitutes 0.0046% of total GHG emission. This issue will be further developed and concluded in the next submission.

5.3.2.2. Estimation of direct N₂O emissions from manure management

Direct nitrous oxide emissions from manure management were estimated based on recommended IPCC methodology [IPCC 2006, equation 10.25] using the same AWMS data as for CH₄ emissions (chapter 5.3.2.1):

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T (N_{(T)} * Nex_{(T)} * MS_{(T,S)}) \right] * EF_{3(S)} \right] * \frac{44}{28}$$

where:

- N₂O_{D(mm)} – direct N₂O emissions from manure management in the country (kg N₂O/year),
- N_(T) – livestock population in given category *T* in the country,
- Nex_(T) – annual average N excretion per head of livestock category *T* in country (kg N/animal/year),
- MS_(T,S) – fraction of total annual nitrogen excretion for each livestock category *T* managed in manure management system *S*,
- EF_{3(S)} – emission factor for direct N₂O emissions from manure management system *S* (kg N₂O–N/kg N),

S – manure management system,

T – livestock category,

44/28 – conversion of $(\text{N}_2\text{O}-\text{N})_{(\text{mm})}$ emissions to $\text{N}_2\text{O}_{(\text{mm})}$ emissions.

Data on animals' nitrogen excretion rates (Nex, kg N/head/year) are mostly country specific ones [IUNG 2014, Pastuszak, Igras 2012], except of rabbits and fur bearing animals which were taken from on IPCC 2006 GLs (Table 5.3.9). Following the ERT 2018 recommendation (FCCC/ARR/2020/POL A.6,7) Nex for cattle and poultry were updated. Cattle Nex parameters (Table 5.3.8) were based on the IPCC 2006 GLs methodology (equations 10.31 and 10.32) with gross energy (GE) as presented in Chapter 5.2.2 and percent of crude protein in diet (CP%) based on country study [Walczak 2020] (presented in Tables 5.2.7 and 5.2.8). Fraction of N intake that is retained by animal ($\text{N}_{\text{retention}}$) are taken from Table 10.10 of the IPCC 2006 GLs: 0.2 for dairy cows and 0.07 for other cattle.

The same Nex parameters are used in CLRTAP-NECD inventory. Nex for poultry comes from publication summarizing international project concerning emissions of nitrogen and phosphorus from Polish territory to the Baltic Sea [Pastuszak, Igras 2012] and are presented in Table 5.3.9.

Country specific Nex values are generally in line with parameters published by EMEP/EEA for most livestock categories. The basis for assessment of Nitrogen excretion rates (Nex) by [IUNG 2014, Pastuszak, Igras 2012] constitutes the standard amounts of nitrogen in faeces and urine determined for different groups of livestock animals grounded on standard quantity, sort and digestibility of fodder applied.

Table 5.3.8. Country specific Nitrogen excretion rates (Nex) in manure for cattle and swine [kg N/animal]

Livestock categories	1990	1995	2000	2005	2010	2015	2016	2019	2020	2021
Dairy cattle > 2 years	102.42	101.85	102.81	105.43	105.81	111.48	112.82	112.90	114.32	118.13
Young cattle <1 year	44.34	45.41	47.32	46.43	45.49	44.46	44.33	44.33	44.42	44.42
Young cattle 1-2 years	64.11	64.23	62.20	59.95	59.57	56.65	56.35	55.23	55.23	55.23
Heifers > 2 years	56.89	57.07	54.93	52.86	53.05	51.88	51.60	51.10	51.10	51.10
Bulls > 2 years	83.00	85.93	88.48	87.16	85.86	84.94	86.81	84.50	84.50	84.50
Other cattle (weighted mean)	53.98	54.71	54.51	53.00	53.08	51.34	51.05	51.08	51.12	50.96
Swine (weighted mean)	9.97	9.97	10.03	9.86	10.07	10.43	10.34	10.88	10.91	10.93

Table 5.3.9. Nitrogen excretion rates (Nex) for other livestock and swine subcategories used in emission calculations in 1990–2021 [kg N/animal]

Livestock categories	Nex	Reference
Swine:		
Piglets (< 20 kg)	2.6	CS [IUNG, 2014]
Piglets (20-50 kg)	9.0	
Fattening pigs (> 50 kg)	15.0	
Butcher hogs	18.0	
Sows	20.0	
Sheep	9.5	CS [IUNG, 2014]
Horses	55.0	CS [IUNG, 2014]
Goats	8.0	CS [IUNG, 2014]
Hens	0.725	CS [Pastuszak, Igras 2012]
Broilers	0.435	CS [Pastuszak, Igras 2012]
Turkeys	1.554	CS [Pastuszak, Igras 2012]
Ducks	1.381	CS [Pastuszak, Igras 2012]
Geese	1.640	CS [Pastuszak, Igras 2012]
Rabbits	8.10	D [IPCC 2006 table 10.19]
Minks and polecats	4.59	D [IPCC 2006 table 10.19]
Foxes, racoons	12.09	D [IPCC 2006 table 10.19]

The exemptions are sheep and goats where Nex values for Poland are among group of countries with lower factor than the default ones in IPCC 2006 GLs. The country specific Nex values were established based on livestock categories raised in Poland as well as country specific conditions and international literature and research. Sheep (as well as goats) in Poland are fed on pastures for around half a year and housed for another half. Sheep and goats are fed mostly on roughage from extensive pastures and meadows. Winter feeding cover hay, straw and root crops. Additional protein fodder is not widely applied among sheep and goats, if applied it is limited to lambs. It should be mentioned here that Nex is established for entire group of sheep of which about 30% are lambs and other immature animals.

Table 5.3.10. Population of fur-bearing animals in 1983 according to species

Fur-bearing females	1983
Foxes	164 403
Minks	40 948
Nutrias	464 039
Polecats and polecats-ferrets	20 695
Chinchillas	4 242
Yenots	596

For rabbits and other fur-bearing animals the *Tier 1* method and default Nex values were used from [IPCC 2006, table 10.19] where Nex for rabbits amounts to 8.1 kg N/head/yr. As the detail disaggregation of fur-bearing animals listed in national statistics was given only up to 1983 (tab. 5.3.10) the share from 1983 was used to establish the weighted mean Nex value (6.36 kg N/head/yr) for all fur-bearing animals using default Nex values: 12.09 for foxes and 4.59 kg N/head/yr for minks, polecats and others. The next available data on rabbits and fur-bearing animals (but without disaggregation for species) was published by Statistics Poland in 1996 in frames of national agricultural census. Since that time data on fur-bearing animals are published periodically (see Chapter 5.2.2).

Table 5.3.11. Abatement techniques related to cover the slurry tanks

NH ₃ abatement techniques	% of animal population covered in years			
	2005	2010	2014	Since 2019
Cattle slurry under cover	0.0	43.5	44.8	100
Swine slurry under cover	0.0	61.8	67.2	100

Table 5.3.12 Emission factors for calculating N₂O emissions from manure management [IPCC 2006]

Animal Waste Management Systems	Emission factor (EF ₃) [kg N ₂ O-N/kg N]
Liquid/slurry with natural crust cover	0.005
Liquid/slurry without natural crust cover	0.000
Solid storage	0.005
Pit storage below animal confinements	0.002
Poultry manure with litter	0.001
Poultry manure without litter	0.001

Default values of N₂O emission factors for given management systems from [IPCC 2006, table 10.21] were applied (table 5.3.12). As relates to liquid/slurry animal manure storage the reduction measures are taken after 2005 directed to cover such tanks in part of farms (tab. 5.3.11). The same reduction measures are taken into account for estimation of NH₃ and NO_x emissions under NECD and UNECE CLRTAP reporting and are based on case study (Walczak 2016). Therefore N₂O EFs characterised as “with natural crust cover” for the part of slurry under cover were applied and “without natural crust cover” (tab. 5.3.12) for the rest of slurry and period before 2006. Data between years 2005–2010–2014–2019 were interpolated.

5.3.2.3. Indirect N₂O emission from manure management

Following IPCC 2006 Guidelines the indirect N₂O emissions from manure management were estimated based on equations: 10.27 (N volatilisation) and 10.29 (N leaching) as well as nitrogen excretion rates (Nex) and manure management systems shares (MS) described in previous subchapters related to GHG

emissions from manure management. Emission factor for calculation of N_2O emissions from atmospheric nitrogen deposition was assumed as 0.01 kg $\text{N}_2\text{O-N}$ while emission factor for N_2O emissions from nitrogen leaching and runoff was adopted as 0.0075 kg $\text{N}_2\text{O-N}$ (default EFs from IPCC 2006).

Nitrogen losses related to volatilisation from manure management were calculated based on equation 10.26 [IPCC 2006] where fractions of managed manure nitrogen for given livestock category that volatilises as NH_3 and NO_x in given manure system (Frac_{GAS}) are taken from [IPCC 2006 table 10.22]. Nitrogen losses due to leaching from manure management were estimated based on equation 10.28 [IPCC 2006] applying fraction of managed manure nitrogen losses for livestock categories due to runoff and leaching during manure storage as the difference between Nitrogen loss from manure management $\text{Frac}_{\text{LOSSM}}$ [IPCC 2006 Table 10.23] and Nitrogen loss due to volatilisation of NH_3 and NO_x from manure management $\text{Frac}_{\text{GASSMS}}$ [IPCC 2006 Table 10.22].

Here recommendation A.18 from review report FCCC/ARR/2020/POL was also implemented where updated Nex parameters for cattle and poultry were applied.

5.3.3. Uncertainties and time-series consistency

Description of uncertainties is given in Chapter 5.2.3.

5.3.4. Source-specific QA/QC and verification

Activity data related to livestock population come from national statistics prepared by the Statistics Poland (GUS). Data on Animal Waste Management Systems are elaborated by the National Research Institute of Animal Production which develops activities aiming at obtaining representative data on the production of main livestock categories. Collection of this data is based on appointing a suitable monitoring for various institutions like statistical office, Farmers Chambers, Centres for Agricultural Advice and Veterinary Inspection. Partially monitoring is covered also by Institute's employees.

Emphasis was put on data consistency between sub-categories and between sectors using agricultural data. Also emphasis on comparison and consistency is checked with the data applied in the UNECE CLRTAP and NECD reporting in Agriculture sector. Emission factors and methodology is compared with international literature and other countries methods/EF applied. Calculations were examined with focus on formulas, units and trends consistency. In 2019 additional cross check for emission calculation was done by the modelling team working in frames of the EU project CAKE (Centre for Climate and Energy Analyses – <http://climatecake.pl/?lang=en>) elaborating, among others, model for policy assessment of mitigation actions undertaken in agriculture. All major GHG emission agricultural sources reported under UNFCCC following IPCC methodology were considered. Generally QC procedures follow QA/QC plan presented in Annex 7.

As a part of verification specific data related to livestock breeding are compared with other European countries (tab. 5.3.13). As the National Inventory Reports are elaborated by Parties in the same time, only data related to emission factors and other characteristics can be compared from previous reporting year. Cross-check for dairy cattle generally indicates that Polish characteristics corresponds to neighbouring countries (after recalculation) where milk production influence N excretion rates. As relates to weighted mean Nex for poultry (revised in this submission), check made for other European countries and IPCC defaults suggests that Polish country specific parameters coincide well also with IPCC defaults (Table 5.3.13).

Methane IEF for dairy cattle in Poland is also in lower range due to specific dairy cattle breeding conditions, including relatively small share of liquid AWMS, described in Chapter 5.2.2 and 5.3.2. Generally the CH_4 EFs range between European countries is relatively high: from 6.8 up to 30.0 kg $\text{CH}_4/\text{animal}/\text{year}$ depending, among others, on AWMS shares and climatic conditions. The range of CH_4 EFs for manure management for swine in European countries varies significantly depending, among

others, on climatic conditions and AWMS share: from 1.3 in Austria in to even 6.5 kg CH₄/animal/year in Ireland.

Table 5.3.13. Comparison of CH₄ Implied Emission Factors related to manure management and Nitrogen excretion rates resulting in N₂O emissions for cattle and swine in 2020

Country	Dairy cattle		Non-dairy cattle		Swine	Poultry
	CH ₄ IEF [kg/head/yr]	Nex [kg N/head/yr]	CH ₄ IEF [kg/head/yr]	Nex [kg N/head/yr]	CH ₄ IEF [kg/head/yr]	Nex [kg N/head/yr]
Austria	17.1	107	6.8	52	1.3	0.53
Czechia	13.3	109	3.5	59	2.0	0.50
Germany	23.2	122	7.7	44	4.8	0.66
France	11.1	117	3.3	60	4.1	0.47
Hungary	30.5	132	9.9	53	3.5	0.73
Lithuania	13.6	114	7.3	45	3.5	0.52
Poland	7.8	115	1.7	51	1.4	0.73
Romania	6.8	83	2.5	44	2.8	1.14
Slovakia	8.3	115	2.1	43	2.6	0.91
Ireland	11.4	109	5.1	55	6.5	0.55
IPCC default value	11.0	70	6.0	50	3 (market swine) 4 (breeding swine)	0.36 for broilers – 1.84 for turkeys

5.3.5. Source-specific recalculations

- Correction of population has been made for goats and horses for the following years: 2015-2016 and 2018–2020, as well as for poultry for 2020;
- Update of DE parameters for cattle for 2018-2020 influencing GEs and EFs;

Table 5.3.14. Changes in CH₄ emissions from manure management due to recalculations

Change	1988	1989	1990	1991	1992	1993	1994
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	1995	1996	1997	1998	1999	2000	2001
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	2002	2003	2004	2005	2006	2007	2008
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	2009	2010	2011	2012	2013	2014	2015
kt	0.00	0.00	0.00	0.00	0.01	0.00	-0.03
%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	-0.06%
Change	2016	2017	2018	2019	2020		
kt	-0.03	-0.46	-0.90	-1.32	-1.70		
%	-0.05%	-0.92%	-1.79%	-2.70%	-3.36%		

Table 5.3.15. Changes in N₂O emissions from manure management due to recalculations

Change	1988	1989	1990	1991	1992	1993	1994
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	1995	1996	1997	1998	1999	2000	2001
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	2002	2003	2004	2005	2006	2007	2008
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	2009	2010	2011	2012	2013	2014	2015
kt	0.00	0.00	0.00	0.00	0.01	0.00	0.01
%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.09%
Change	2016	2017	2018	2019	2020		
kt	0.01	0.02	0.04	0.06	0.07		
%	0.08%	0.27%	0.47%	0.63%	0.72%		

5.3.6. Source-specific planned improvements

- Update of AWMS shares for cattle and swine after Agricultural Census 2020 results.

5.4. Agricultural Soils (CRF sector 3.D)

5.4.1. Source category description

Nitrous oxide emissions from agricultural soils amounted to 52.9 kt N₂O in 2021 and significantly decreased since base year by about 25% (Fig. 5.4.1). Since 1993 emissions stabilised with few percent changes between years. There are several main driving forces influencing emissions variability during entire inventoried period: nitrogen mineral and organic fertilizers use and crops production.

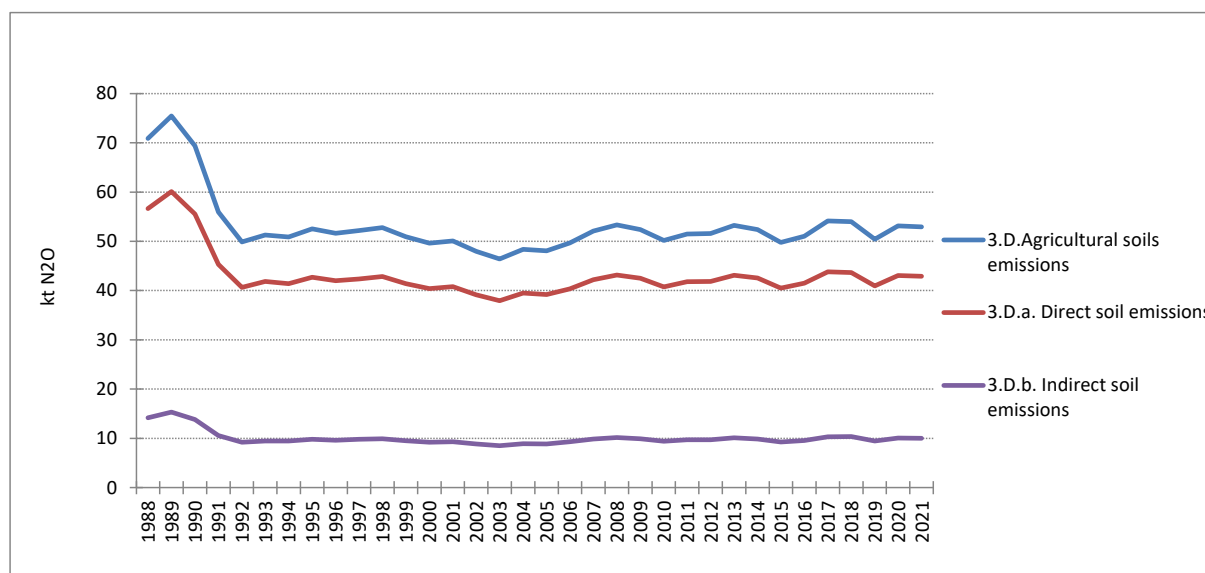
As a result of economic transformation of the Polish economy in 1989 significant changes were observed in relation to crop production and usage of agricultural land. For instance the decrease of agricultural land of which share in total country area changed from 59.2% in 1989 up to 54% in 1996 and 52% in 2020. Between 1990 and 2002 the decrease of sown area by 3.5 million hectares occurred, but in recent years rise again. Also the decrease of mineral fertilisers' use drop from 164 kg per 1 ha of agricultural land in 1989/90 to 93 kg in 2001/02 and increased again to 132.9 kg in 2019/2020. Since 1988 production of certain crops in Poland changed noteworthy – potatoes cultivation dropped by almost 80% up to 2021 while maize production increased more than 30-fold (table 5.4.1).

Table 5.4.1. Main crops production in Poland [kt]

Year	wheat	barley	maize	oats	rye	triticale	cereal mixed	millet & buckwheat	pulses edible	potatoes	rape & agrimony	All vegetables	All fruits
1988	7582	3804	204	2222	5501	1731	3387	73	565	34707	1199	5179	2168
1989	8462	3909	244	2185	6216	2404	3466	72	615	34390	1586	5067	2078
1990	9026	4217	290	2119	6044	2721	3554	43	609	36313	1206	5259	1416
1991	9270	4257	340	1873	5900	2449	3683	39	680	29038	1043	5637	1873
1992	7368	2819	206	1229	3981	1711	2612	36	380	23388	758	4518	2385
1993	8243	3255	290	1493	4992	1894	3200	50	411	36270	594	5823	2705
1994	7658	2686	189	1243	5300	1631	3026	30	215	23058	756	5198	2109
1995	8668	3278	239	1495	6288	2048	3844	45	268	24891	1377	5746	2115
1996	8576	3437	350	1581	5653	2130	3520	51	277	27217	449	5253	2781
1997	8193	3866	416	1630	5299	1841	4105	49	260	20776	595	5136	2887
1998	9537	3612	497	1460	5663	2058	4274	58	289	25949	1099	6096	2517
1999	9051	3401	599	1447	5181	2097	3914	60	317	19927	1132	5457	2387
2000	8503	2783	923	1070	4003	1901	3084	74	264	24232	958	5721	2247
2001	9283	3330	1362	1305	4864	2698	4060	58	211	19379	1064	5428	3413
2002	9304	3370	1962	1486	3831	3048	3608	40	229	15524	953	4537	3018
2003	7858	2831	1884	1182	3172	2812	2812	44	238	13731	793	4870	3309
2004	9892	3571	2344	1430	4281	3723	4322	72	270	13999	1633	5283	3521
2005	8771	3582	1945	1324	3404	3903	3916	83	253	10369	1450	5220	2923
2006	7060	3161	1261	1035	2622	3197	3379	59	206	8982	1652	4919	3212
2007	8317	4008	1722	1462	3126	4147	4257	96	286	11791	2130	5475	1694
2008	9275	3619	1844	1262	3449	4460	3673	82	235	10462	2106	5023	3843
2009	9790	3984	1706	1415	3713	5234	3884	93	272	9703	2497	5601	3749
2010	9408	3397	1994	1516	2852	4576	3339	146	356	8188	2229	4878	2826
2011	9339	3326	2392	1382	2601	4235	3373	109	335	9362	1862	5575	3414
2012	8608	4180	3996	1468	2888	3349	3920	128	482	9041	1866	5431	3838
2013	9485	2934	4040	1190	3359	4273	3021	135	375	7290	2678	4986	4128
2014	11629	3275	4468	1459	2793	5247	2922	135	467	7689	3276	5607	4189
2015	10958	2961	3156	1220	2013	5339	2250	99	715	6314	2701	4795	4100
2016	10828	3441	4343	1358	2200	5102	2415	160	653	8872	2219	5610	4644
2017	11666	3793	4022	1465	2674	5312	2847	144	630	9172	2697	5705	3151
2018	9820	3048	3864	1166	2167	4086	2506	116	501	7478	2202	5271	5072
2019	11012	3374	3734	1233	2461	4583	2472	118	499	6599	2373	5019	3933
2020	12669	3001	6822	1658	2960	6195	2080	118	695	8008	3125	5087	4491
2021	12119	3018	7461	1656	2520	5451	2232	178	768	7081	3191	5279	5059
2021/ 1988	59.8	-20.7	3557.2	-25.5	-54.2	214.9	-34.1	143.9	35.9	-79.6	166.2	1.9	133.4

Within agricultural soils category 81% of N₂O emissions are related to direct soil cultivation, while about 19% are generated in indirect emission processes. The main sources of N₂O emissions estimated relate to direct soil cultivation covering:

- Inorganic N fertilizers use,
- Organic N fertilizers use: animal manure and sewage sludge,
- Urine and dung deposited by grazing animals,
- Crop residues,
- Mineralisation/immobilisation associated with loss/gain of soil organic matter,
- Cultivation of organic soils (i.e. histosols).

Figure 5.4.1. N₂O emissions from agricultural soils

5.4.2. Methodological issues

5.4.2.1. Direct N₂O emissions from managed soils (CRF sector 3.D.a)

Direct N₂O emissions from managed soils has been estimated based on equation 11.1 from the IPCC 2006:

$$N_2O_{Direct} - N = (F_{SN} + F_{ON} + F_{CR} + F_{SOM})EF_1 + F_{OS} * EF_2 + F_{PRP} * EF_{3PRP}$$

where:

$N_2O_{Direct} - N$ = annual direct N₂O–N emissions produced from managed soils (kg N₂O–N/year),

F_{SN} = annual amount of synthetic fertiliser N applied to soils (kg N/year),

F_{ON} = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils (kg N/year),

F_{CR} = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils (kg N/year),

F_{SOM} = annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes of land use or management (kg N/year),

F_{OS} = annual area of managed/drained organic soils (ha),

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N/year),

EF_1 = emission factor for N₂O emissions from N inputs (kg N₂O–N/kg N input),

EF_2 = emission factor for N₂O emissions from drained/managed organic soils (kg N₂O–N/ha/year),

EF_{3PRP} = emission factor for N₂O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals (kg N₂O–N/kg N input).

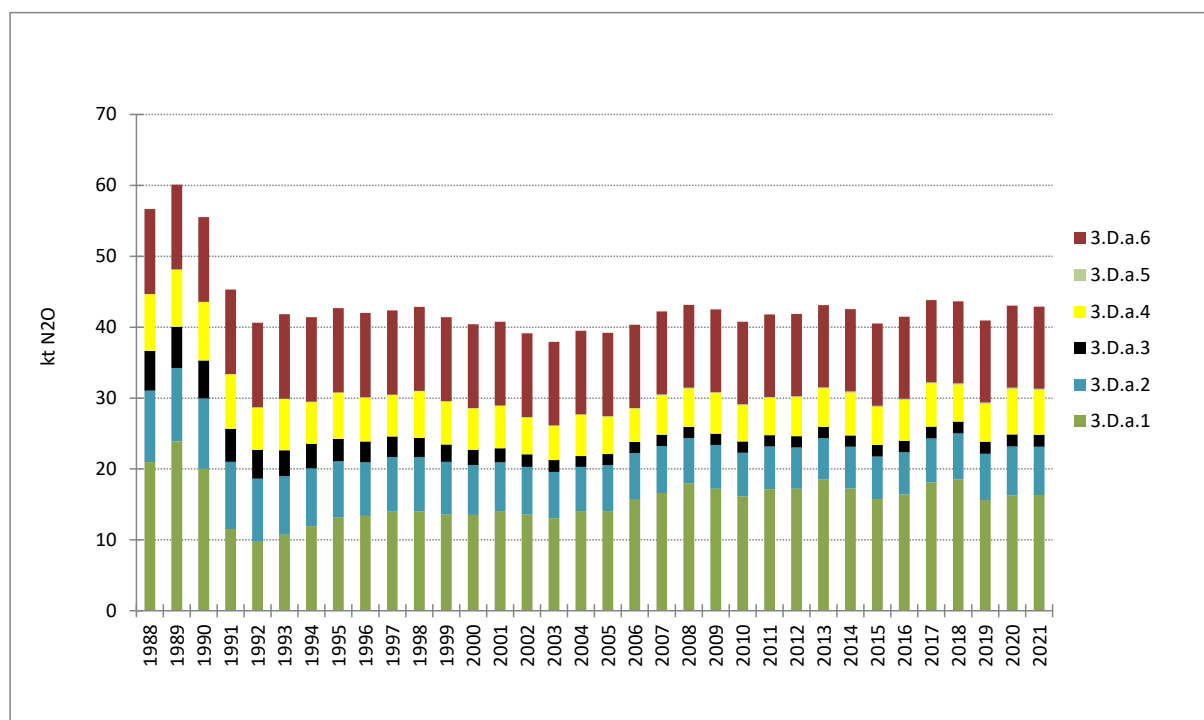
The following default values of N₂O emission factors to estimate direct emissions from managed soils were applied [IPCC 2006, table 11.1]:

EF_1 = 0.01 kg N₂O–N/kg N input,

EF_2 = 8 kg N₂O–N/ha/year (for temperate organic crop and grassland soils),

EF_{3PRP} = 0.02 for cattle, swine and poultry, 0.01 for sheep, goats and horses.

In 2021 about 38% of direct N₂O emissions comes from the use of synthetic nitrogen fertilizers (3.D.a.1), about 27% relates to management of organic soils, 16% to organic fertilizers applied to soils and 15% to crop residues. Only 4% of direct N₂O emissions comes from urine and dung left by grazing animals on pastures (fig. 5.4.2). N₂O emissions related to mineralisation of soils as a result of changes of land use or management are insignificant (0.4%).

Figure 5.4.2. Direct N₂O emissions from specific subcategories

Synthetic nitrogen fertilizers (F_{SN}) (CRF sector 3.D.a.1)

N₂O emission from synthetic fertilizers was estimated based on the amount of nitrogen synthetic fertilizer applied to soils come from national statistics and for the last year from [IFA database] (staying in line with national statistics). Data regarding consumption of mineral and lime fertilizers is developed on the basis of reporting and sample surveys, ie. regular surveys on the structure of agricultural holdings (R-SGR) carried out every three years and the June Agricultural Surveys (R-CzBR) conducted between research R- SGR. The data based on information collected in sample surveys include:

- generalized results of the sample survey conducted in individual farms,
- information obtained from the whole population of agricultural farms of legal persons and organizational units without legal personality (approx. 5 thous.)

Present level of fertilizing is still lower than it was in 1988–1989. The drop of nitrogen fertilizers use in 1989–1992 amounted to 41% and gradually increased up to 2007 when exceeded 1 million tons (table 5.15). 2019 was the first year since 2007 when usage of mineral fertilizers drop below 1 million tons but again in 2020 and 2021 slight increase above 1 million tons occurred.

As part of the Act on Fertilisers and Fertilisation, *inter alia*, the following measures are introduced: limitation of the natural fertiliser dose to 170 kg N/ha/year, a ban on the use of natural fertilisers from the end of November to the beginning of March and mandatory training for fertilizer service providers [NC8/BR5 POL 2022].

Table 5.4.2. Nitrogen fertilizers use (F_{SN}) in Poland [kt N]

1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1 335	1 520	1 274	735	619	683	758	836	852	890	891	862
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
861	895	862	832	895	895	996	1 056	1 142	1 095	1 028	1 091
2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
1 095	1 179	1 098	1 004	1 043	1 151	1 179	994	1 034	1 038		

Nitrous oxide emissions amounted in 2021 about 16.3 kt N₂O. Generally trend in N₂O emissions follow nitrogen fertilizers use and range from the highest emissions with 23.9 kt N₂O in 1989 to the lowest emissions with 9.7 kt N in 1992.

Organic nitrogen fertilizers (F_{ON}) (CRF sector 3.D.a.2)

Organic nitrogen fertilisers cover both animal manure as well as sewage sludge applied to fields.

The amount of nitrogen in **animal manure applied to soils** is calculated according to the method described in chapter 5.3.2.2. Following guidelines given in chapter 10.5.4 and using equation 10.34 [IPCC 2006], all nitrogen excreted on pasture, range and paddock as well as all nitrogen volatilised prior to final application to managed soils is subtracted from the total excreted manure. The amount of managed manure nitrogen that is lost in the manure management system is taken from table 10.23 [IPCC 2006] for particular livestock categories. Nitrogen from bedding material was taken into account in total Nitrogen applied to soils. Data related to Nitrogen added in straw was calculated in line with Ammonia emissions from manure management for straw based systems and amounts to: dairy cattle; 6 kg N/animal/yr., other cattle 2 kg N/animal/yr., fattening pigs: 0.8 kg N/animal/yr., sows 2.4 kg N/animal/yr., sheep and goats 0.08 kg N/animal/yr., horses 2 kg N/animal/yr. The fractions of animal manure burned for fuel, used for feed and fuel were neglected because these activities do not occur in Poland.

Here recommendation A.18 from review report FCCC/ARR/2020/POL was also implemented where updated Nex parameters for cattle and poultry were applied.

Nitrous oxide emissions from animal manure applied to soils in 2021 was about 6.7 kt N_2O . Trend of emissions is driven by trend of livestock population, mainly cattle and sheep after 1989, and changes in AWMS share. Here ERT 2018 and 2020 recommendation on update cattle and poultry Nex parameters for entire trend was implemented increasing N_2O emissions in this subsector.

Activity data on the amount of **sewage sludge applied on the fields** were taken from national statistics [GUS 2022d] and regards both - industrial and municipal sewage sludge applied in cultivation of all crops marketed, including crops designed to produce fodder as well as this applied in cultivation of plants intended for compost production. As the consistent reporting of data concerning application of sewage sludge in agriculture in the public statistics starts in 2003, the activities since 1988 were supplemented based on annual mean changes of AD in 2003–2009 where constant increasing trend was noted (fig. 5.4.3). Diminishing trend back to 1988 corresponds to the percentage of people using sewage treatment plants that ranges from 29% in 1988, through 50% in 1998, and 64% in 2009 and the number of municipal sewage treatment plants, which increased from 558 in 1988 up to 1923 in 1998 and 3153 in 2009 [GUS 2010d]. The growth of usage of sewage sludge for agriculture purposes stopped and stabilized after 2009 due to legal limitations and precise determination of parameters for sewage sludge used for specific purposes.

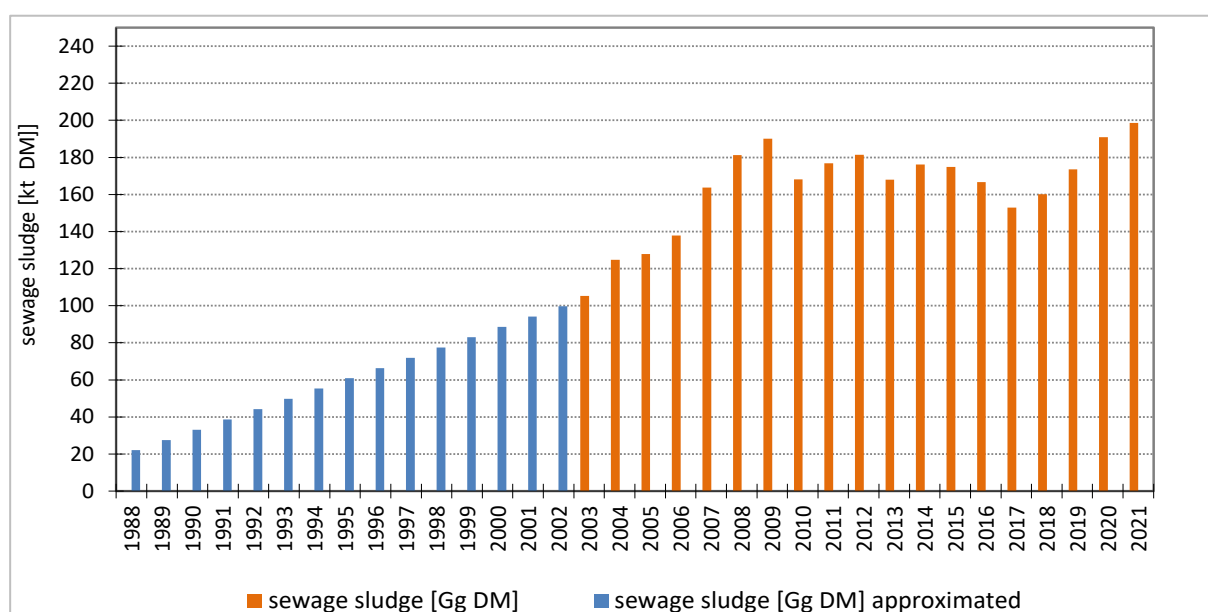


Figure 5.4.3. Amounts of sewage sludge applied in agriculture [kt DM]

The mean content of nitrogen in sewage sludge was taken as 2.61% from publication [Siebielec, Stuczyński 2008] where analysis of nitrogen content in domestic sewage sludge applied in agriculture was made. The study covered a group of 60 biosolids collected in 2001-2004 from 43 municipal sewage treatment plants. The same N content was assumed for both – municipal and industrial sewage sludge because majority of it applied in agriculture (about 76%) come from municipal treatment plants.

In Poland application of sewage sludge as fertilizer is relatively small, after increasing trend 2003–2009, certain stabilisation was noticed up 2017 and further growth thereafter. Emissions of N₂O for this subcategory amount to 0.08 kt N₂O in 2021.

Urine and dung deposited by grazing animals (F_{PRP}) (CRF sector 3.D.a.3)

Emission of N₂O resulting from animal urine and dung deposited on pastures by grazing livestock is calculated based on equation 11.5 [IPCC 2006] using: animal population (tables 5.2.2, 5.2.3), total amount of nitrogen in animal excreta (N_{ex}) estimated based on country specific parameters presented in tables 5.3.8 and 5.3.9 as well as data on fraction of manure related to grazing animals (table 5.3.2).

Here recommendation A.18 from review report FCCC/ARR/2020/POL was also implemented where updated N_{ex} parameters for cattle and poultry were applied.

Emissions in 2021 from pasture, range and paddock manure were 1.7 kt N₂O and stabilized since 2002. This value is much lower than in 1988 by about 69% what was caused by decreasing livestock population as well as decreasing percentage of livestock grazed.

Crop Residues (F_{CR}) (CRF sector 3.D.a.4)

N₂O emission from crop residue returned to soils was generally estimated based on modified equation 11.6 from [Corrigenda for the IPCC 2006 GLs]:

$$F_{CR} = \sum_T \{Crop_{(T)} * Area_{(T)} * Frac_{Renew(T)} * [R_{AG(T)} * N_{AG(T)} * (1 - Frac_{Burn(T)} - Frac_{Remove(T)}) + R_{BG(T)} * N_{BG(T)}]\}$$

where:

- F_{CR} = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually, kg N/yr
- Crop_(T) = harvested annual dry matter yield for crop T, kg d.m./ha
- Area_(T) = total annual area harvested of crop T, ha/yr
- Frac_{Renew(T)} = fraction of total area under crop T that is renewed annually.
- R_{AG(T)} = ratio of above-ground residues dry matter (AG_{DM(T)}) to harvested yield for crop T (Crop_(T)), kg d.m./kg d.m.,
- N_{AG(T)} = N content of above-ground residues for crop T, kg N/kg d.m.,
- Frac_{Burn(T)} - fraction of crop residues burned as indicated in sector 3.F
- Frac_{Remove(T)} = fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction, kg N/kg crop-N
- R_{BG(T)} = ratio of below-ground residues to harvested yield for crop T, kg d.m./kg d.m.
- N_{BG(T)} = N content of below-ground residues for crop T, kg N/kg d.m.
- T = crop or forage type

R_{BG(T)} is calculated by multiplying R_{BG-BIO} in Table 11.2 by the ratio of total above-ground biomass to crop yield (= [(AG_{DM(T)} * 1000 + Crop_(T)) / Crop_(T)], calculating AG_{DM(T)} from the information in Table 11.2. Values of nitrogen content in below-ground residues for specific crops N_{BG(T)} were taken from table 11.2 [IPCC 2006]. For permanent pastures and meadows, which are renewed on average every 20 years, Frac_{Renew} = 1/20. For annual crops Frac_{Renew} was taken as 1.

Data on N content in the above-ground residues, ratio of above-ground residues in dry matter to harvested yield for crops, fraction of crops burned come from country studies [Łoboda 1994, IUNG 2012] where experimental and literature data as well as default emission factors were used and are given in table 5.5.1. Fraction of total above-ground crop biomass that is removed from the field as a crop product (FracR) were consulted with the Institute of Soil Science and Plant Cultivation – State Research Institute and is presented in table 5.4.3.

Table 5.4.3. Fraction of total above-ground crop biomass that is removed from the field as a crop product (Frac_{Remove}) according to crops/group of crops

crop	Frac _{Remove}	crop	Frac _{Remove}
wheat	0.70	sugar beet	0.25
rye	0.70	rape	0.10
barley	0.70	other oil-bearing	0.10
oats	0.70	flux straw	0.90
triticale	0.70	tobacco	0.65
cereal mixed	0.70	hop	0.01
millet & buckwheat	0.70	hey from pastures and meadows	0.95
maize	0.10	hey from pulses	0.95
pulses edible	0.10	hey from legumes	0.95
pulses feed	0.10	vegetables	0.10
potatoes	0.01		

Activity data concerning crop production was taken from national statistics [GUS R3 2022] (table 5.4.1). The default emission factor of 0.01 kgN₂O-N/kg N [IPCC 2006, table 11.1] multiplied by 44/28 was used for estimating the N₂O emissions from N inputs from crop residues.

Emission from above- and belowground crop residues in 2021 was 6.3 kt N₂O and is lower by about 21% than in 1988 due to drop in area sown and crop production.

Mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM}) (CRF sector 3.D.a.5)

In response to question obtained during ERT 2020 the additional analysis was made for this subcategory resulting in preparation of N₂O emission calculation for mineralization/ immobilization processes associated with loss/gain of soil organic matter for cropland remaining cropland.

As there are no relevant country specific EFs on nitrogen mineralized in mineral soils on cropland as a result of loss of soil C through change in land use or management practices the reported assessment is based on application of default EF and relevant country specific activity data on cropland remaining cropland area reported in 4B category. For the purpose of the assessment, default value of 10 for C:N ratio has been used in this particular situation to estimate potential emissions. Furthermore, the value of 0.01 kg N₂O–N / kg N has been applied for EF1 for N mineralised from mineral soil as a result of loss of soil carbon [IPCC 2006, Table 11.1].

N₂O emissions associated with mineralization process taking place in mineral soils related to loss of soil C from soil organic matter are insignificant and span from 0.04 kt in 1988 up to 0.16 kt in 2021.

Cultivation of organic soils (F_{OS}) (CRF sector 3.D.a.6)

Following recommendation A.19 from the review report FCCC/ARR/2018/POL the area of cultivated organic soils was updated and unified [Walęzak et al, 2020]. The main basis for establishing histosols area under this Submission was the project *Spatial Information System on Wetlands in Poland* (GIS Mokradla) elaborated in 2004–2006 by the Institute of Technology and Life Sciences. Here vector layers were identified with organic soils and associated with Corine Land Cover maps published for: 1990, 2000, 2006, 2012 and 2018. The land cover classes were divided into IPCC classification where

cropland and grassland in Agriculture sector were taken into account. Data between years covered by CLC were interpolated, data for 1988-1989 were extrapolated based on changes after 1990. Generally organic soils area under agricultural use decreases: cropland by 1% and grassland by 4% in 1988–2021 (fig. 5.4.4).

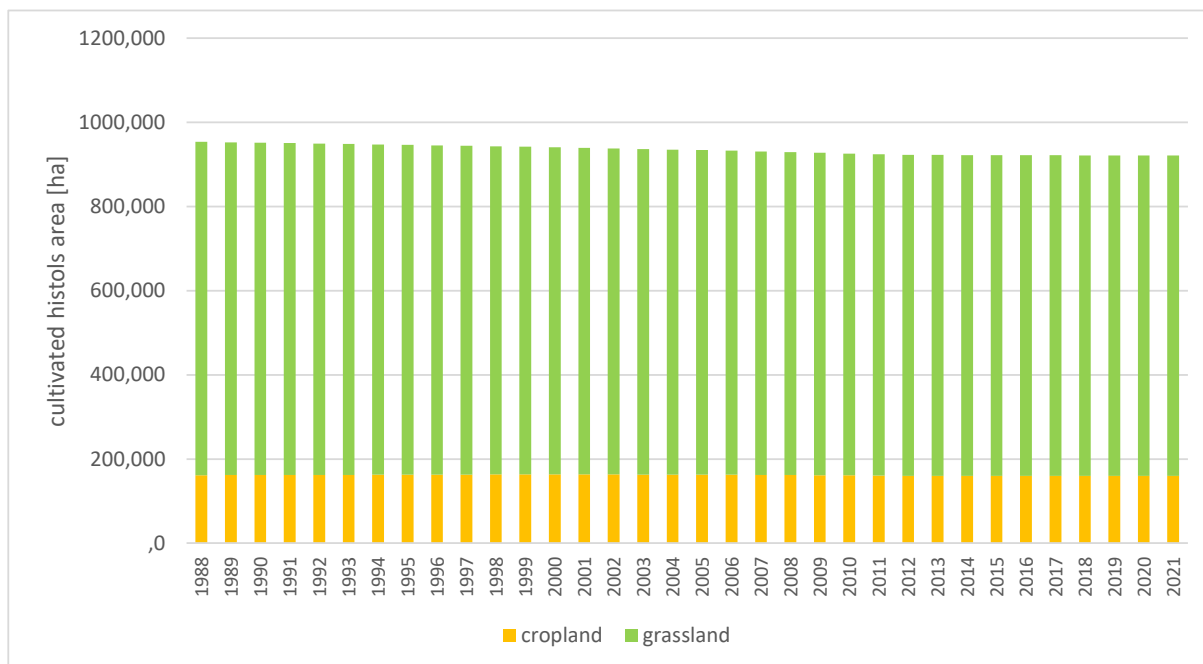


Figure 5.4.4. Area of cultivated histosols under cropland and grassland

The default emission factor of 8 kgN₂O-N/kg N [IPCC 2006, Chapter 11, table 11.1] is applied.

Nitrous oxide emissions from cultivated histosols for agricultural purposes in Poland in 2021 was about 11.6 kt N₂O and is falling since 1988 because of continuous progress of mineralization of organic matter as well as increasing area of histosols occupied by forest and scrub communities following cultivation termination of these areas.

5.4.2.2. Indirect N₂O emissions from managed soils (CRF sector 3.D.b)

Atmospheric deposition (CRF sector 3.D.b.1)

Indirect emissions of N₂O from atmospheric deposition of N volatilised were assessed using equation 11.9 [IPCC 2006]:

$$N_2O_{(ATD)} - N = [(F_{SN} * Frac_{GASF}) + ((F_{ON} + F_{PRP}) * Frac_{GASM})] * EF_4$$

where:

N₂O_(ATD)-N – annual amount of N₂O-N produced from atmospheric deposition of N volatilised from managed soils (kg N₂O-N/year),

F_{SN} - annual amount of synthetic N fertilizer applied to soils (kg N/year),

F_{ON} - annual amount of organic N fertilizer applied to soils (animal manure and sewage sludge nitrogen) (kg N/year),

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N/year),

Frac_{GASF} - fraction of synthetic fertilizer that volatilises as NH₃ and NO_x (kg of N applied),

Frac_{GASM} - fraction of organic fertilizer materials that volatilises as NH₃ and NO_x (kg of N applied),

EF₄ - emission factor for N₂O emissions from atmospheric deposition of N on soils and water surfaces (kg N–N₂O).

Nitrogen amounts from synthetic fertilizers as well as from organic additions to soils (livestock manure and sewage sludge) correspond to values presented in chapter 5.4.2.1. Parameters characterising $\text{Frac}_{\text{GASF}}$ and $\text{Frac}_{\text{GASM}}$ are taken from table 11.3 [IPCC 2006] and amount respectively: 0.1 kg $\text{NH}_3\text{-N}+\text{NO}_x\text{-N}$ /kg N applied and 0.2 kg $\text{NH}_3\text{-N}+\text{NO}_x\text{-N}$ /kg N applied. Also the default emission factor EF_4 [IPCC 2006, table 11.3] is used amounting to 0.01 kg $\text{N}_2\text{O-N}$ (kg $\text{NH}_3\text{-N}+\text{NO}_x\text{-N}$ volatilised).

Table 5.4.4. Volatized nitrogen from synthetic and organic fertilizers applied to soils

Year	Volatized N [kt N/yr]	Year	Volatized N [kt N/yr]
1988	300.42	2005	182.61
1989	323.97	2006	194.12
1990	290.70	2007	200.93
1991	226.03	2008	206.39
1992	203.12	2009	198.74
1993	198.06	2010	191.34
1994	203.31	2011	196.55
1995	205.80	2012	194.20
1996	201.17	2013	202.37
1997	206.35	2014	195.28
1998	205.05	2015	187.37
1999	197.65	2016	190.65
2000	189.99	2017	205.19
2001	190.60	2018	211.29
2002	183.92	2019	193.71
2003	177.43	2020	202.57
2004	179.00	2021	201.82

Here recommendation A.18 from review report FCCC/ARR/2020/POL was also implemented where updated Nex parameters for cattle and poultry were applied.

[Nitrogen leaching and run-off \(CRF sector 3.D.b.2\)](#)

Indirect emissions of N_2O from leaching and runoff of N from soils were assessed using equation 11.10 [IPCC 2006]:

$$\text{N}_2\text{O}_{(\text{L})}\text{-N} = (\text{F}_{\text{SN}} + \text{F}_{\text{ON}} + \text{F}_{\text{PRP}} + \text{F}_{\text{CR}} + \text{F}_{\text{SOM}}) * \text{Frac}_{\text{LEACH-(H)}} * \text{EF}_5$$

where:

$\text{N}_2\text{O}_{(\text{L})}\text{-N}$ – annual amount of $\text{N}_2\text{O-N}$ produced from leaching and runoff of N additions to managed soils (kg $\text{N}_2\text{O-N}$ /year),

F_{SN} = annual amount of synthetic fertiliser N applied to soils (kg N/year),

F_{ON} = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils (kg N/year),

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N/year),

F_{CR} = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils (kg N/year),

F_{SOM} = annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes of land use or management (kg N/year),

$\text{Frac}_{\text{LEACH-(H)}}$ - fraction of all N added to/mineralised in managed soils (kg N / kg of N additions),

EF_5 – emission factor for N_2O emissions from N leaching and runoff (kg $\text{N}_2\text{O-N}$).

Nitrogen additions to soils correspond to values presented in chapter 5.4.2.1. $\text{Frac}_{\text{LEACH-(H)}}$ equals 0.3 kg N/kg N added and is the default value taken from [IPCC 2006, table 11.3]. The default emission factor

EF₅ equal 0.0075 kg N₂O-N/kg N leached and runoff was used for calculation of N₂O-N emissions produced from leaching and runoff of N [IPCC 2006, table 11.3].

Table 5.4.5. Nitrogen losses through leaching and runoff from nitrogen added to soils

Year	N losses [kt N/yr]	Year	N losses [kt N/yr]
1988	803.947	2005	510.193
1989	868.102	2006	532.154
1990	785.467	2007	568.003
1991	596.718	2008	586.535
1992	511.824	2009	574.335
1993	538.374	2010	541.492
1994	531.612	2011	561.348
1995	559.489	2012	563.321
1996	548.265	2013	587.155
1997	555.974	2014	575.849
1998	568.031	2015	537.151
1999	542.647	2016	556.037
2000	526.594	2017	600.182
2001	535.527	2018	596.799
2002	505.868	2019	545.143
2003	484.327	2020	584.877
2004	515.583	2021	581.948

Here recommendation A.7 from review report FCCC/ARR/2020/POL was also implemented where updated Nex parameters for cattle and poultry were applied.

Indirect emissions related to atmospheric deposition of nitrogen volatilised from managed soils amounted to 3.2 kt N₂O while those related to nitrogen leaching and runoff from managed soils amounted to 6.9 kt N₂O in 2021. The emissions trend since 1992 is rather stable after significant drop in 1989-1992 accompanying serious decrease in mineral fertilisers use as well as in animal population.

5.4.3. Uncertainties and time-series consistency

Description of uncertainties is given in Chapter 5.2.3.

5.4.4. Source-specific QA/QC and verification

Activity data related to mineral fertilisers use or crop production come from national statistics prepared by the Statistics Poland (GUS). Overall final estimation of cereals and potatoes output was verified by means of simulative calculation of crops quantity according to the distribution of output between: sale, sowing/planting, fodder and self consumption. Final estimation of sugar beets, rape and turnip rape, and some species of industrial crops were verified with procurement data for these crops. Estimation of fodder crops output in private farms, conducted by local experts of Statistics Poland, was additionally verified by the calculation of fodder crops according to the directions of their use. Total area of fodder crops comprises the area of meadows, pastures and field crops for fodder. This area does not include the area of cereals, potatoes, and other agricultural crops, a part of which was directly or indirectly used for fodder.

Emphasis was put on data consistency between sub-categories and between sectors using agricultural data. Also emphasis on comparison and consistency is checked with the data applied in the UNECE CLRTAP and NECD reporting in Agriculture sector. Emission factors and methodology is compared with international literature and other countries methods/EF applied. Calculations were examined with focus on formulas, units and trends consistency. In 2019 additional cross check for emission calculation was done by the modelling team working in frames of the EU project CAKE (Centre for Climate and Energy Analyses – <http://climatecake.pl/?lang=en>) elaborating, among others, model for policy

assessment of mitigation actions undertaken in agriculture. All major GHG emission agricultural sources reported under UNFCCC following IPCC methodology were considered. Generally QC procedures follow QA/QC plan presented in Annex 7.

As a part of verification specific data related to agricultural soils are compared with other European countries. As the National Inventory Reports are elaborated by Parties in the same time, only data related to emission factors and other characteristics can be compared from previous reporting year.

Comparison of N₂O EFs among EU countries indicate that only Ireland, Netherlands and UK use country specific factors from inorganic and organic N fertilizers while rest of EU countries, including Poland, apply IPCC 2006 GLs default EFs.

5.4.5. Source-specific recalculations

- Correction of population has been made for goats and horses for the following years: 2015–2016 and 2018–2020, as well as for poultry for 2020;
- Update of production of other oil-bearing crops in 2020 based on Agricultural Census 2020 as well adding soya production for period since 2004;
- Update in area of land where N is mineralised in mineral soils as a result of loss of soil C through change in land use or management for years: 1988–1999 and 2015–2020;
- Update of organic areas based on CLC and GIS Mokradla in 2004–2011 and 2015–2020;
- Correction of wheat yield in 1989 and beet yield in 1990;

Table 5.4.7. Changes in N₂O emissions from agricultural soils resulting from recalculations

Change	1988	1989	1990	1991	1992	1993	1994
kt	0.00	0.04	-0.01	0.00	0.00	0.00	0.00
%	0.00%	0.06%	-0.01%	0.00%	0.00%	0.00%	0.00%
Change	1995	1996	1997	1998	1999	2000	2001
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	2002	2003	2004	2005	2006	2007	2008
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change	2009	2010	2011	2012	2013	2014	2015
kt	0.00	0.00	0.00	0.00	0.00	0.00	0.02
%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%
Change	2016	2017	2018	2019	2020		
kt	0.02	0.09	0.18	0.25	0.31		
%	0.04%	0.18%	0.33%	0.51%	0.59%		

5.4.6. Source-specific planned improvements

Presently no improvements are planned.

5.5. Field Burning of Agricultural Residues (CRF sector 3.F)

5.5.1. Source category description

Greenhouse gas emissions in 2021 from field burning of agricultural residues amounted to 1.11 kt CH₄ and 0.04 kt N₂O. The share of GHG emissions from field burning of agricultural residues in total agricultural emissions is 0.1%. The trend of GHG emissions within this category is presented on figure 5.5.1 and fluctuates following the annual crop production.

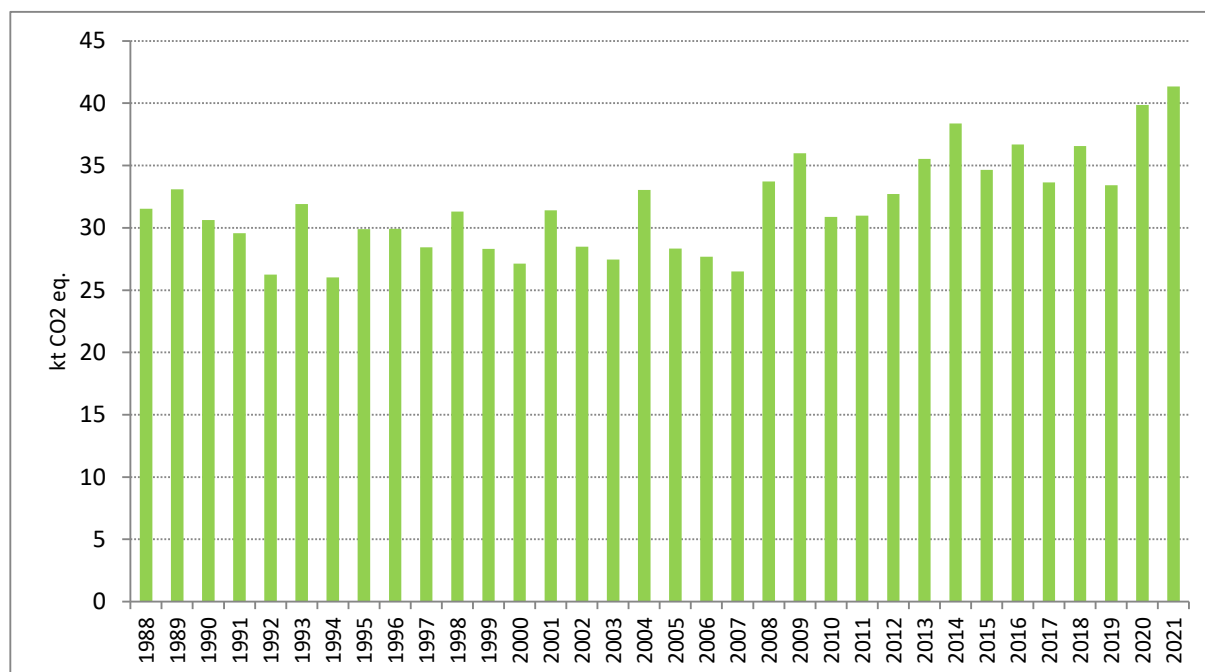


Figure 5.5.1. CH₄ and N₂O emissions from field burning of agricultural residues presented as CO₂ equivalent

5.5.2. Methodological issues

While estimating GHG emissions in this subcategory only methane and nitrous oxide are taken into account assuming that carbon dioxide released during burning of crop residues is reabsorbed during the next growing season.

Estimation of CH₄ and N₂O emissions from burning of agricultural residues in fields is still based on the IPCC methodology as published in 1997. This method is more detail and covers specific crops burned, than the method described in IPCC 2006 GLs (Chapters 2.4 and 5.2.4). These parameters and emissions are also consistent with calculations made for category 3.1.a.4 Crop residues retained to soils.

For domestic purposes 43 crops were selected for which residues can potentially be burned [Łoboda *et al* 1994]. Within this group certain plants were excluded for which residues can be composted or used as forage. So finally there were selected 38 crops which were then aggregated into 32 groups containing cereals, pulses, tuber and root, oil-bearing plants, vegetables and fruits potentially could be burned on fields.

Activity data on crop production comes from public statistics [GUS R3 2021, GUS R10 2021]. Factors applied for emissions calculation were taken from country studies [Łoboda 1994, IUNG 2012] where experimental and literature data as well as default emission factors were used. Production of main crops is presented in the table 5.4.1.

Table 5.5.1. Selected crop residue statistics employed in GHG estimation from field burning of agriculture residues (3.F) and direct soil emissions related to crop residues returned to soils (3.D.a.4)

Crops	Residue to crop ratio	Dry matter fraction	Fraction burned in fields	Fraction oxidized	Carbon fraction of residue	Nitrogen fraction of residue
winter wheat	0.90	0.85	0.005	0.90	0.4853	0.0068
spring wheat	0.85	0.85	0.005	0.90	0.4853	0.0068
rye	1.40	0.86	0.005	0.90	0.4800	0.0053
spring barley	0.80	0.86	0.005	0.90	0.4567	0.0069
oats	1.10	0.86	0.004	0.90	0.4700	0.0075
triticale	1.10	0.86	0.005	0.90	0.4853	0.0063
cereal mixed	0.90	0.86	0.004	0.90	0.4730	0.0071
buckwheat & millet	1.70	0.86	0.002	0.90	0.4500	0.0090
maize	1.30	0.52	0.002	0.90	0.4709	0.0094
edible pulses	0.90	0.86	0.001	0.90	0.4500	0.0180
feed pulses	1.30	0.85	0.001	0.90	0.4500	0.0203
potatoes	0.10	0.25	0.100	0.85	0.4226	0.0203
rape	1.20	0.87	0.030	0.90	0.4500	0.0068
other oil-bearing crops	3.50	0.87	0.030	0.90	0.4500	0.0068
flax straw	0.25	0.86	0.001	0.90	0.4500	0.0072
tobacco	1.25	0.50	0.002	0.85	0.4500	0.0180
hop	4.00	0.25	0.020	0.90	0.4500	0.0158
hay from greenland	0.05	0.23	0.001	0.90	0.4500	0.0198
hay from pulses	0.05	0.23	0.001	0.90	0.4500	0.0203
hay from clover and lucerne	0.05	0.23	0.001	0.90	0.4500	0.0275
tomatoes	0.60	0.15	0.050	0.85	0.4500	0.0225
other ground vegetables	0.35	0.15	0.010	0.90	0.4500	0.0248
vegetables under cover	0.40	0.35	0.010	0.90	0.4500	0.0270
apples	1.50	0.35	0.050	0.90	0.4500	0.0275
pears and other fruits	1.50	0.35	0.070	0.90	0.4500	0.0149
plums	1.50	0.35	0.100	0.90	0.4500	0.0149
cherries	1.50	0.35	0.100	0.90	0.4500	0.0149
sweet cherries	1.50	0.35	0.100	0.90	0.4500	0.0149
strawberries	0.50	0.18	0.010	0.90	0.4500	0.0149
raspberries	1.20	0.30	0.250	0.90	0.4500	0.0248
currants	1.20	0.30	0.250	0.90	0.4500	0.0149
gooseberries and other berries	1.20	0.30	0.250	0.90	0.4500	0.0149

5.5.3. Uncertainties and time-series consistency

Description of uncertainties is given in Chapter 5.2.3.

5.5.4. Source-specific QA/QC and verification

Activity data related to mineral fertilisers use or crop production come from national statistics prepared by the Statistics Poland. Overall final estimation of cereals and potatoes output was verified by means of simulative calculation of crops quantity according to the distribution of output between: sale, sowing/planting, fodder and self consumption. Final estimation of sugar beets, rape and turnip rape, and some species of industrial crops were verified with procurement data for these crops. Estimation of fodder crops output in private farms, conducted by local experts of CSO, was additionally verified by the calculation of fodder crops according to the directions of their use. Total area of fodder crops comprises the area of meadows, pastures and field crops for fodder. This area does not include the area of cereals, potatoes, and other agricultural crops, a part of which was directly or indirectly used for fodder.

Emphasis was put on data consistency between sub-categories and between sectors using agricultural data. Also emphasis on comparison and consistency is checked with the data applied in the UNECE CLRTAP and NECD reporting in Agriculture sector. Emission factors and methodology is compared with international literature and other countries methods/EF applied. Calculations were examined with

focus on formulas, units and trends consistency. In 2019 additional cross check for emission calculation was done by the modelling team working in frames of the EU project CAKE (Centre for Climate and Energy Analyses – <http://climatecake.pl/?lang=en>) elaborating, among others, model for policy assessment of mitigation actions undertaken in agriculture. All major GHG emission agricultural sources reported under UNFCCC following IPCC methodology were considered. As a result some amendment in crop residues related N₂O emissions were done in the inventory. Generally QC procedures follow QA/QC plan presented in Annex 7.

Field burning of agricultural residues is reported only by few European countries, in most of countries legal ban is introduced. In Poland also certain legal limitations are obligatory related to places and time of residues burning but some potential activity can occur.

5.5.5. Source-specific recalculations

Insignificant recalculations were made in this submission that relate to updating the production of other oil-bearing crops in 2020 based on Agricultural Census 2020 as well adding soya production for period since 2004.

5.5.6. Source-specific planned improvements

No improvements are planned presently.

5.6. CO₂ emissions from liming, urea and other carbon-content fertilizers use (CRF sectors 3.G–3.I)

5.6.1. Liming (CRF sector 3.G)

Emissions of CO₂ from limestone (CaCO₃) and dolomite (CaMg(CO₃)₂) application to agricultural soils in 2021 amounted to 430 kt and 871 kt respectively. Trend in CO₂ emissions of both fertilizers drop since 1988, in line with fertilizers use (Fig. 5.6.1), due to significant changes of agricultural farms after 1989 (see chapter 5.1) as well as current economic situation at rural market (prices of means of production vs. prices of agricultural goods).

The annual carbon emission from agricultural lime application is calculated with Tier 1 method using equation 11.12 and the default emission factors for carbon conversion of 0.12 and 0.13 for limestone and dolomite respectively [IPCC 2006]:

$$\text{CO}_2\text{-C Emission} = (M_{\text{limestone}} * EF_{\text{limestone}}) + (M_{\text{dolomite}} * EF_{\text{dolomite}})$$

where:

CO₂-C Emission = annual C emissions from lime application; t C/year

M_{limestone} – annual amount of calcic limestone (CaCO₃); t / year

M_{dolomite} – annual amount of dolomite (CaMg(CO₃)₂); t / year

EF_{limestone} – emission factor for limestone – 0.12 t C / t limestone

EF_{dolomite} – emission factor for dolomite – 0.13 t C / t dolomite

Activity data on use of lime fertilizers, in division for calcic limestone and dolomite, is available in national statistics on an annual basis in pure nutrient (CaO, CaO+MgO) [GUS R3 2022]. Based on country study [Radwański 2006b] it was established that application of oxides of lime occurs in Poland in limited amount, carbonate limes dominate (respectively 12% and 88%). As the oxides of lime do not contain inorganic carbon they are not included in calculations for CO₂ estimation from application to soils [Chapter 11.3.1 IPCC 2006].

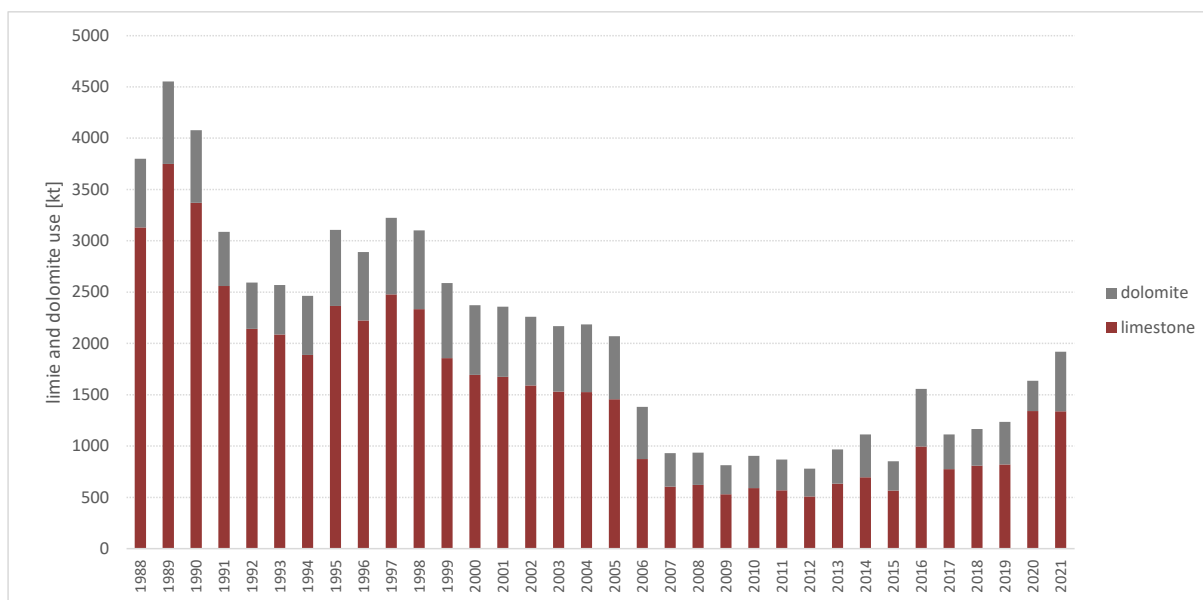


Fig. 5.6.1. Limestone and dolomite use in Poland

5.6.2. Urea fertilization (CRF sector 3.H)

Adding urea to soils during fertilisation leads to a loss of atmospheric CO₂ that was fixed in the industrial production process of the fertilizer. Emissions related to this process in Poland amounted to 399 kt CO₂ in 2020 and drop since 1988 by 21%.

The annual carbon emission from urea application is calculated Tier 1 method using equation 11.13 [IPCC 2006]:

$$\text{CO}_2\text{-C Emission} = M * EF$$

where:

$\text{CO}_2\text{-C Emission}$ – annual C emissions from urea application; t C/year

M – annual amount of urea fertilization; t urea/year

EF – emission factor; t C/t urea

Annual amount of urea used for application to soils is derived from IFA database (Tab. 5.6.1). Emission factor is the default one from the IPCC 2006 GLs: 0.20 t C/ t urea.

Table 5.6.1. Urea share in N fertilizers used in Poland

1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
26.2%	27.1%	28.5%	18.9%	24.3%	21.1%	20.4%	20.9%	21.1%	18.7%	23.0%	28.7%
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
33.8%	24.8%	23.2%	24.1%	25.8%	28.0%	26.1%	27.0%	25.8%	27.1%	28.9%	29.1%
2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
29.4%	29.6%	29.1%	29.9%	29.1%	27.8%	27.2%	26.3%	26.6%	24.5%		

It should be noted here that data for Poland published in the IFA database are shifted by one year comparing to the data published in Eurostat and used in the inventory what is related to the fact that fertilizers are published in national statistics for farming years. It means that in the IFA database amount of N fertilizer published as 2019 are those published by national statistics for 2019/2020 farming year while in Eurostat data assigned for 2019 are those from 2018/2019.

5.6.3. Other carbon-containing fertilizers (CRF sector 3.1)

CO_2 emissions from calcium ammonium nitrate (CAN) use is calculated in line with recalculations made under CLRTAP-NECD reporting on NH_3 emissions from Nitrogen fertilizers use.

The use of CAN in Poland is based on data published at [IFA database] and presented in the Table 5.6.2. It has been confirmed that data on CAN use is collected and reported separately from other carbonate fertilizers in the national statistics.

The annual carbon emission from CAN use is calculated with Tier 1 method using equation 11.12 and the default emission factor based on carbonate carbon contents of CaCO_3 as 12% (the same as for limestone) according to [IPCC 2006, Chapter 11.3.1]:

$$\text{CO}_2\text{-C Emission} = M * EF$$

where:

$\text{CO}_2\text{-C Emission}$ – annual C emissions from CAN application; t C/year

M – annual amount of CAN expressed in CaCO_3 ; t/year

EF – emission factor as for limestone – 0.12 t C/t CaCO_3

Table 5.6.2. CAN use in Poland [kt N]

1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
138.3	165.4	150.3	98.4	78.2	104.0	131.0	153.0	165.0	166.3	191.5	234.3
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
188.9	147.7	160.7	170.0	161.5	160.5	165.0	182.0	180.0	172.1	167.0	200.2
2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
189.9	200.8	190.1	167.9	174.0	189.9	200.1	108.1	121.6	90.3		

5.6.4. Uncertainties and time-series consistency

Description of uncertainties is given in Chapter 5.2.3.

5.6.5. Source-specific QA/QC and verification

Description is given in Chapter 5.2.4.

5.6.6. Source-specific recalculations

No recalculation was made in this submission.

5.6.7. Source-specific planned improvements

Presently no improvements are planned.

6. LAND USE, LAND USE CHANGE AND FORESTRY (CRF SECTOR 4)

6.1. Overview of sector

The greenhouse gas inventory of the Land Use, Land Use Change and Forestry (LULUCF) sector covers all CO₂ emissions and removals due to gains and losses in the relevant carbon pools of the predefined six land-use categories, as well as non-CO₂ emissions from biomass burning and disturbance associated with land-use conversions. It should be noted that a number of factors used in the estimations of GHG's assumes default values (recommended by the IPCC). Those factors are considered to be modified on the basis of in-country analysis.

Data included in this inventory is based on statistical data presented in statistical journals published by the Statistics Poland. The data relating to the land area by the type of land use (in accordance with the methodology recommended by IPCC 2006) is based on data on the condition and changes in the registered intended use of land were developed on the basis of annual reports on land, introduced in the following Regulations: of the Minister of Agriculture and Municipal Management of 20 February 1969 on land register (MP No. 11, item 98), from 1997 – of the Minister of Spatial Economy and Construction and of the Minister of Agriculture and Food Economy 17 December 1996 on register of land and buildings (O. J. No. 158, item 813), and from 2002 of the Minister of Regional Development and Construction of 29 March 2001 on register of land and buildings (O. J. No. 38, item 454).

Amendments to the regulations introduced changes in land classifications. Subsequent changes were implemented inter alia due to adoption of the international standards. Beginning with data for 1997 on, the registers of land were prepared by the Head Office of Geodesy and Cartography as well as voivodship branches of geodesy and land management. The data are presented, taking into consideration of cadastral units area. Available activity data and methodologies did not allow the exclusions of indirect and natural GHG emissions from the present estimation of anthropogenic GHG emissions for the relevant activities.

According to the report of a rather recent IPCC meeting (Expert Meeting on Revisiting the Use of Managed Land as a Proxy for Estimating National Anthropogenic Emissions and Removals, 5-7 May 2009, Sao Paulo, Brazil), there are currently no scientifically sound methods to separate out indirect and natural GHG emissions and removal (IPCC, 2010). On the other hand, this is not necessarily needed if appropriate proxies are used. The above mentioned meeting, among others, stated that, although not perfect, the currently applied proxy, i.e. the so called “managed land” proxy is one that approximates the effects of direct human induced activities. We also note that this separation is taken care of by the various steps of the accounting, thus, no additional separation is necessary, and we have indeed not have done any

6.1.1. The greenhouse gas inventory overview of the Land Use, Land-Use Change and Forestry (LULUCF) sector

The greenhouse gas inventory of LULUCF sector comprises emissions and removals of CO₂ due to overall carbon gains or losses in the relevant carbon pools of the predefined six land-use categories. These activities in 2021 altogether resulted in net removals estimated to be equal to 20 094 kt of CO₂ equivalent.

The description of the methodological details in the subsequent sections follows the structure of the national inventory reports as outlined in the Appendix to Annex I (Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories) of Decision 24/CP.19 (Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention).

In estimating emissions and removals, the IPCC 2006 Guidelines have been applied as a methodological basis since 2016 inventory. In general, we apply Tier 2 methodology with country specific data where relevant data became accessible. We also apply “best estimates”, i.e. we have made use of all data and

information that exist within the country in relation to the forest GHG inventory. In all other cases, we refer to the source of the data applied (i.e., the 2006 IPCC GL).

Table 6.1. Sectoral estimates for LULUCF

Greenhouse gas source and sink categories	Net CO ₂ emissions/removals	CH ₄	N ₂ O
	(kt)		
LULUCF total	-21 844.52	0.28	6.57
A. Forest land	-22 240.28	0.23	0.56
1. Forest land remaining forest land	-20 437.68	0.21	0.01
2. Land converted to forest land	-1 802.61	0.01	0.55
B. Cropland	1 699.99	NO,NA	0.04
1. Cropland remaining cropland	1 605.79	NO	NO
2. Land converted to cropland	94.20	NO	0.04
C. Grassland	-282.60	0.05	0.00
1. Grassland remaining grassland	702.24	0.05	0.00
2. Land converted to grassland	-984.84	NO	NO
D. Wetlands	1 585.91	NO,NA	0.00
1. Wetlands remaining wetlands	11.77	NO	0.00
2. Land converted to wetlands	1 574.14	NO	NO
E. Settlements	2 269.49	NO	5.97
1. Settlements remaining settlements	-204.95	NO	NO
2. Land converted to settlements	2 474.44	NO	5.97
F. Other land	NO,NA	NO,NA	NO,NA
1. Other land remaining other land			
2. Land converted to other land	NO,NA	NA	NA
G. Harvested wood products	-4 877.03	NA	NA
H. Other	NA	NA	NA

The most important category recognised to be the main source of CO₂ removals is 4.A *Forest land*. This situation is, to some extent, related to the recorded growth of timber resources. It shall be noted that the recorded growth is the result of timber harvest carried out in accordance with the forest sustainability principle and furthermore persistent enlargement of the forest area. Most removals are generated by biomass increment in the *Forest Land remaining Forest Land* and the *Land converted to Forest Land* categories. The net sink in these categories is mainly due to the fact that the forest area has been increasing, and that the total increment of the growing stock in forest lands, as far as recent observations are providing, has always been higher than the annual harvest.

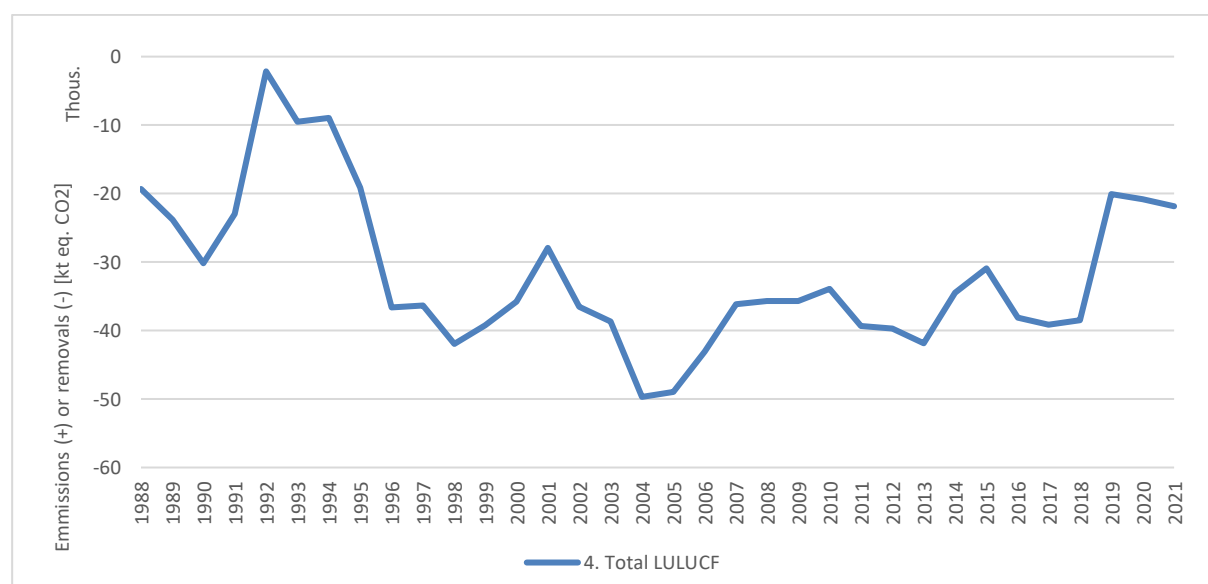


Figure 6.1. Trends in emissions/removals from the LULUCF sector by land-use

In this submission, Poland reports on carbon stock changes as well as greenhouse gas emissions and removals from *Forest Land* (CRF 4.A), *Cropland* (CRF 4.B), *Grassland* (CRF 4.C), *Wetland* (CRF 4.D) and *Settlements* (CRF 4.E). N₂O emissions from N in mineral soils that is mineralized/immobilized in association with loss of soil C are reported in CRF Table 3.D for Cropland remaining Croplands. CRF Table 4(III) reports N₂O emissions for all other land use and land use change categories associated with gain of organic matter resulting from change of land use or management of mineral soils. N₂O emissions from fertilization in Wetlands (CRF 4(I)) do not occur in Poland; N₂O emissions from fertilization in other land use categories, where relevant, are reported under the *Agriculture* sector (CRF 3). In addition, CO₂ emissions from liming are reported in CRF table 3G, whereas CO, CH₄, N₂O and NO_x emissions from biomass burning are reported in CRF table 4(V).

6.1.2. Country area balance in 2021

Table 6.2. Country area balance in 2021

Year	2021
Greenhouse gas source and sink categories	Area [ha]
4. Total land-use categories	31 272 040
4.A. forest land	9 450 112
4.A.1. <i>forest land remaining forest land</i>	8 890 756
4.A.2. <i>land converted to forest land</i>	559 356
total organic soils on forest land, of which:	340 455
on forest land remaining forest land	306 847
on land converted to forest land	33 608
4.B. cropland	13 816 063
4.B.1. <i>cropland remaining cropland</i>	13 529 263
4.B.2. <i>land converted to cropland</i>	286 800
total organic soils on cropland, of which:	159 989
on cropland remaining cropland	159 949
on land converted to cropland	40
4.C. grassland	4 205 416
4.C.1. <i>grassland remaining grassland</i>	3 899 684
4.C.2. <i>land converted to grassland</i>	305 732
total organic soils on grassland, of which:	797 426
on grassland remaining grassland	760 975
on land converted to grassland	36 451
4.D. wetlands	1 364 940
4.D.1. <i>wetlands remaining wetlands</i>	1 308 106
4.D.2. <i>land converted to wetlands</i>	56 834
total organic soils on wetland, of which:	73 814
on wetlands remaining wetlands	16 980
on land converted to wetlands	56 834
4.E. settlements	2 355 385
4.E.1. <i>settlements remaining settlements</i>	1 932 867
4.E.2. <i>land converted to settlements</i>	422 518
total organic soils on settlements, of which:	12 457
on settlements remaining settlements	7 400
on land converted to settlements	5 057
4.F. other land	80 124
4.F.1. <i>other land remaining other land</i>	NO
4.F.2. <i>land converted to other land</i>	80 124
total organic soils on other land, of which:	NO
on other land remaining other land	NO
on land converted to other land	NO
Country area balance	31 272 040

Land-use transition matrices (implementing approach 2 methodological assumptions) are included in the Annex 6. LUC matrices have been resolved to minimise inconsistencies as far as they can with the available datasets. Because several different data sources have been combined it has not been possible to reduce all inconsistencies to zero, but the variation is very small difference between the sum of all changes and the overall category totals to ensure that the sum of categories consistently adds up to the recently reported total area of Poland.

6.1.3. Land uses classification for representing LULUCF areas

For the reporting purposes to the United Nations Framework Convention on Climate Change it is recommended to assign national land-use categories (as specified in the Regulation of the Minister of Administration and Digitization of 29 November 2013 amending the regulation on the registration of land and buildings (*Journal of Laws 2013 pos. 1551*)) to the appropriate categories of land use consistently to the IPCC guidelines (Chapter 3.3.1. of IPCC 2006 Guidelines of the Volume 4). To fulfil the above mentioned recommendations available data were summarized taking into account the assessment provided in the table 6.3.

Table 6.3. Land use classification

IPCC category	National Land Identification System
4.A Forest land	forest land
4.B Cropland	arable land, orchards
4.C Grassland	permanent meadows and pastures; woody and bushy land
4.D Wetland	land under waters (marine internal, surface stands); land under ponds; land under ditches; ecological arable land; wasteland
4.E Settlements	agricultural build-up areas; build-up and urbanized areas
4.F Other land	miscellaneous land

Domestic land statistics are covered with the statistical surveys program of official statistics (more information is available at: <https://bip.stat.gov.pl/dzialalnosc-statystyki-publicznej/program-badan-statystycznych/pbssp-2021/>). Land statistics are characterized mainly by the PBSSS statistical survey No 1.01.02(002) Resources and changes in land use, land threats and protection.

As a matter of the scope land statistics covers full land use assessment taking into consideration cadastral (geodesic) area of the country by land use in particular years. We would like to note that the reported total area of all land use categories is equal to the total official land area of Poland as published by the annual land-use statistics (i.e. 31,270,040 ha). To avoid any inconsistencies in the reported times series, the latest of the annually published total area is reported for each inventory year in the GHG inventory. Furthermore, land statistics covers also net losses or gains in the area of specific land-use categories/activities and what these conversions represent (i.e., changes both from and to a category).

These conversions, such as information on areas of agricultural land designated for non-agricultural purposes and forest land designated for non-forest and non-agricultural purposes are utilised for the purpose of LULUC matrix preparation. The development of the annual land use and land use change data in Poland involves elements of both Approach 1 and 2. The identification of IPCC land-use categories, which is based on Polish statistical categories as well as the main data sources (together with a reference with respect to the Approach it allows for), is reported in following table:

Table 6.4. Approaches applied in preparation of LUC matrix

IPCC category	Data source	Associated IPCC approach
4.A Forest land	Land-use statistics Spatial Information System on Wetlands in Poland (complemented by CLC-change 1990-2000; CLC-change 2000-2006, CLC-change 2006-2012; CLC change 2012-2018)	Approach 2/3
4.B Cropland	Land-use statistics Spatial Information System on Wetlands in Poland (complemented by CLC-change 1990-2000; CLC-change 2000-2006, CLC-change 2006-2012; CLC change 2012-2018)	Approach 1/2
4.C Grassland	Land-use statistics Spatial Information System on Wetlands in Poland (complemented by CLC-change 1990-2000; CLC-change 2000-2006, CLC-change 2006-2012; CLC change 2012-2018)	Approach 1/2

IPCC category	Data source	Associated IPCC approach
4.D <i>Wetland</i>	Land-use statistics Spatial Information System on Wetlands in Poland (complemented by CLC-change 1990-2000; CLC-change 2000-2006, CLC-change 2006-2012; CLC change 2012-2018)	Approach 1/2
4.E <i>Settlements</i>	Land-use statistics Spatial Information System on Wetlands in Poland (complemented by CLC-change 1990-2000; CLC-change 2000-2006, CLC-change 2006-2012; CLC change 2012-2018)	Approach 1/2
4.F <i>Other land</i>	Land-use statistics Spatial Information System on Wetlands in Poland (complemented by CLC-change 1990-2000; CLC-change 2000-2006, CLC-change 2006-2012; CLC change 2012-2018)	Approach 1/2

In order to develop the most accurate overall area estimates for the entire AFOLU sector, the statistical sources on the various land use/change categories/activities were treated hierarchically during the compilation of land use change matrices. Since the land statistics are regarded as the most accurate and are the most important for the overall accuracy in the LULUCF sector, the hierarchy of the available sources was established as follows:

- 1) land-use statistics;
- 2) forestry statistics;
- 3) domestic spatial data;
- 4) external spatial data (e.g. CLC).

In terms of land use change matrices development starting with 1988, first, annual land use changes were addressed based on available statistics (i.e. available information on LUC areas, such as data on areas of agricultural land designated for non-agricultural purposes and forest land designated for non-forest purposes). In case of organic soils, while developing the land use change matrices beginning with 1988, first periodic land use changes (for the periods 1992-2000, 2000-2006; 2006-2012; 2012-2018) were estimated using the CLC databases. Annual land use change values of organic soils were then calculated from periodic ones using interpolation (until 2018). For 1988 and 1989 annual land use change values of organic soils as calculated for the period 1990-2000 were applied. Areas in the land use change categories were calculated by applying the default assumption that all land-use transitions that originated from the remaining categories take place in a period of 20 years, and the areas in the conversion categories are not converted again during the 20 year transition period.

There is one, small notation. In general total country area (total land area) slightly fluctuate over the reported period with the following reason. Statistics Poland in the statistical yearbooks (Environment), indicated that country total area variations are driven mainly by geodesic re-measurements at subsequent surveys. The fact that the country borders are very unstable was considered as the main factor of relative area changes. Polish borderline is constantly changing as a result of water erosion. The same changes in the area are driven by the land borders movement. A significant part of Polish border runs along the rivers mainstreams, where a large part of these rivers is unregulated, so the frequent changes in the location of the mainstream occurs. Country area fluctuations were reflected in the changes of the area of other land. Additionally, we noted that for the period 1968-1989, limited CSO statistics on land use are available. Stating that for the purpose of LUC matrix development, the latest available data was applied back to 1968.

It is worth to note that in the second half of 2018, Head Office of Geodesy and Cartography undertook actions aimed at publishing land and building records data directly from poviats resources. The undertaking was to provide publicly available network services that would enable the use of land and building records data in state IT systems and systems created by commercial companies.

The services concerned are:

1. KIEG - (National Integration of Land Records) a service providing the ability to generate a map of land and building records for any area of the country.
2. ULDK - (Cadastral Plot Location Service) a service for locating cadastral plots. It allows spatial location of the indicated plot based on its identifier, precinct name and plot number, or based on the X, Y coordinates of any point inside.

All technical details related to services can be found on the pages of these services, i.e.

- <https://integracja.gugik.gov.pl/cgi-bin/KrajowaIntegracjaEwidencjiGruntow>
- <https://uldk.gugik.gov.pl>

These land statistics are generally characterized by the PBSSP statistical survey No 1.01.02(002) Resources and changes in land use, land threats and protection. Moreover, the CLC data sets, including statistics on land cover and spatial data from Spatial Information System on Wetlands (GIS Mokradła Polski) in Poland, had been compiled and applied to expand relevant activity data to the extend possible. This approach allows assigning the area of organic soils (taken from GIS Mokradła Polski) to the relevant land use and land use change categories. Contextually, the judgement was based, mostly on Corine Land Cover (CLC) vector maps (with a scale of 1:100,000, a minimum cartographic unit (MCU) of 25 ha and Map of Wetlands and Grasslands and the Map of Poland's Hydrographic Division (both with a scale of 1:100,000). Therefore, the mapping homogeneous landscape patterns was possible. Also, in terms of CLC nomenclature a 3-level hierarchical classification system (44 classes) was utilised. For this judgement CLC land-cover categories were classified into IPCC land-use categories (forest land: 311, 312, 313, 324; cropland 211, 212, 213, 221, 222; grassland: 231, 321; settlements: 111, 112, 121, 122, 123, 124, 131, 132, 133, 141, 142; wetlands: 411, 412, 511, 512; other land: 331, 332, 333).

Although, data on land cover change from the CLC databases has not been included in assessing the land use change data, a research in this field has been initiated to fulfil the obligation as contained in the part 3 of the annex V to the EU reg. 1999/2018, focusing on possibilities of including this data in the inventory by 2023.

The aim of above described study is to address the following objectives:

- 1) to determine the most accurate land cover map based on a time series of Sentinel-2 data using machine learning approaches;
- 2) to verify the EAGLE concept by developing and testing an approach for integration and population of land use information and delivering the enhanced LCLU database;
- 3) to design and develop web-based application enabling to query the enhanced LCLU database as well as to integrate and extract statistics from the CLMS adjusted to the user needs;
- 4) to proof if and how enhanced LCLU database and CLMS can be used in spatial planning;
- 5) to proof if and how the enhanced LCLU database and CLMS can be used in the agricultural management and environmental monitoring;
- 6) to demonstrate the usefulness of the enhanced LCLU database and CLMS for reporting GHG emissions and removals from LULUCF.

It is worth to note that Chapter 3 of the Volume 4 of the 2006 IPCC Guidelines (Consistent representation of lands) describes three Approaches for representing land area. However the existing level of information allows the implementation of Approach 2 (Total land-use area, including changes between categories) with additional information available for reanalysing existing inventories with reference to boundaries of geographic areas or from sampling program only.

6.1.4. Key categories

Key category assessment for LULUCF categories is included in annex 1.

6.2. Forest Land (CRF sector 4.A)

6.2.1. Source category description

Estimations for this subcategory were based on IPCC methodology described in the chapter 4 of IPCC 2006 guidelines of the Volume 4. GHG balance in this category in 2021 is a net CO₂ sink, estimated to be equal to 22 240 kt CO₂. Overall trend in the reporting period is presented on graph below. Considerable fluctuations in the early 90's are associated with the natural disturbances and their impact on consistently increasing wood resources. As for the 2019 data, we have observed a significant change in the dynamics of forest resources growth. This particular situation is driven, inter alia, by the effects of tree stand ageing (affecting trees size, shape and biomass allocation, and well as consequently allometric relationships). Furthermore the effects of natural disasters such as long-term droughts since 2014, hurricane winds in 2017, and - importantly - significant changes in the dynamics of dead wood decomposition have its own considerable impact on annually observed level of carbon accumulation in forests. Decomposition level and the overall structure of dead wood resources has been reflected in the estimation of CSC in relevant carbon reservoir.

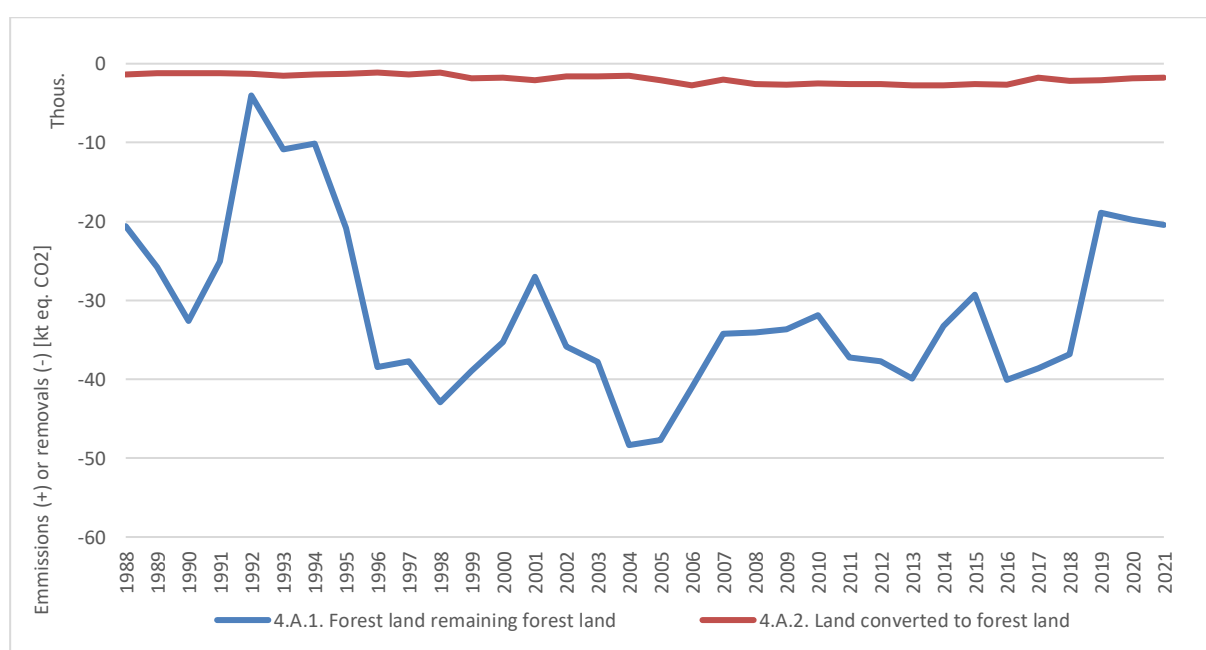


Figure 6.2. Trends in emissions/removals for the category 4.A. *Forest land*

Most removals are generated by biomass gains in the category *forest land remaining forest land (FL_FL)* and the *land converted to forest land (L-FL)* categories. The net sink in this category is mainly due to the fact that the forest area is continuously increasing, and that the total increment of the growing stock in forest land has always been larger than the annual harvest for the last decades.

6.2.1.1. Area of forest land in Poland in year 2021

Forest land reported under subcategory 4.A is classified as a “forest” according to Art. 3 of *Act on Forests of 28 Sep 1991 (Journal of Law of 1991 No 101 item 444, as amended)*. This assessment is in line with internationally adopted standard which takes into account the forest land associated with forest management. Forest land area in Poland, as of 1 January 2022, was equal to 9 450 112 ha (*STATISTIC POLAND; Environmental protection 2022*).

Table 6.5 Forest land area by provinces as of the end of inventory year (1/3)

No.	Voivodship	Unit	2008	2009	2010	2011	2012
1.	Dolnośląskie	[ha]	606 104	607 327	608 387	609 279	610 583
2.	Kujawsko-pomorskie	[ha]	425 207	426 170	427 147	427 843	428 254
3.	Lubelskie	[ha]	568 601	572 620	576 420	579 237	581 002
4.	Lubuskie	[ha]	706 788	707 583	708 201	709 002	709 881

No.	Voivodship	Unit	2008	2009	2010	2011	2012
5.	Łódzkie	[ha]	386 172	387 711	388 597	389 350	390 358
6.	Małopolskie	[ha]	439 126	438 280	439 765	440 114	440 432
7.	Mazowieckie	[ha]	802 158	804 912	808 810	812 973	817 869
8.	Opolskie	[ha]	257 858	258 170	258 246	258 399	258 570
9.	Podkarpackie	[ha]	671 363	674 450	677 953	680 166	683 371
10.	Podlaskie	[ha]	621 718	624 856	626 532	627 235	628 678
11.	Pomorskie	[ha]	676 165	677 673	678 226	679 898	681 014
12.	Śląskie	[ha]	400 709	399 592	399 954	401 747	402 014
13.	Świętokrzyskie	[ha]	331 492	332 089	332 487	332 980	402 364
14.	Warmińsko-mazurskie	[ha]	752 146	755 050	760 064	763 567	334 385
15.	Wielkopolskie	[ha]	778 863	780 795	783 340	784 649	785 648
16.	Zachodniopomorskie	[ha]	826 934	828 508	830 633	832 735	834 009
Total		[ha]	9 251 404	9 275 786	9 304 762	9 329 174	9 353 731

Table 6.5 Forest land area by provinces as of the end of inventory year (2/3)

No.	Voivodship	Unit	2013	2014	2015	2017	2018
1.	Dolnośląskie	[ha]	610 968	611 562	611 919	612 305	612 893
2.	Kujawsko-pomorskie	[ha]	428 491	428 772	429 045	429 605	429 953
3.	Lubelskie	[ha]	582 307	583 447	584 477	573 550	586 630
4.	Lubuskie	[ha]	710 350	710 858	711 077	711 424	711 666
5.	Łódzkie	[ha]	390 950	391 259	391 722	372 238	392 880
6.	Małopolskie	[ha]	440 664	440 672	440 683	440 846	440 942
7.	Mazowieckie	[ha]	824 660	828 607	835 112	836 080	836 789
8.	Opolskie	[ha]	258 846	258 982	259 139	258 932	259 270
9.	Podkarpackie	[ha]	683 462	685 002	686 848	687 992	689 055
10.	Podlaskie	[ha]	629 184	630 047	630 622	631 277	632 106
11.	Pomorskie	[ha]	681 537	682 244	682 783	683 461	684 089
12.	Śląskie	[ha]	402 307	402 989	403 341	403 765	404 096
13.	Świętokrzyskie	[ha]	334 796	335 083	335 277	335 770	336 315
14.	Warmińsko-mazurskie	[ha]	769 824	771 463	774 906	777 517	780 690
15.	Wielkopolskie	[ha]	785 998	786 497	786 015	786 783	787 065
16.	Zachodniopomorskie	[ha]	834 760	835 094	833 205	840 435	841 291
Total		[ha]	9 369 403	9 382 578	9 395 171	9 381 979	9 425 730

Table 6.5 Forest land area by provinces as of the end of inventory year (3/3)

No.	Voivodship	Unit	2019	2020	2021	2022
1.	Dolnośląskie	[ha]	612977	612793	612728	615249
2.	Kujawsko-pomorskie	[ha]	430009	430075	430182	430254
3.	Lubelskie	[ha]	586396	587070	587886	588134
4.	Lubuskie	[ha]	712013	712196	712234	712593
5.	Łódzkie	[ha]	393164	393197	393350	391931
6.	Małopolskie	[ha]	441054	441156	441128	441279
7.	Mazowieckie	[ha]	837674	837796	837936	838091
8.	Opolskie	[ha]	259284	259286	259409	259189
9.	Podkarpackie	[ha]	689972	690359	690499	691244
10.	Podlaskie	[ha]	633635	633929	633873	634966
11.	Pomorskie	[ha]	684212	684132	684315	684810
12.	Śląskie	[ha]	404583	404760	404277	404596
13.	Świętokrzyskie	[ha]	336772	337233	337441	337815
14.	Warmińsko-mazurskie	[ha]	783616	785399	786956	787857
15.	Wielkopolskie	[ha]	786809	787353	787495	788463
16.	Zachodniopomorskie	[ha]	841908	842387	843165	843641
Total		[ha]	9 434 078	9 439 123	9 442 874	9 450 112

Difference between the areas reported by Poland under FAO and UNFCCC

Data on the condition and changes in the registered intended use of land, developed on the basis of annual reports on land prepared by the Head Office of Geodesy and Cartography, was applied in the estimations and reported under the UNFCCC. National statistics prepared and published on the

basis of those reports, describes areas of all land uses, including forest land, with the consideration of the geodesic area [e.g. "Statistics Poland; Environmental Protection 2022"].

In relation to the FAO reports, data collected and reported there was developed on the basis of information obtained from stand-alone statistical surveys in subsequent years. As a result of various methods, which were applied for data collection and processing some notable differences can occur. What needs to be emphasized, statistical approach used in stand-alone statistical surveys do not consider all land use types in the same survey at the same time. Therefore, with regard to the data comparability and accuracy reported under the UNFCCC, information obtained from statistical surveys on land areas, which partially covers country territory, could not be applied in GHG inventory.

6.2.1.2. Habitat structure

The diversity of growing conditions for forests in Poland is linked to the natural-forest habitats allocations and is presented on Fig. 6.3. Poland has mainly retained forests on the poorest soils, which is reflected in the structure of forest habitat types. Mixed coniferous habitats prevail, accounting for 29.4% (*Statistics Poland; Forestry 2022*) of the total forest area. Pure coniferous habitats are estimated to 20.3% of forest area. Mixed deciduous habitats are estimated to 26.7%. Finally pure coniferous habitats are estimated to 23.0% of forest area. Each group has its own allocation in a further distinction of forests area between lowland, upland, and mountain habitats.

Table 6.6. General characteristic of forest habitat structure

Specification	Habitats in percent										
	Lowland				Upland				Mountain		
	coniferous forests	coniferous forests mixed	mixed forests	forests (decid.)	coniferous forests mixed	mixed forests	forests (decid.)	coniferous forests	coniferous forests mixed	mixed forests	Forests (decid.)
	[%]										
Total	20.1	28.2	23.1	13.4	0.7	1.5	4.5	0.2	0.5	2.1	5.1

Source: Statistics Poland; Forestry 2022

6.2.1.3. Species composition

The geographical distribution of habitats is, to a great extent, reflected in the spatial structure of dominant tree species. Apart from the mountain regions where spruce (west) and spruce and beech (east) are the main species in stand composition, and a few other locations where stands have diversified species structure, in most of the country stands with pine prevail as the dominant species.

In terms of forest area, coniferous species dominate in Polish forests, accounting for 68.6% of the total forest area. Poland offers optimal climatic and site conditions for pine within its Euro-Asiatic natural range, which resulted in development of a number of important ecotypes. Pine accounts for 58.6.1% of the area of forests in all ownership categories, for 60.8% in the State Forests and for 55.3% in the privately-owned forests.

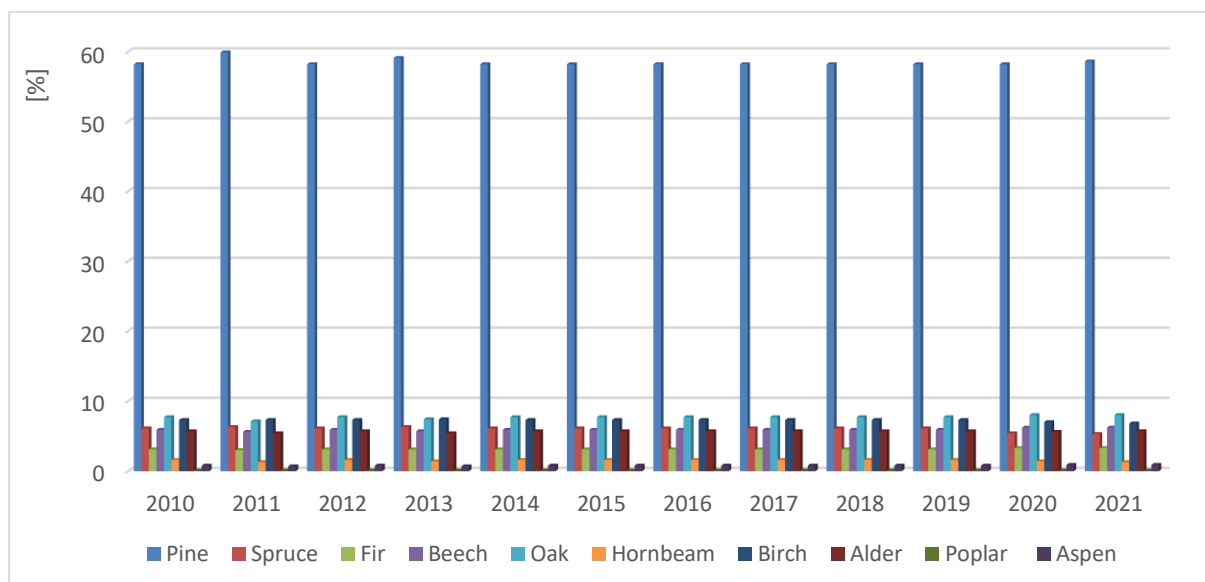


Figure 6.3. Species structure of dominant tree species (as of 1 January 2021)

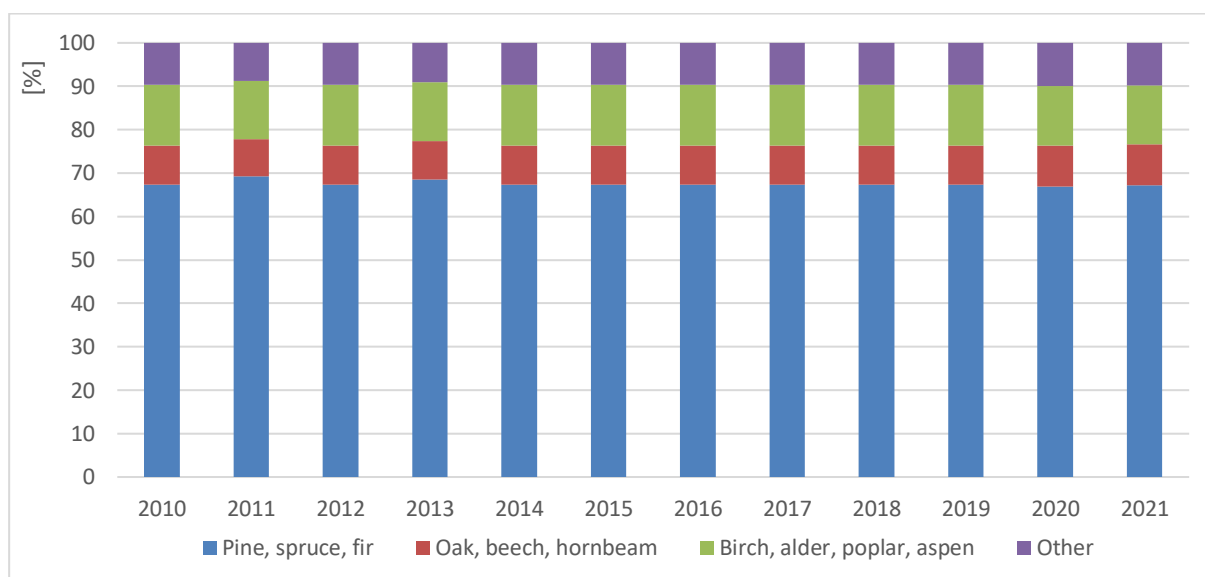


Figure 6.4. Structural changes of tree species by aggregated groups of dominant tree species (as of 1 January 2021)

Since 1945 forest species structure has undergone significant changes, expressed, inter alia, by increased share of stands for deciduous trees. Considering state forests, where it is possible to trace this phenomenon on the basis of annual updates of forest land area and timber resources, total area of deciduous stands increased from 13 to 31.4%. Despite the increase in the area of deciduous forests, their share is still below potential, arising from the structure of forest habitats.

6.2.1.4. Age structure

Stands aged 41–80 years, representing age classes III and IV prevail in the age structure of forests and cover. Notably representing 22.4% and 26.5% of standing wood resources and 21.5% and 21.6% of the forest area respectively. Moreover, stands aged 41–80 years are dominating in total forests area, with their total share equal to nearly 43.1%. Stands over 80 years old, including stands in the restocking classes, account for 28.4% of the total forest area.

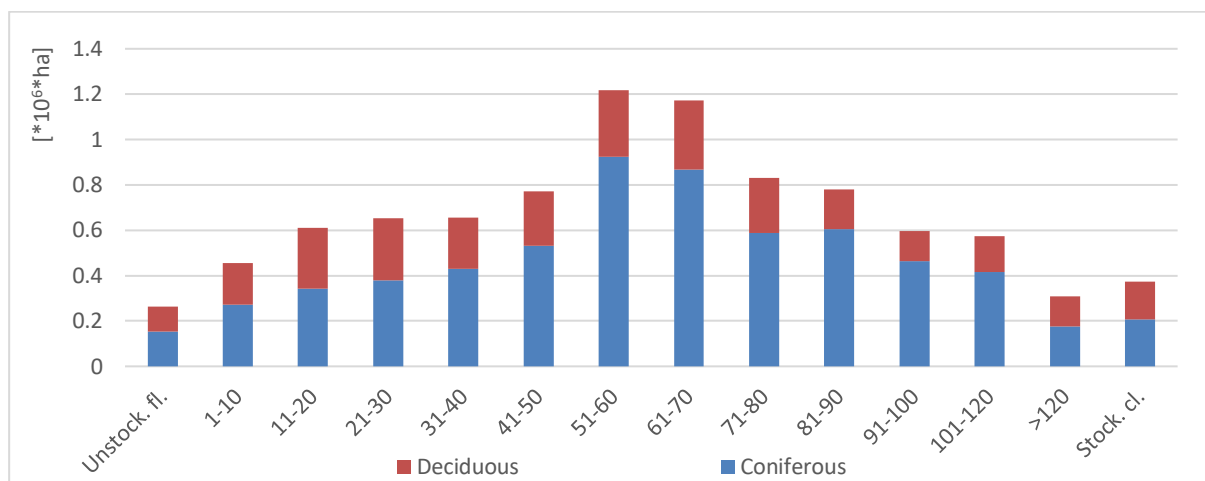


Figure 6.5. Forest area by age classes including temporary unstocked forests (Unstock. fl.) and forests under stocking and restocking, as well as with structure under development (Stoc. cl.) as of 1 January 2021.

6.2.1.5. Structure of timber resources by volume

According to the Statistical Yearbook “Forestry 2022”, estimated timber resources, as of the beginning of 2021 (as of 1 Jan. 2021) amounted to 2 668 959 thous. m³ of gross merchantable timber, including 2 201 038 thous. m³ in the public forests and 467 921 thous. m³ in forests owned privately.

6.2.2. Information on approaches used for representing land area and on land-use databases used for the inventory preparation

According to the description suggested in the chapter 3.3.1. of IPCC 2006 Guidelines of the Volume 4, managed forest land areas associated with the forestry activities in Poland is identified using Approach 3. Geographic boundaries encompassing units of land subject to multiple activities are identified based on data *on the condition and changes in the registered intended use of land* developed on the basis of annual reports on land.

6.2.3. Land-use definitions and classification system used and their correspondence to the LULUCF categories

According to the regulations of art. 3 of the Act on Forests of September 28th 1991 (*Journal of Law of 1991 No 101 item 444, as amended*), forest land is the area:

- 1) of contiguous area greater than or equal to 0.10 ha, covered with forest vegetation (or plantation forest) – trees and shrubs and ground cover, or else in part deprived thereof, that is:
 - a. designated for forest production, or
 - b. constituting a Nature Reserve or integral part of a National Park, or
 - c. entered on the Register of Monuments;
- 2) of contiguous area greater than or equal to 0.10 ha, associated with forest management.

This subcategory includes entire land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory with:

- minimum area: 0.1 hectare,
- minimum width of forest land area: 10 m,
- minimum tree crown cover: 10% with trees having a potential to reach a minimum height of 2 metres at maturity in situ. Young stands and all plantations that have yet to reach a crown density of 10 percent or a tree height of 2 metres are included under forest. Areas normally forming part of the forest area that are temporarily un-stocked as a result of human

intervention, such as harvesting or natural causes such as wind-throw, but which are expected to revert to forest are also included.

With regard to the regulations of art. 3 of the act on forests, forest land considered a subject to the forest management is the area:

- 1) of contiguous area greater than or equal to 0.10 ha, covered with forest vegetation (or plantation forest) – trees and shrubs and ground cover, or else in part deprived thereof, that is:
 - a. designated for forest production, or
 - b. constituting a Nature Reserve or integral part of a National Park, or
 - c. entered on the Register of Monuments;
- 2) of contiguous area greater than or equal to 0.10 ha, associated with forest management.

Provisions of this act allow to standardize the definition of forest land as a part of land use scheme. Poland has established a system of regulations allowing to identify, collect, process, report and publish data of land use in the annual statistics. Annual summary reports on land use areas submitted by the Head Office of Geodesy and Cartography are prepared on the basis of regulations of *Act on geodesy and cartography* (Journal of Laws of 1989 No. 30, item. 163, as amended) constituting the basis for the statistical publications fulfilling requirements of National Land Identification System.

For the specific purposes of GHG inventory, data provided by National Statistics have been continuously applied. Taking into account inventory specific needs, system improves to provide better data by statistical sampling associated to NFI combined with spatial information from register of land and buildings.

6.2.4. Forest Land remaining Forest Land (CRF sector 4.A.1)

GHG balance in this category is a net sink. In 2021 net CO₂ sink was about 20 438 ktCO₂ eq. Methodological assumptions are provided in the following chapters.

6.2.4.1 Methodological issues

Due to the intensive forest monitoring as described above, all forest stands are continuously accounted for. This also means that all changes in the biomass carbon stocks of the forests due to any causes from growth through harvests, natural disturbances and deforestation are captured by the forestry statistics of each stand at least on a decade scale, and those of the whole forest area even on an annual basis.

6.2.4.2 Subcategory area

Land use change matrix is presented in the annex 6.

According to the provisions of the decision 9/CP. 2 *Communications from Parties included in Annex I to the Convention: guidelines, schedule and process for consideration* where it is decided that the four Parties that have invoked Article 4.6 of the Convention, which requested in their first communications for flexibility to use base years other than 1990, Poland has chosen the year 1988 to be set as a starting point for the reporting of transitions in line with the IPCC 2006 guidelines.

6.2.4.3. Living biomass

Carbon stock changes

Carbon stock-change method to estimate emission and removals balance related to the subcategory 4.A.1 *Forest Land remaining Forest land* were estimated with the available methods and factors that were possible to be applied to national circumstances. In this particular case, the stock-difference method required biomass carbon stock inventories for a given land area, at two points in time. Annual biomass change is the difference between the biomass stock at time t_1 and time t_0 , divided by the number of years between the inventories (Equation 2.8). Annual change in carbon stocks in living biomass reservoir was estimated considering the changes in forest resources on forest land all forms of ownership, using the information contained in the statistical yearbooks "Forestry". Estimations were based on the equation 2.8 contained in the IPCC guidelines as suggested in the Volume 4, Chapter 2.3.1.1. Data sources contains tables describing forest resources structure by species and age classes.

As mentioned above, the general methodology to estimate emissions and removals in the forestry sector is based on the IPCC methodology (IPCC 2006). However, wherever it was possible, country specific data was used (Tier 2), and IPCC default values (Tier 1) were only used in a few cases. Changes in carbon stocks in the biomass pool are accounted annually on the basis of the Polish forestry statistics which provides relevant information, describing aboveground volume of all forests at the country level, available annually for the each inventory year. Moreover gross merchantable volume stock used in the above mentioned calculations is estimated on the basis of data obtained from the most recent 5-year cycle of large-scale inventory, which is published in the form of official statistics by the Statistics Poland.

Recently submitted estimates of the carbon stock changes in living biomass for the subcategory forest land remaining forest land are aiming to maintain time-series consistency as much as possible. Since recent statistical data is not fully comparable with historical statistics data published up to 2009, historical data was considered comparable when calibrated using the calibration factors obtained in line with the calculation method as provided in the chapter 5.3.3.2 of the Volume 1 of the IPCC 2006 Guidelines. . Recent implementation of more detailed methodologies aims in finding a common point in time for which reflected comparisons of could be made, considering existing data limitations.

Furthermore, the stock-change method application might not imply in a proportion between the annual stock differences and the average growing stock. As indicated during the ERT 2018 fluctuation

in the ratio of implied carbon stock change factors in living biomass is affected by the changes in the species and age-structure distribution of the timber resources. This statement is supported by the preliminary results of the Carbon Budget Model of the Canadian Forest Sector, as provided on the Fig. 5. *Compatibility of data included in the forest reference level with the data contained in the 2018 National Inventory Report of the Polish National Forestry Accounting Plan* (https://bip.mos.gov.pl/fileadmin/user_upload/bip/strategie_plany_programy/Krajowy_Plan_Rozliczen_dla_Lesnictwa/NFAP_2019_POLAND_ENG_FINAL.pdf). In this particular case the annual stock differences (which are the differences of average growing stocks of two consecutive years), also reflect the changes in the species and age-structure distribution of the timber resources.

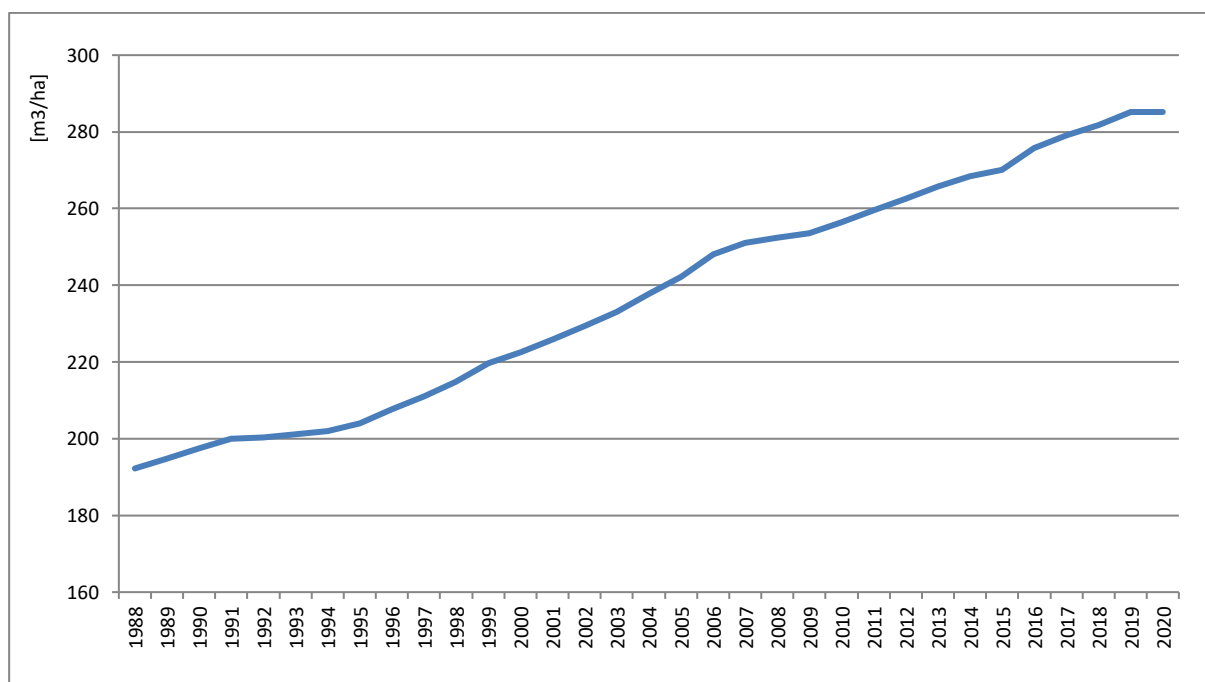


Figure 6.6. Average volume stock of merchantable timber in Polish forests (with pre 2009 data calibrated)

Fortunately, the State Forest Holding's data base also contains aggregate annual statistics on total growing stocks by species and age classes. These statistics are produced by a bottom-up approach, i.e. growing stocks of stands are aggregated by species and age classes.

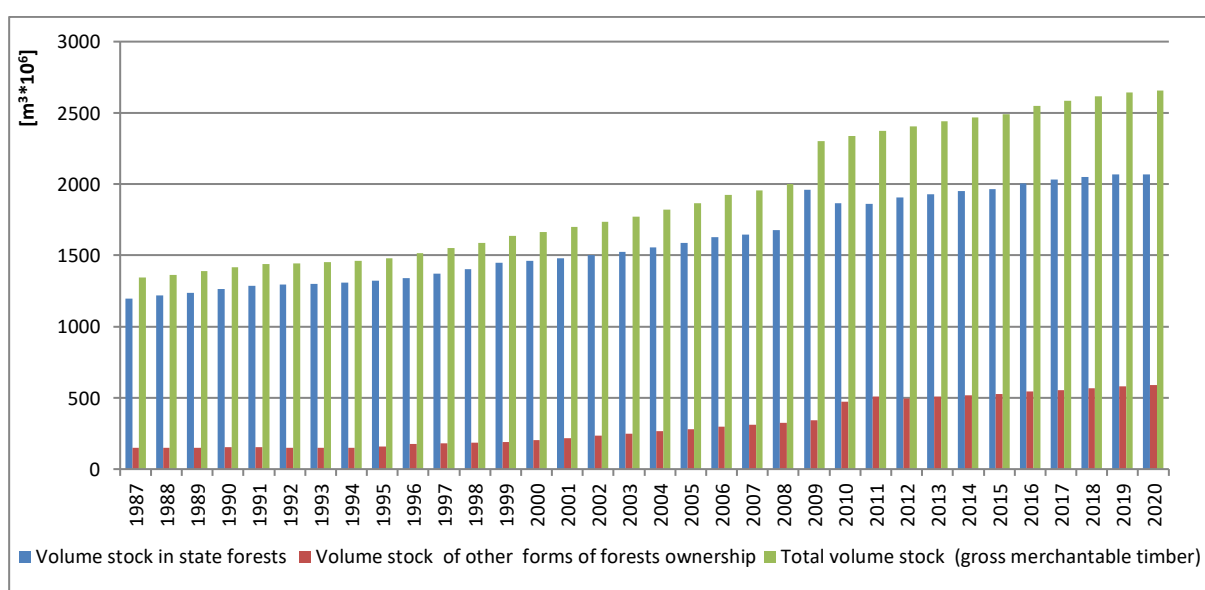


Figure 6.7. Volume stock of merchantable timber in Polish forests (as of 1 January)

There are uncertainties around these statistics, however, they are regarded smaller than those associated with a gain-loss method and systematic errors. We noted that since growing stocks and their changes incorporate the effects of all processes mentioned above, no particular inferences on emissions and removals can be made separately for any of these processes.

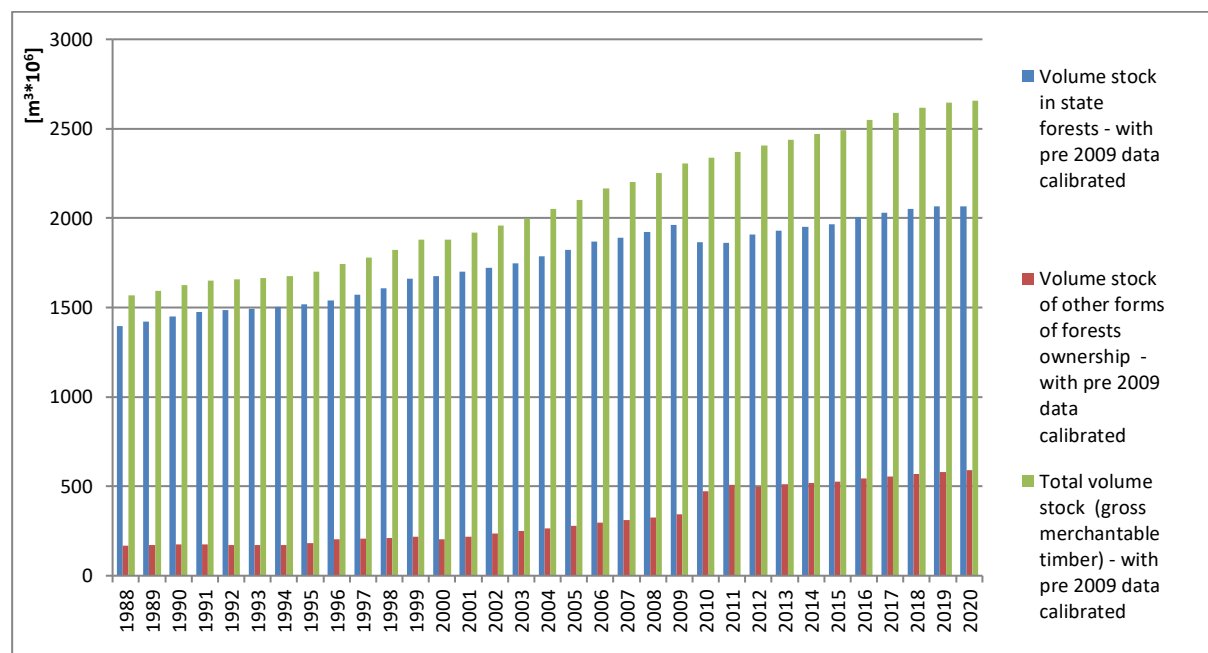


Figure 6.8. Volume stock of merchantable timber in Polish forests with pre-2009 data calibrated (as of 1 January)

Data provided on the graph above was prepared on the basis of data collected from the periodical forest inventory surveys by the Forest Management and Geodesy Bureau. To eliminate potential overestimations of carbon sinks linear calibration of pre-2009 data sets was applied. The inventory data is stored in a publically available databases, i.e. the Forest Data Bank (<https://www.bdl.lasy.gov.pl/portal/tworzenie-zestawienia-rw>). During the continuous survey of the forest inventory, the main stand measures (such as height, diameter, basal area, and density) are estimated by various measurement methods. The survey also includes mapping of the forest area. The survey methods applied in individual stands depend on species, age and site. Since the recent forest inventory scheme is based on survey's considering measurements of individual sample plots, more accurate and fully comparable results were obtained since 2009.

preparation for subcategory 4.A.1, tables of volume stock based on the forest area (without forest area used for forest management) as of 1 January have been prepared, by reducing volume stock tables of total forests – namely in Ia and Ib age subclasses – assuming they representing the relevant area resources.

However, while assessing potential volume stock of merchantable timber for subcategory 4.A.1 namely by subtracting areas and corresponding volume from the overall volume stocks, we find difficulties in obtaining suitable data to be considered applicable for CSC estimation in subcategory 4.A.2. Moreover, it is worth to note that the national forest inventory does not provide any official information on annual increment data exclusively for age class I (1-20 years) available for inventory compilation. Therefore alternative solutions, such as assessment of carbon (C) stock changes for any direct human-induced expansion of forest with Carbon Budget Model (CBM) to estimate C stock changes and emissions are being investigated

Another problem encountered in the information compilation process is the lack of detailed data on annual increase in volume stock by species due to biomass growth that could be utilized while using Equation 2.9 of the chapter 2 in the volume 4 of the IPCC 2006. Furthermore, while considering country-specific data on roundwood removals by species (that could be utilized while using Equation

2.12 of the chapter 2 in the volume 4 of the IPCC 2006), we have found very limited information in this regard (limited to the information on aggregated annual wood removals)

For carbon stock changes in biomass, the system of calculations allows for the use of even simpler sensitivity analysis than before. This is especially true if only the major sources of CO₂ emissions and removals are considered, which represent the bulk of all emissions and removals. The reason for this is that the equation inherent in the calculation is simple: only volume stock changes, wood density, root-to-shoot ratio, and carbon fraction factors are involved. With respect to accuracy and precision, the reported estimated values are generally accurate and precise as far as practicable. Where uncertainty seems to be high, and for non-quantifiable factors, the principle of conservativeness is always applied. With regard to carbon stock change estimation, it can be concluded that many sources of error were removed by switching from the process-based method to the stock-change method. Thus, it is expected that current estimates better reflect emissions and removals associated with forest land than previous estimates.

In order to fulfil the obligation contained in art 8 of the regulation 2018/841 (LULICF Reg.), taking into account that information contained in the NIR shall demonstrate methodological consistency between the reference level and reporting for managed forests during the first accounting period under LULUCF Reg.(2021-2025), and with the view of revising FRL by due date, we were focusing on preparation specific data inputs for the CBM CFS implementation in term of relevant projections. This process has also covered development of country-specific BEF values and root-to-shoot ratios. Although, modelling framework is planned to be incorporated in the compilation of GHG inventory in near future, some data inputs for the CBM CFS, covering country-specific BEF values and root-to-shoot ratios are available already. Nevertheless, format, structure and level of aggregation of this data do not allow it to be applied in the GHG inventory at this stage.

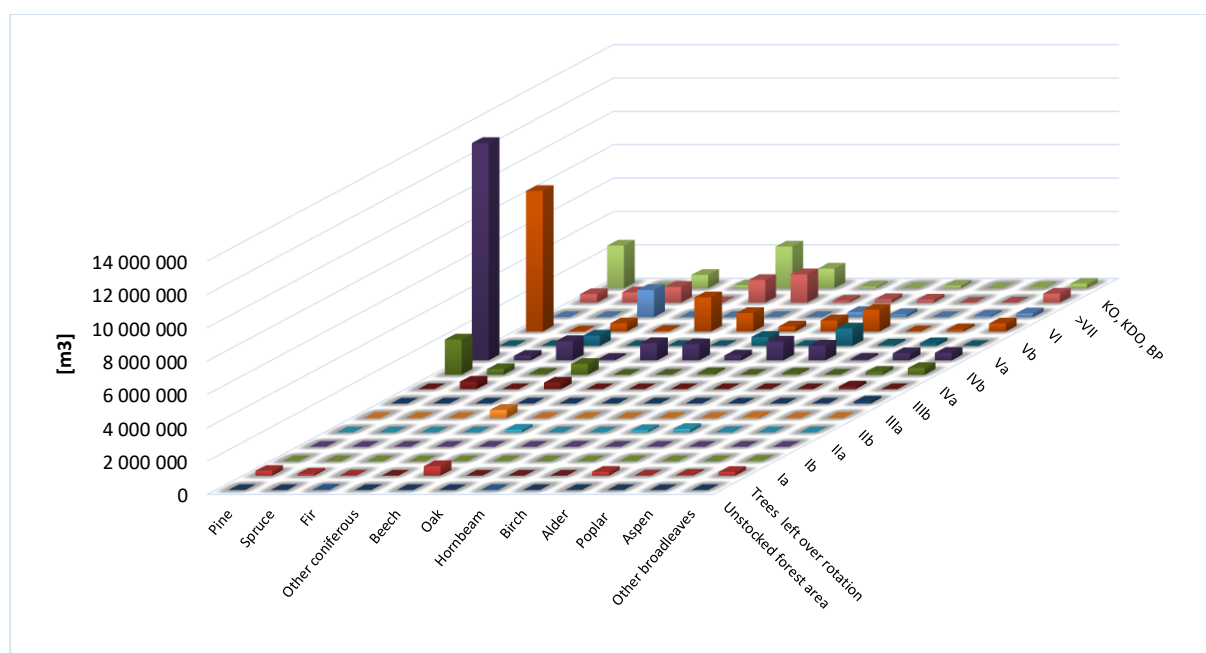


Figure 6.9. Annual level of volume stock changes (increases) of merchantable timber in Polish forests by species and age classes in 2020

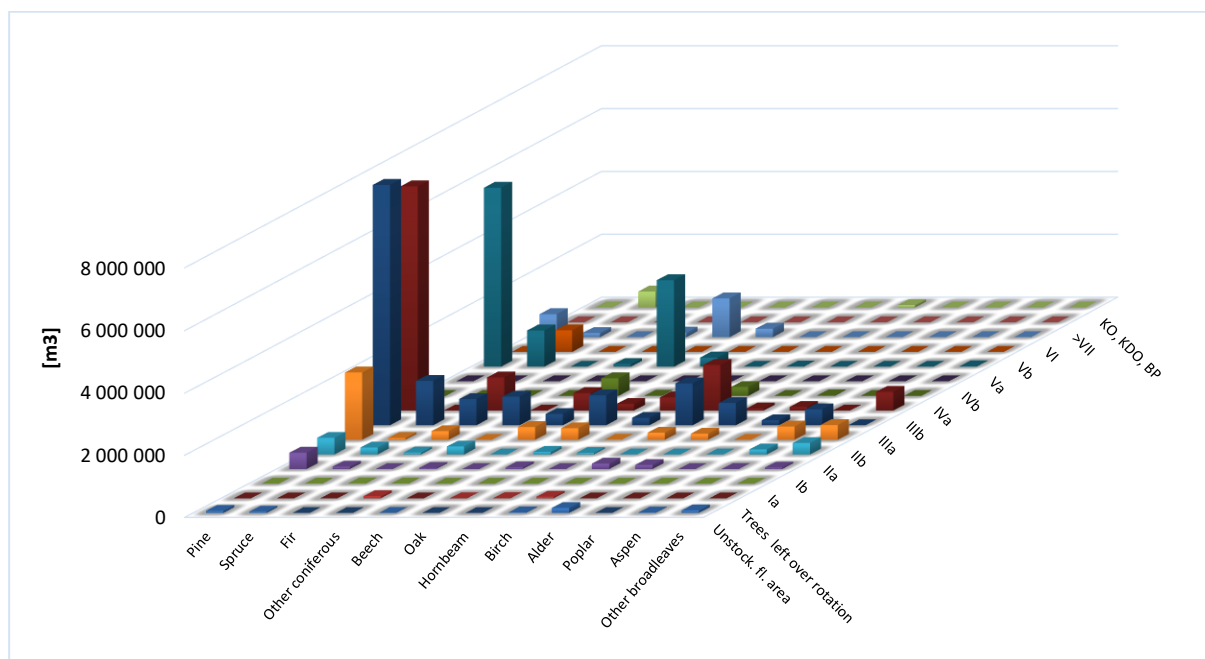


Figure 6.10. Annual level of volume stock changes (declines provided in a form of absolute values) of merchantable timber in Polish forests by species and age classes in 2020

6.2.4.4. Basic wood density

The current form of the equation 2.8 of chapter 4 of the Volume 4 of the IPCC 2006 (p. 2.12) actually triggered the use of a weighted mean of wood density. Basic wood density by species can only be applied when the volume of the average merchantable growing stock by single species is provided. Since the average merchantable growing stock has been applied in the eq. 2.8, the weighted mean of wood density was also applied to adjust the BCEF (as provided in the section 2.3.1.1 of the chapter 2 of the Volume 4 of the IPCC 2006. In the calculation of specific wood density (oven dry) by species, air dry wood density values by species (with the humidity at the level of 15%) and volumetric shrinkage of wood by species were used. Basic wood density values by major tree species obtained with the simplified approach by multiplication of air-dry wood density with relevant wood shrinkage is presented in the table 6.9.

Table 6.7. Air-dry wood density [t/m^3]³

Species	Air-dry wood density [t/m^3]
Pine	0.52
Spruce	0.47
Fir	0.45
Beech	0.73
Oak	0.69
Hornbeam	0.83
Birch	0.65
Alder	0.53
Poplar	0.45
Aspen	0.44

Data source: Krzysik F.. Wood science (In Polish). PWN Warszawa 1975

Table 6.8. Volumetric wood shrinkage [%]

Species	Volumetric wood shrinkage [%]
Pine	12.4
Spruce	12.0
Fir	11.7

³ with the level of 15% of wood humidity

Species	Volumetric wood shrinkage [%]
Beech	17.6
Oak	12.6
Hornbeam	19.7
Birch	14.2
Alder	12.6
Poplar	14.3
Aspen	11.0

Data source: Krzysik F. Wood science (In Polish). PWN Warszawa 1975

Air-dry wood density [t/m^3] was multiplied by the volumetric shrinkage of wood to estimate basic wood density (oven dry) by species. Results are presented in the table below. Almost in all cases country specific dry wood density is lower than value provided by the IPCC in the table 4.14 on p. 4.71 of chapter 4 of the Volume 4 of the IPCC 2006:

$$D = \text{Air-dry wood density } [\text{t/m}^3] * (1 - \text{volumetric shrinkage of wood})$$

Table 6.9. Basic wood density by major tree species

Species	Basic wood density [t/m^3]
	A
Pine	0.43
Spruce	0.38
Fir	0.36
Beech	0.57
Oak	0.57
Hornbeam	0.63
Birch	0.52
Alder	0.43
Poplar	0.35
Aspen	0.36
Other	0.36

6.2.4.5. Biomass conversion and expansion factor

Due to lack of proper country-specific data and in order to be consistent with previous estimate, IPCC default values for the BEF 2 (table 3 A.1.10 of the IPCC 2003 GPG) were used. Recent approach to estimate the BCEF, is consistent with the guideline provided in the section 2.3.1.1 p. 2.13 of chapter 4 of the Volume 4 of the IPCC 2006.

Table 6.10. BEF factors⁴

Climatic zone	Forest type	Minimum dbh (cm)	BEF ₂ (overbark)
Temperate	Spruce, Fir, Other coniferous	0-12.5	1.15
	Pines	0-12.5	1.05
	Broadleaf	0-12.5	1.20

With the broad range of the BEF's available, and due to lack of proper country-specific data and in order to be consistent with previous estimate, IPCC default values for the BEF 2 (table 3 A.1.10 of the IPCC 2003 GPG) were used. Poland applied the minimum values of factors available to limit their positive impact on overall carbon stock changes reported for the category forest land remaining forest land as well as for the activity forest management (conservative approach). A conservative approach is applied that allows for selective accounting of carbon pools and also allows to reduce monitoring

⁴ BEF₂ values applied in the inventory are at the lower end of the range of default values in table 3A1.10 of the IPCC good practice guidance for LULUCF.

costs could be to include all those pools anticipated to have reduced carbon stocks while omitting selected pools anticipated, with a sufficient level of certainty, to have unchanged or increased carbon stocks. Similar approaches could be used for fluxes of non-CO₂ greenhouse gases. Under this approach, verifiability would mean that only increases in carbon stocks and removal by sinks that can be monitored and estimated could potentially be credited.

In order to assess biomass conversion and expansion factors for expansion of merchantable growing stock volume to above-ground biomass, tonnes above-ground biomass (m³ growing stock volume), transforming merchantable volume of growing stock directly into its aboveground biomass default biomass expansion factor (BEFs) and country specific D values that were separately assessed has been utilised. The following conversion has been applied: BCEFs = BEFs x D. Recent process, related to the possibility of using country-specific BCEFs values is assuming application of default biomass expansion factor (BEFs) only. Nevertheless, BEFs assessment is carried out as an independent activity in parallel to subsequent improvements introduced into the inventory preparation. Since the official data is not yet available, Poland has continued its consideration of application of the default values results to obtain a consistent time series in the GHG inventory.

With respect to the estimation related to the biomass stock, data from the forest monitoring system is used, the primary objective of which has been to obtain accurate information on the status and development of all forests in the country. The forest inventory was designed to collect data at the stand level, but provide accurate estimates at aggregated levels.

With respect to net annual CO₂ removals, actual values may deviate from estimated values as the stock volume inventory for the whole country is not able to capture all inter-annual variability of timber growth and harvests, which can be high due to the variability of meteorological conditions. Also noting that the inter-annual variability of the estimated net removals in the Forest Land sector is due to a number of reasons, including the continuously, although slowly, changing structure of the forests by species, site fertility and age, and the variability of annual harvests and mortality. All these effects have rather different delayed effects, and these effects may be rather small relative to the total volume stocks, when applying default factors adjusted to national circumstances

It can be concluded that the carbon stock change estimation based on assumptions described above seem to be reliable and not affects accuracy of the emissions and removals associated with forest land.

6.2.4.6. Root-to-shoot ratio

Root-to-shoot ratio was adjusted based on default values proposed to be used by the IPCC in IPCC 2006 Guidelines of the Volume 4, table 4.4.

Table 6.11. R factors⁵

Species	Ratio of below-ground biomass to above-ground biomass (R)				
	Above-ground biomass [tonne root d.m./ha ⁻¹]				
	<50	50-70>	<70-75>	<75-150>	<150
Pine	0.40	0.29	0.29	0.29	0.20
Spruce	0.40	0.29	0.29	0.29	0.20
Fir	0.40	0.29	0.29	0.29	0.20
Beech	0.46	0.46	0.46	0.23	0.24

⁵ default values applied in the inventory for "Oak AGB < 50 tonnes/ha" and "Oak AGB 50–70 tonnes/ha" are the same as the IPCC default for "Quercus spp. AGB >70 tonnes/ha" in accordance with table 4.4 of the 2006 IPCC Guidelines. The value of 0.3 for "Quercus spp. AGB > 70 tonnes/ha" was used due to the lack of the appropriate value in Table 4.4 of the chapter 4 of the IPCC 2006 Guidelines. Nevertheless, the current approach applied should be recognized in terms of conservative approach, limiting the positive effect of young oak forest on overall carbon stock changes. Additionally, it should be noted that process related to the possibility of using country-specific values for the Root-to-shoot ratio is carried out as an independent activity in parallel to subsequent improvements introduced into the inventory preparation (this process also including Tier 3 models implementation).

Ratio of below-ground biomass to above-ground biomass (R)					
Species	Above-ground biomass [tonne root d.m./ha ⁻¹]				
	<50	50-70>	<70-75>	<75-150>	<150
Oak	0.30	0.30	0.30	0.23	0.24
Hornbeam	0.46	0.46	0.46	0.23	0.24
Birch	0.46	0.46	0.46	0.23	0.24
Alder	0.46	0.46	0.46	0.23	0.24
Poplar	0.46	0.46	0.46	0.23	0.24
Aspen	0.46	0.46	0.46	0.23	0.24

The above R (weighted mean) value has been applied in the equation 2.8 of chapter 4 of the Volume 4 of the IPCC 2006 (p. 2.12) for recent estimates of CO₂ removals. As indicated above, process related to the possibility of using country-specific values for the Root-to-shoot ratio is carried out as an independent activity in parallel to subsequent improvements introduced into the inventory preparation. Since the official data is not yet available, Poland has continued its consideration of application of the default values results to obtain a consistent time series in the GHG inventory.

6.2.4.7. Carbon fraction

Estimations are based on the following default factors (table 6.9).

Table 6.11. CF factors

Species	IPCC
Pine	0.51
Spruce	0.51
Fir	0.51
Beech	0.48
Oak	0.48
Hornbeam	0.48
Birch	0.48
Alder	0.48
Poplar	0.48
Aspen	0.48

6.2.4.8. Dead organic matter

Dead organic matter (DOM) comprises dead wood and litter. Estimating the carbon dynamics of dead organic matter pools allows for increased accuracy in the reporting of where and when carbon emissions and removals occur. For example, only some of the carbon contained in biomass killed during a biomass burning is emitted into the atmosphere in the year of the fire. Most of the biomass is added to dead wood, litter and soil pools (dead fine roots are included in the soil) from where the C will be emitted over years to decades, as the dead organic matter decomposes. Decay rates differ greatly between regions, ranging from high in warm and moist environments to low in cold and dry environments.

In forest ecosystems, DOM pools tend to be largest following stand-replacing disturbances due to the addition of residual above-ground and below-ground (roots) biomass. In the years after the disturbance, DOM pools decline as carbon loss through decay exceeds the rate of carbon addition through litter fall, mortality and biomass turnover. Later in stand development, DOM pools increase again. Representing these dynamics requires separate estimation of age-dependent inputs and outputs associated with stand dynamics and disturbance-related inputs and losses. These more complex estimation procedures require higher Tier methods.

The Tier 1 assumption for both dead wood and litter pools for all land-use categories is that their stocks are not changing over time if the land remains within the same land-use category. Thus, the carbon in biomass killed during a disturbance or management event (less removal of harvested wood products)

is assumed to be released entirely to the atmosphere in the year of the event. This is equivalent to the assumption that the carbon in non-merchantable and non-commercial components that are transferred to dead organic matter is equal to the amount of carbon released from dead organic matter to the atmosphere through decomposition and oxidation.

Recent inventory in terms of method applied to estimate carbon dynamics of dead organic matter is following the estimation procedure described for Tier 2 method, described in the section 2.3.2.1 of the Chapter 2 of the Volume 4 of the IPCC 2006. Estimates are considering the difference in DOM pools at two points in time requiring detailed inventories that include repeated measurements of dead wood pool dynamics. The changes in carbon stocks in the dead wood pool for an area remaining in a land-use category between inventories was estimated using method, described in Equation 2.19. Basic wood density, carbon fractions, provided in Section 6.2.4.4 and 6.2.4.7 has been applied.

6.2.4.9. Mineral soils

Annual change in carbon stocks in this carbon reservoir was estimated using equation 2.25 contained in IPCC 2006 Guidelines of the Volume 4, section 2.3.3. For the needs of equation application, default reference values of SOC_{ref} were considered to be used linked with the dominant tree habitats.

Table 6.13. Forest habitat types in Poland with the SOC_{ref} assignment

SOC _{ref}	Forest habitat types
high active SOC ref (50 [MgC/ha])	Fresh mixed forest, moist mixed forest, mixed upland forest, mountain mixed forest, fresh broadleaved forest, moist broadleaved forest upland forest, mountain forest
low active SOC ref (33 [MgC/ha])	Moist coniferous forest, mountain coniferous forest, high- mountain coniferous forest, 0.5*fresh mixed coniferous forest, moist mixed coniferous forest, upland mixed coniferous forest, mountain mixed coniferous forest
sandy SOC ref (34 [MgC/ha])	Dry coniferous forest, fresh coniferous forest 0.5*fresh mixed coniferous forest
wetland SOC ref (87 [MgC/ha])	Marshy coniferous forest, boggy mountain coniferous forest, boggy mixed coniferous forest, boggy mixed forest, alder forest, ash- alder swamp forest, mountain alder forest, floodplain forest, mountain floodplain forest

Table 6.14. Percentage share of soil types by land use system (for time t and 20)

Habitats	2021 (t)	2001 (t-20)
high activity	46.3	37.7
low activity	17.6	19.2
sandy	31.3	39.1
wetland	4.7	4.1
Total	100.0	100.0

The reason of the increase of the amount of soil carbon in all forests is that about one-third of all forests are afforestation's since 1945, and most of these forests are still in their intensive growing phase, which means that carbon stocks of soil organic matter pool have not saturated yet.

Additionally, no major disturbances or other processes have occurred that could have resulted in substantial emissions from the soil organic matter. Therefore, quantitative estimates can be made on the increase. Carbon stock changes in mineral soils were estimated based on following references contained in the IPCC 2006 Guidelines of the Volume 4, section 2.3:

- transitional period - 20 years,
- $f_{\text{man intensity}} = 1.0$,
- $f_{\text{dist regime}} = 1.0$,
- $f_{\text{forest type}} = 1.0$.

Poland made justification for the country specific values for the soil organic carbon contents. Consist with the results of the analysis determining the direction and rate of change in SOC content indicate that the C stock in the 1m layer of mineral soils derived from sand under the coniferous forests is with the range 65-90 Mg C*ha⁻¹, comparable results are obtained for the deciduous. The C stock in the 1m layer of mineral soils derived from soil under the deciduous forests with the range 65-115 Mg C*ha⁻¹.

Average C stock in the 1m layer of mineral soils derived from soils under the deciduous forests with high activity clay are with the range 140-250 Mg C*ha⁻¹. Presented results were obtained from the country study "The balance of carbon in the biomass of the main forest-forming species in Poland" Poznań, Kórnik, Warszawa, Kraków, Sękocin 2011. Having stated that, country experts decided to use default SOC ref values provided by the IPCC for the whole time series. Estimation of C stock changes in mineral soil pool in the subcategory forest land remaining forest land is based on changes of areas of forest habitat types. The assumptions made, allow to assign the in-direct impact of forest vegetation, associated with a particular forest habitat, on structure and forest litter decomposition directly related to the CS changes in the upper soil layers. On the basis of annually reported forestry data on area of forest habitat structure, following assignment was made.

6.2.4.10. Organic soils

Following recommendation A.19 from the review report FCCC/ARR/2018/POL the area of cultivated organic soils was updated and unified [Walęzak et al, 2020]. The main basis for establishing histosols area under this Submission was the project *Spatial Information System on Wetlands in Poland* elaborated in 2004-2006 by the Institute of Technology and Life Sciences. Here available vector layers were compared with Corine land cover data, used as a proxy. Recent approach utilises Corine Land Cover maps published for: 1990, 2000, 2006, 2012 and 2018. The land cover classes were divided into IPCC classification where particular land uses were taken into account. Data between years covered by CLC were interpolated, data for 1988-1989 were extrapolated based on changes between 1990 -2000.

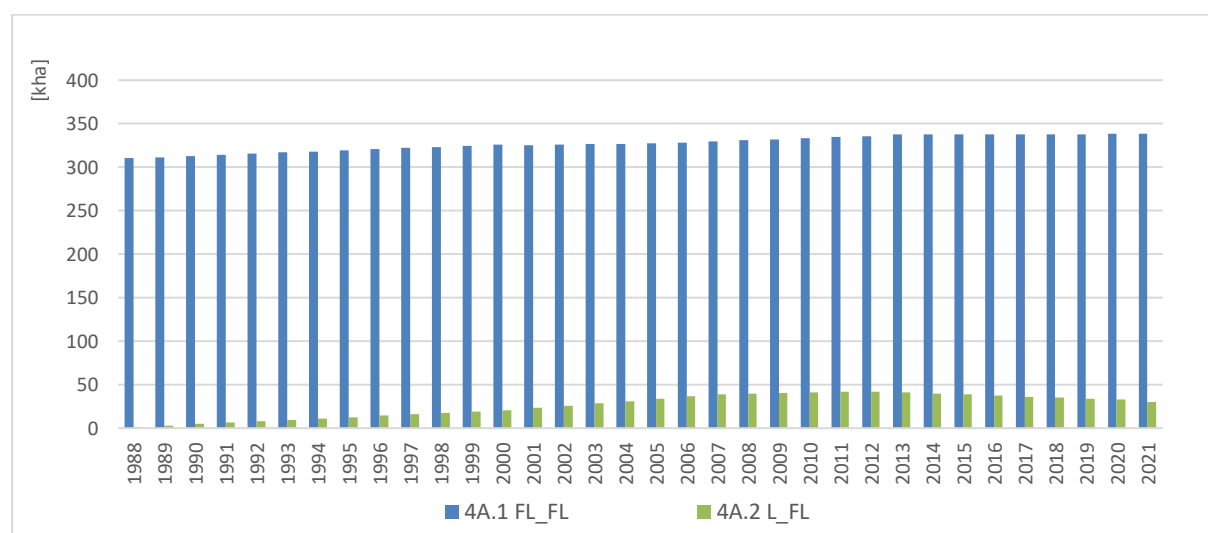


Figure 6.11. Organic soils area on forest land in the period 1988-2021

Table 6.15. CO₂ emission factor for drained organic soils

Name	Volume	Unit
EF _{drainage}	0.68	[tC/ha*y ⁻¹]

The same EF was applied for the estimation of CO₂ emissions on land subject to the categories 4.A.1 as well as for the land subject to the subcategory 4.A.2.

6.2.4.11. Biomass burning

According to the article 30 of *Act on forests of 28th September, 1991 (Journal of Law of 1991 No 101 item 444, as amended)* the burning of surface soil layers or remnants of vegetation is forbidden. In relation to this record it is considered that controlled biomass burning does not occur on forests. CH₄, N₂O, CO and NO_x emissions from uncontrolled forest fires were calculated using following equation 2.27 (IPCC 2006, page 2.42.):

Table 6.16. Emissions ratios for calculation CH₄, N₂O, CO and NO_x emissions from forests fires [table 2.5 p. 2.47 of IPCC 2006 Guidelines, Volume 4]

Compound	Ratio [g/kg d.m burnt]		
G _f CH ₄	4.7	default	[IPCC 2006]
G _f CO	107	default	[IPCC 2006]
G _f N ₂ O	0.26	default	[IPCC 2006]
G _f NO _x	3.0	default	[IPCC 2006]

Table 6.17. Fraction of biomass combusted

Compound	Ratio		
C _f	0.45	default	[IPCC 2006]

Table 6.18. Mass of available fuel

Year	Unit	Compound (M _b)	Year	Unit	Compound (M _b)
1988	[t. d.m./ha ⁻¹]	109.1	2005	[t. d.m./ha ⁻¹]	98.0
1989	[t. d.m./ha ⁻¹]	109.2	2006	[t. d.m./ha ⁻¹]	98.1
1990	[t. d.m./ha ⁻¹]	109.2	2007	[t. d.m./ha ⁻¹]	96.8
1991	[t. d.m./ha ⁻¹]	112.4	2008	[t. d.m./ha ⁻¹]	98.4
1992	[t. d.m./ha ⁻¹]	110.9	2009	[t. d.m./ha ⁻¹]	98.8
1993	[t. d.m./ha ⁻¹]	103.4	2010	[t. d.m./ha ⁻¹]	104.1
1994	[t. d.m./ha ⁻¹]	99.4	2011	[t. d.m./ha ⁻¹]	102.4
1995	[t. d.m./ha ⁻¹]	100.7	2012	[t. d.m./ha ⁻¹]	104.3
1996	[t. d.m./ha ⁻¹]	101.9	2013	[t. d.m./ha ⁻¹]	120.3
1997	[t. d.m./ha ⁻¹]	100.8	2014	[t. d.m./ha ⁻¹]	111.9
1998	[t. d.m./ha ⁻¹]	101.6	2015	[t. d.m./ha ⁻¹]	110.6
1999	[t. d.m./ha ⁻¹]	98.2	2016	[t. d.m./ha ⁻¹]	113.3
2000	[t. d.m./ha ⁻¹]	99.0	2017	[t. d.m./ha ⁻¹]	115.5
2001	[t. d.m./ha ⁻¹]	97.8	2018	[t. d.m./ha ⁻¹]	114.9
2002	[t. d.m./ha ⁻¹]	98.5	2019	[t. d.m./ha ⁻¹]	118.0
2003	[t. d.m./ha ⁻¹]	97.7	2020	[t. d.m./ha ⁻¹]	116.2
2004	[t. d.m./ha ⁻¹]	99.4	2021	[t. d.m./ha ⁻¹]	120.7

6.2.5. Land converted to Forest Land (CRF sector 4.A.2)

GHG balance in this category is a net sink. In 2021 net CO₂ sink was approximately 1 803 kt CO₂ eq. For the methodologies used, see following chapters.

6.2.5.1 Methodological issues

Due to the intensive forest monitoring as described above, all forest stands are continuously accounted for. This also means that all changes in the biomass carbon stocks of the forests due to any causes from growth through harvests, natural disturbances and deforestation are captured by the forestry statistics of each stand at least on a decade scale, and those of the whole forest area even on an annual basis.

Afforestation of orchards, in terms of planning regulations, is strictly limited, encouraging the conservation of traditional orchards which helps to guarantee the survival of a wide range of trees and fruit varieties that are particular to each region of the country – and supports the growing popularity of locally-produced food. Fruit trees age much more quickly than most other species found in the countryside so they rapidly accumulate the 'veteran' features associated with over-mature trees. Large volumes of standing dead wood in the form of 'stag's heads', whole limbs and rotting heartwood are specific habitats favoured by suites of very specialised organisms that have become increasingly rare

in the countryside. The presence of old trees spaced within permanent grassland creates a range of habitats very similar to those found in wood pasture landscapes. The main principles of the planning regulations are covered by the following relevant regulations:

1. Ordinance of the Minister of Agriculture and Rural Development of 18 June 2007 on the detailed conditions and procedures for granting financial assistance under the "Afforestation of agricultural land and afforestation of non-agricultural land" covered by the Rural Development Program 2007-2013 (OJ 2007 No. 114, item 786);
2. Ordinance of the Minister of Agriculture and Rural Development of 21 September 2007 amending the Regulation on detailed conditions and procedures for granting financial assistance under the "Afforestation of agricultural land and afforestation of non-agricultural land" area covered by the RDP 2007-2013 (Official Journal from 2007 No. 185, item 1316);
3. Ordinance of the Minister of Agriculture and Rural Development of 18 July 2008 amending the Regulation on detailed conditions and procedures for granting financial aid under the "Afforestation of agricultural land and afforestation of non-agricultural land" covered by the RDP 2007-2013 (Journal of Laws of 2008, No. 134, item 853);
4. Ordinance of the Minister of Agriculture and Rural Development of 19 March 2009 on detailed conditions and procedure for granting financial aid under the measure "Afforestation of agricultural land and afforestation of non-agricultural land", covered by the RDP 2007-2013 (Journal of Laws of 2009 no. 48, item 390);
5. Ordinance of the Minister of Agriculture and Rural Development of 31 May 2010 amending the Regulation on detailed conditions and procedures for granting financial assistance under the "Afforestation of agricultural land and afforestation of non-agricultural land" covered by the RDP for 2007-2013 (Journal of Laws of 2010 No. 94, item 608).

6.2.5.2. Subcategory area

Land use change matrix is presented in the annex 6.

6.2.5.3. Living biomass

Annual change in carbon stocks in living biomass reservoir was estimated considering the annual gains and losses with the equation 2.16 (section 2.3.1 of IPCC 2006 guidelines of the Volume 4). For the needs of equation application, default reference values of biomass increment were considered to be used.

Table 6.19. Default biomass increment

Name	Value	Unit
G _{ext}	4	[t d.m./ha/year]

Poland does not have indicated nationally appropriate values of G_{ex} available, yet. National Forest Inventory has not provided annual data related to increment, exclusively from age class I (1–20 years old). Hence, application of the default values results in a consistent time series of both the area and the GHG information. With respect to the estimation related to the biomass, data from the forest monitoring system is used, the primary objective of which has been to obtain accurate information on the status and development of all forests in the country. The forest inventory was designed to collect data at the stand level, but provide accurate estimates at aggregated levels.

Annual change in carbon stocks in biomass is estimated with the use of Equation 2.7 in Chapter 2. Tier 1 follows the default approach. It implies the use of default parameters provided in Section 4.5. This approach can be also applied, if the data on previous land uses are not available, which may be the case, when areas are estimated using Approach 1 from Chapter 3. It implies the use of default parameters in Tables 4.1 through 4.14. Since the annual decrease in carbon stocks in biomass due to losses, ΔC_L , considers the biomass loss due to wood removal (L wood-removals), fuelwood removal (L fuelwood) and disturbances (L disturbance) attributed to Land Converted to Forest Land, this should

be estimated using Equation 2.11 in Chapter 2. Furthermore, living biomass changes after the conversion were estimated based on the equation 2.10 (as well as 2.9) where default G_w for extensively managed forests was applied in the eq. 2.9. This approach was applied with the respect to the conservative assumptions based on in-country forestry practices, considering also the fact that application of the default value results in a consistent time series of both the area and the GHG information.

It is important to emphasise the essence of the idea of preserving the sustainability of a forest, which does not apply to a single stand, but rather to a forest regarded as a whole, which is formed by stands of different tree thickness and of different ages subject to different management methods in an extensive area. The sustainability of a forest is a biological concept which is supreme with respect to the sustainability of use and the maintenance of different functions and it is often defined as a state of dynamic equilibrium between the processes of regeneration, survival and loss of trees and stands at forest holding level. In practice, this means that a forest holding occupies an extensive forest area and is represented by stands in practically all the age classes.

However, Poland is exploring the possibility to estimate carbon stock changes in the biomass pool of the newly established forests with an empirical model of growing stock over age on a unit area of afforestation. In order to estimate the volume data, we are analysing available species-specific simplified models for the young forests using a sample of young stands of varying age (known based on the year of the afforestation) for which volume was known. This volume would preferably be available either from direct assessment or from yield tables (in this last case, height would be measured). Nevertheless, accuracy cannot always be quantified partly because the error distributions are unknown due to lack of measured data and partly because calculation errors or assumptions cannot be quantified. However, calculation errors during the development of the GHG inventory are highly unlikely due to the double checking of the data processing as described in the QA/QC section.

For carbon stock changes in biomass, the system of calculations allows for the use of a simple sensitivity analysis. This is especially true if only the major sources of CO₂ emissions and removals are considered, which represent the bulk of all emissions and removals. The reason for this is that the equation used for the calculation is relatively simple.

6.2.5.4. *Dead organic matter*

Carbon stock changes in dead wood on afforested and reforested areas is assumed to be equal to zero, therefore reported as 'NO'. The accumulation of dead wood was assumed to be marginal on afforested and reforested sites and also dead wood pool cannot decrease on those sites, because there is actually no dead wood there before the conversion. The dead wood starts to accumulate when natural mortality or thinnings occur that is nearly at the age of over 20 years. To keep correctness in CRF tables notation keys NO (not occurring) were used in the relevant table. Additionally, when an area is afforested, first it is cleared of all above-ground biomass in case there was any, however, no DW and LI are usually present on these lands prior to afforestation. After afforestation, dead woody debris, litter as well as dead trees start to accumulate. In lack of representative measurements, the rate and timing of accumulation is not known, however, standard forestry experience suggests that they depend on species, site and silvicultural regime, and quickly accumulate over time. Fast growing species are usually planted so that no large amount of deadwood is produced, or thinned so that self-thinning does not ensue, but litter is continuously produced even in these stands. On the other hand, slow-growing species tend to produce dead wood and litter even at an early stage. The above demonstration is based upon well-established principles of forest science, the every-day experiences of forestry practice, the experience and data of forest surveys, as well as sound reasoning. Because of this, although no representative measurements have been made as mentioned, the level of confidence of the demonstration is suggested to be very high. The potential carbon gains might have a positive impact on final carbon balance related to the category 4.A.2 *Land converted to forest land*, therefore recent approach may lead to the potential overestimation of net emissions (underestimation of net removals).

Current demonstration that this reservoir is not a source depends on the data availability, generally following justifications were considered:

1. direct implementation of Tier 1 description suggested in the chapter 4.2.2.1 of IPCC 2006 Guidelines of the Volume 4, assuming that the average transfer rate into the dead organic matter reservoir is equal to the transfer rate out of this pool so the net change is in equilibrium;
2. expert judgments based on a combination of qualitative and quantitative arguments, like international references to the neighbouring country's GHG's inventories;
3. conservative assumptions based on in-country forestry practices, as described below.

In the last decades, the close-to-nature forest management has been promoted in Poland and clear cuts were limited, especially after the adoption of the most recent Forest Act of 1991. This Act requests that semi natural forests must be managed in an increasingly natural way, which includes leaving more deadwood in the forest after harvests than before, as well as creating and maintaining gaps, and enhancing species mixture. It should be noted that the recent increasing share of broadleaved species in the species structure drives important positive role in the final changes of CS in dead organic matter pool. As a result of the implementation of these requirements, we can assume the accumulation of dead wood in the Polish forests is stable.

The other reason of the increase of dead organic matter stock in all forests is that about one-third of all forests are afforestation since 1945 (post World War II afforestation) and most of these forests are still in their intensive growing phase, which means that carbon stocks of the dead organic matter pool have not saturated yet. Finally, no major disturbances or other processes have occurred that could have resulted in substantial emissions from the dead organic matter pool.

Forest carbon accounting guidance from the Intergovernmental Panel on Climate Change (IPCC) has become the primary source of information for methods, accounting equations and parameters. However, IPCC guidance is vast and often difficult to navigate. In response, a number of tools for forest carbon accounting have emerged. These vary in terms of geographical coverage, forestry activities and the carbon pools accounted for, as well as the level of data input required. The DOM wood carbon pool includes all non-living woody biomass and includes standing and fallen trees, roots and stumps with diameter over 7 cm (over bark). The DOM including litter carbon pool includes all non-living biomass with a size greater than the limit for soil organic matter (SOM), commonly 2 mm, and smaller than that of DOM wood, 7 cm diameter over bark. This pool comprises biomass in various states of decomposition prior to complete fragmentation and decomposition where is transformed to SOM.

The relevant assumption for the land converted to forest land (4.A.2), under the the Tier 1 is that dead wood and litter pools increase linearly from zero (in the non-forest land-use category) to the default values for the climate region over a period of T years (the current default applied is 20 years for both litter and dead wood carbon pools).

Accordingly, as stated in the section 2.3.2, the Tier 1 assumption is that only carbon stocks in dead wood and litter pools in non-forest land are assumed to be equal to zero, and that carbon in dead organic matter pool increases linearly to the value of mature forests over a specified time period (default = 20 years). Additionally, the Tier 1 assumption for the conversion of unmanaged to managed forest land is that the dead organic matter carbon stocks in unmanaged forests are similar to those of managed forests and that no carbon stock changes need to be reported. Nevertheless, the conversions of non-forest land to forest land result, in all probability, in net removals in the DOM & litter pools. However, reporting zero emissions in these pools is considered as the most acceptable approach for L-FL until a more advanced estimation would be developed.

In relation to the category 4.A.2 in Poland, relevant data has not been collected in a representative sample of stands on deadwood (and litter). Despite this, based on very limited data that we have, it seems justified to state that these pools continue to sequester carbon, rather than to lose carbon, in the medium-term, and that they are not a source. To demonstrate that the DOM reservoir (DW+ Litter) is not a source, the following arguments shall be considered. Until the late 20th century, across

all Europe, deadwood in managed forests was removed because it was thought that forests have to be “sanitised” to be healthy. Over time this led to the widespread improvement of woodland biodiversity. It has since been acknowledged that a wide range of plant and animal species depend on dead and dying wood for habitat (e.g. European otter) or as food source (e.g. beetles). Generally speaking, the greater the volume of deadwood, the greater the value of forest for biodiversity. The amount of deadwood in forests is now increasingly used as a key international indicator of ecosystem biodiversity. Poland has less deadwood in its forests than most other EU countries. With 5.7 m³/ha of standing and lying deadwood, Poland ranks fourth lowest among the 20 EU countries for which data are available (Forest EUROPE, UNECE, FAO 2013). The volume of deadwood is much higher (up to 35 m³/ha) in forests of national parks.

Furthermore, current evidence for the EU forests suggests that, in the long term, deadwood (not including stumps, usually retained after felling) should average roughly 20 m³/ha (Humphrey and Bailey, 2012). This does not mean deadwood must be uniformly distributed; efforts to create, maintain and manage deadwood habitats should be directed where they are most needed, especially in areas of high ecological value.

Additionally, progress has been made in reducing deadwood removal related to sanitary thinning. Sanitary thinning primarily consists of removing trees damaged by factors such as wind damage, pests, pollution and severe weather. In some areas it is used as an opportunity to remove old, natural decaying trees so as to enhance forest productivity. This is the case in Poland, where sanitary thinning has included both damaged trees and deadwood. Nevertheless, except in 2007, deadwood removal from sanitary thinnings as share of merchantable timber has been halved since 2000 and was down to 15% in 2012.

Another reason for the increase of the amount of deadwood and litter in all forests is that about one-third of all forests are afforestation since 1945, and most of these forests are still in their intensive growing phase, which means that carbon stocks of dead organic matter pools have not saturated yet. These results are based on a small but anyway systematic sampling, and show a varying and slowly increasing tendency of net accumulation of the number of standing dead trees. Finally, no major disturbances or other processes have occurred that could have resulted in substantial emissions from the dead organic matter. Therefore, although no quantitative estimates can be made on the increase, the Tier 1 assumption can safely be made, at least on average in the long run. Therefore, when the Tier 1 method is applied which assumes that the dead wood and litter stocks are at equilibrium, the related carbon stock changes for these pools are not estimated.

Poland would like to highlight that since the dead organic matter pool and its carbon stock change is assumed as insignificant amounts and to keep the notations keys use relevant, notation key “NO” is applied in relevant CRF table.

6.2.5.5. Mineral soils

Annual change in carbon stocks in the litter reservoir was estimated using equation 2.25 as contained in the chapter 2 of the Volume 4 of the IPC 2006. For the needs of equation application, default reference values of SOC_{ref} were considered to be used linked with the dominant tree habitats.

Table 6.20. Forest habitat types in Poland with the SOC_{ref} assignment

SOC _{ref}	Forest habitat types
high active SOC ref (50 [MgC/ha])	Fresh mixed forest, moist mixed forest, mixed upland forest, mountain mixed forest, fresh broadleaved forest, moist broadleaved forest upland forest, mountain forest
low active SOC ref (33 [MgC/ha])	Moist coniferous forest, mountain coniferous forest, high- mountain coniferous forest, 0.5*fresh mixed coniferous forest, moist mixed coniferous forest, upland mixed coniferous forest, mountain mixed coniferous forest
sandy SOC ref (34 [MgC/ha])	Dry coniferous forest, fresh coniferous forest 0.5*fresh mixed coniferous forest

SOC _{ref}	Forest habitat types
wetland SOC ref (87 [MgC/ha])	Marshy coniferous forest, boggy mountain coniferous forest, boggy mixed coniferous forest, boggy mixed forest, alder forest, ash- alder swamp forest, mountain alder forest, floodplain forest, mountain floodplain forest

Carbon stock changes in mineral soils were estimated based on following references contained in of IPCC 2006 Guidelines of the Volume 4 [IPCC, 2006]:

- transition period – 20 years,
- $f_{\text{man intensity}} = 1.0$,
- $f_{\text{dist regime}} = 1.0$,
- $f_{\text{forest type}} = 1.0$.

Table 6.21. Percentage share of forest soil types by land use system (for time t)

Habitats	2021 (t)
high activity	46.3
low activity	17.6
sandy	31.3
wetland	4.7
Total	100.0

Table 6.22. Percentage share of cropland soil types by land use system (for time t)

Habitats	2021 (t)
high activity	29.54
low activity	39.42
sandy	19.97
wetland	11.07
Total	100.0

Table 6.23. Percentage share of grassland soil types by land use system (for time t)

Habitats	2021 (t)
high activity	13.73
low activity	43.22
sandy	32.17
wetland	10.89
Total	100.0

6.2.5.5. Organic soils

Table 6.24. CO₂ emission factor for drained organic soils

Name	Volume	Unit
EF _{drainage}	0.68	[tC/ha*y ⁻¹]

6.2.6. Uncertainties and time-series consistency

With respect to the estimation related to the biomass, data from the forest monitoring system is used, the primary objective of which has been to obtain accurate information on the status and development of all forests in the country. The forest inventory was designed to collect data at the stand level, but provide accurate estimates at aggregated levels. Therefore, with respect to net annual CO₂ removals, actual values may deviate from estimated values as the stock volume inventory for the whole country is not able to capture all inter-annual variability of timber growth and harvests, which can be high due to the variability of meteorological conditions. Also noting that the inter-annual variability of the estimated net removals in the Forest Land sector is due to a number of reasons, including the continuously, although slowly, changing structure of the forests by species, site fertility and age, and the variability of annual harvests and mortality. All these effects have rather different delayed effects, and these effects may be rather small relative to the total volume stocks, when applying default factors

adjusted to national circumstances. It can be concluded that the carbon stock change estimation based on assumptions described above seem to be reliable and not affects accuracy of the emissions and removals associated with forest land. Further information is contained chapter 6.6.5.

6.2.7. Category-specific QA/QC and verification

Detailed information contain chapter 6.6.6.

6.2.8. Recalculations

Detailed information contain chapter 6.6.7.

6.2.9. Planned improvements

Detailed information contain chapter 6.6.8.

6.3. Cropland (CRF sector 4.B)

6.3.1. Source category description

Estimations for category 4.B were based on IPCC methodology described in the chapter 5. of IPCC 2006 guidelines of the Volume 4. Overall trend in the reporting period is presented on graph below.

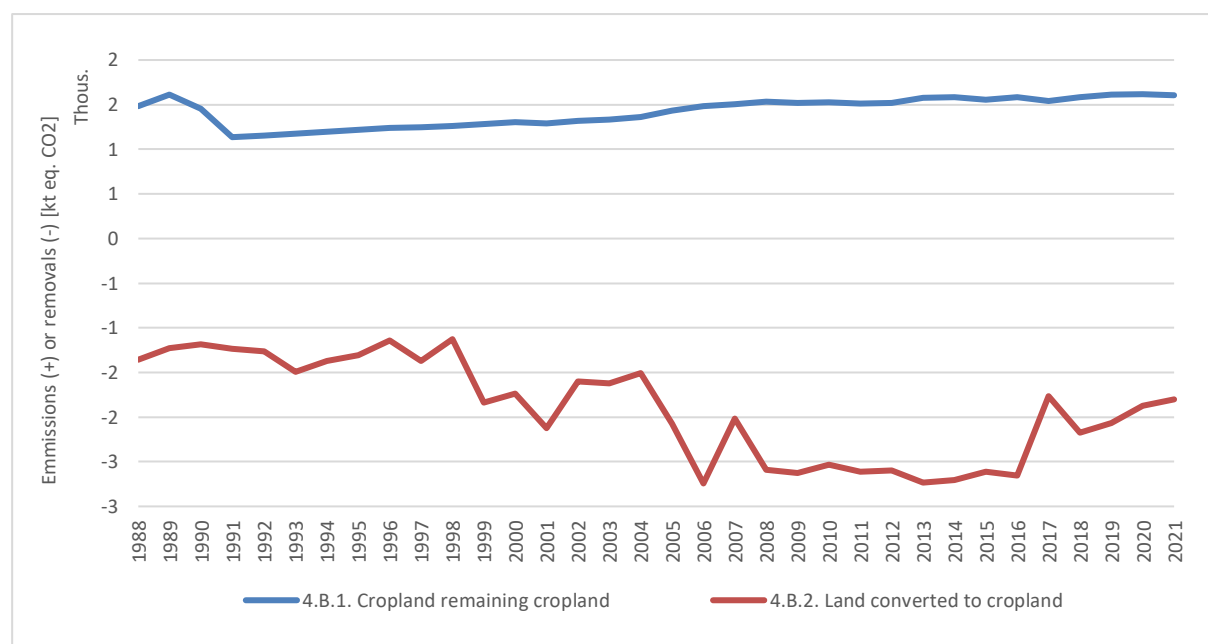


Figure 6.12. Trends in emissions/removals for the category 4.B. *Cropland*

6.3.1.1. Cropland remaining Cropland (CRF sector 4.B.1)

GHG balance in this category was identified as a net CO₂ sink. Net CO₂ balance was equal to 1 606 kt CO₂ eq. of emissions.

Activity data (i.e. area) for the lands divisions included in this category is provided by the land use change matrix, for both 4.B.1 *Cropland remaining Cropland* and 4.B.2 *Land converted to Cropland* subcategories. Estimation of carbon stock changes corresponds to Tier 1, estimating annual rates of growth and loss, for national level data on the major type of perennial crops.

6.3.1.2. Land converted to Cropland (CRF sector 4.B.2)

GHG balance in this category was identified as a net CO₂ source. Net CO₂ balance was equal to 94 kt CO₂ eq. emissions.

6.3.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

According to the description suggested in the chapter 3.3.1. of IPCC 2006 Guidelines of the Volume 4, Poland has selected Approach 2, considering the set of information's available in the register of land and buildings.

6.3.3. Land-use definitions and classification system used and their correspondence to the LULUCF categories

According to the Regulation of the Minister of Administration and Digitization of 29 November 2013 amending the regulation on the registration of land and buildings. (Journal of Laws 2013 pos. 1551), agricultural land considered as cropland consists of:

- arable land includes land which is cultivated, i.e. sowed and fallow land. Arable land should be maintained in good agricultural condition. Cultivated arable land is understood as land sowed or planted with agricultural or horticultural products, willow and hops plantations, area of greenhouses, area under cover and area of less than 10a, planted with fruit trees and bushes, as well as green manure,
- fallow land includes arable land which are not used for production purposes but are maintained in good agricultural condition,
- orchards include land with the area of at least 10a, planted with fruit trees and bushes.

6.3.4. Methodological issues

6.3.4.1. Subcategory area

Land use matrix is provided in the annex 6.

6.3.4.2. Living organic matter on cropland remaining cropland (4.B.1)

Annual carbon stock change in living biomass was calculated based on cropland area covered by perennial woody biomass (orchards). Annual growth rate for perennial woody biomass was calculated using equation 2.7 of IPCC 2006 guidelines of the Volume 4. For calculations there were used default factors as below:

- biomass accumulation rate – 2.1 [tC/ha] table 5.1 p. 5.9,
- harvest/maturity cycle – 30 [year] table 5.1 p. 5.9, biomass carbon loss – 63 [t/ha*yr] table 5.1 p. 5.9.

Estimation of C stocks changes was made individually on each of the two different types of land included in the Cropland category and their subcategories: perennial crops (orchards) and non-woody agricultural land (arable).

6.3.4.3. Living organic matter on land converted to croplands (4.B.2.)

Agricultural land here is represented mainly by arable land or management cycles which include arable land. Current data shows there are conversions from all land use categories to cropland, largest area being the conversions from grasslands. Conversion also occur from Settlements and Other land (i.e. industrial dumps and ecologization, reclamation of river deposits and islands along Danube and other rivers).

Estimates are calculated using equation 2.15 from 2006 Guidelines. Initial C stock changes in biomass are calculated under Tier 1 (ΔC conversions), assuming a biomass C stock of 13.6 t dm/ha for grasslands the default value for the cold temperate wet eco-region (Table 6.4 of 2006 Guidelines) and 5 C/ha for annual crops (Table 5.9 of 2006 Guidelines). Entire amount of C stock in biomass in land use category before conversion is assumed to be lost in the moment of conversion to cropland (e.g. usually the technology implies deep soil preparation and removals of any pre-existing vegetation).

6.3.4.4. Mineral soil

Agricultural land valuation classes with the assignment to IPCC soils types:

- high activity soils - soils having appreciable contents of high activity clays (eg. 2:1 expandable clays such as montmorillonite) which promote long-term stabilization of organic matter, particularly in many carbon-rich temperate soils.

- low activity soils - soils with low-activity clays (eg., 1:1 non-expandable clays such as kaolinite and hydrous oxide clays of iron and aluminium) which have a much lower ability to stabilize organic matter and consequently respond more rapidly to changes in the soil's carbon balance; among these are highly-weathered acid soils of subtropical and tropical regions.
- sandy soil - soils with less than 8% clay and more than 70% sand, which generally have low structural stability and low capacity to stabilize carbon.
- wetland - mineral soils which have developed in poorly-drained, wet environments; they have reduced decomposition rates and high organic matter contents; if drained for agriculture they are subject to large losses of carbon.

Estimation of area of different soil types (high activity soils, low activity soils, sandy and wetland) were based on area of soil valuation classes. The percentage fraction of all soil types in croplands was calculated based on available data sets.

Table 6.25. Area of soil valuation classes

Valuation classes	1976	1979	1985	1990	2000	2021
thous. ha						
agriculture land						
Total	19349.4	19200.5	18945	18804.8	18536.9	NA
I	71	70.7	70	68.7	67.8	NA
II	547.6	551.1	550.3	544.1	536.4	NA
III	4153.2	4152.1	4199.1	4201.6	4201.9	NA
IV	7627.5	7611.8	7545.6	7493.4	7402.9	NA
V	4522	4441	4310.3	4267.2	4197.2	NA
VI	2428.1	2373.8	2269.7	2229.8	2114.9	NA
Land not classified	0	0	0	0	15.8	NA
arable land and orchard						
Total	15173.7	15073.4	14818	14682.8	14451.1	14430.0
I	69	68.5	67.4	66.5	65.0	64.6
II	480	483.8	485	482.2	479.6	482.9
III	3621.5	3618.9	3643.7	3650.7	3664.6	3714.5
IV	5961	5924.2	5807.6	5743.4	5640.2	5688.4
V	3151.8	3114.5	3018.3	2976.2	2908.3	2882.2
VI	1890.4	1863.5	1796.1	1763.8	1682.6	1597.4
Land not classified	0.0	0.0	0.0	0.0	10.8	0

Due to limited data availability, linear interpolation was applied between the subsequent years.

Table 6.26. Interpolated results for the area of cropland under different soil types in a percentage of the total area (1/5)

Soil type	1988	1989	1990	1991	1992	1993	1994
high activity	28.49	28.55	28.60	28.66	28.71	28.77	28.82
low activity	39.15	39.13	39.12	39.11	39.09	39.08	39.07
sandy	20.31	20.29	20.27	20.26	20.25	20.24	20.23
wetland	12.06	12.03	12.01	11.98	11.94	11.91	11.87

Table 6.26. Interpolated results for the area of cropland under different soil types in a percentage of the total area (2/5)

Soil type	1995	1996	1997	1998	1999	2000	2001
high activity	28.88	28.93	28.99	29.04	29.10	29.20	29.22
low activity	39.06	39.05	39.05	39.04	39.03	39.03	39.05
sandy	20.22	20.21	20.20	20.19	20.18	20.13	20.12
wetland	11.84	11.81	11.77	11.74	11.70	11.64	11.62

Table 6.26. Interpolated results for the area of cropland under different soil types in a percentage of the total area (3/5)

Soil type	2002	2003	2004	2005	2006	2007	2008
high activity	29.23	29.25	29.27	29.28	29.30	29.31	29.33
low activity	39.07	39.09	39.10	39.12	39.14	39.16	39.18
sandy	20.11	20.10	20.10	20.09	20.08	20.07	20.07
wetland	11.59	11.56	11.53	11.51	11.48	11.45	11.43

Table 6.26. Interpolated results for the area of cropland under different soil types in a percentage of the total area (4/5)

Soil type	2009	2010	2011	2012	2013	2014	2015
high activity	29.34	29.36	29.38	29.39	29.41	29.42	29.44
low activity	39.20	39.22	39.23	39.25	39.27	39.29	39.31
sandy	20.06	20.05	20.05	20.04	20.03	20.02	20.02
wetland	11.40	11.37	11.34	11.32	11.29	11.26	11.23

Table 6.26. Interpolated results for the area of cropland under different soil types in a percentage of the total area (5/5)

Soil type	2016	2017	2018	2019	2020	2021
high activity	29.46	29.47	29.49	29.50	29.52	29.54
low activity	39.33	39.35	39.36	39.38	39.40	39.42
sandy	20.01	20.00	20.00	19.99	19.98	19.97
wetland	11.21	11.18	11.15	11.12	11.10	11.07

Table 6.26. Valuation classes of agricultural land with the SOC_{ref} assignment

Soil type	Soil valuation classes
high activity	I, II, III
low activity	IV
sandy	V
wetland	other

Valuation classes of agricultural land describe the quality of land in terms of value to agricultural production. Class I corresponds to the highest agricultural value (carbon content) and class VI to the lowest. Valuation classes of agricultural land are presented in table 6.26.

Table 6.27. Soil organic carbon by land use system and soil types

Land-use/ management system	Soil by IPCC	Carbon in soils [Mg C/ha]
		default IPCC
agricultural crops	high activity soils	50
	low activity soils	33
	sandy	34
	wetland	87

For calculations there were used default factors as below:

- stock change factor for land use or land-use change type in the beginning of inventory year - $F_{LU}(0-T) = 0.69$ [IPCC 2006 tab. 5.5 page 5.17].
- stock change factor for management regime in the beginning of inventory year - $F_{MG}(0-T)=1.00$ [IPCC 2006 tab. 5.5 page 5.17].
- Stock change factor for input of organic matter in the beginning of inventory year - $F_i(0-T)=0.92$ [IPCC 2006 tab. 5.5 page 5.17].
- Stock change factor for land use or land-use change type in current inventory year - $F_{LU}(0)=0.69$ [IPCC 2006 tab. 5.5 page 5.17].
- Stock change factor for management regime in current inventory year - $F_{MG}(0)=1.00$ [IPCC 2006 tab. 5.5 page 5.17].
- Stock change factor for input of organic matter in current inventory year - $F_i(0) = 0.92$ [IPCC 2006 tab. 5.5 page 5.17].

6.3.4.5. Organic soils

Following recommendation A.19 from the review report FCCC/ARR/2018/POL the area of cultivated organic soils was updated and unified [Wałęzak et al, 2020]. The main basis for establishing histosols

area under this Submission was the project *Spatial Information System on Wetlands in Poland* elaborated in 2004-2006 by the Institute of Technology and Life Sciences. Here available vector layers were compared with Corine land cover data, used as a proxy. Recent approach utilises Corine Land Cover maps published for: 1990, 2000, 2006, 2012 and 2018. The land cover classes were divided into IPCC classification where particular land uses were taken into account. Data between years covered by CLC were interpolated, data for 1988-1989 were extrapolated based on changes between 1990 -2000.

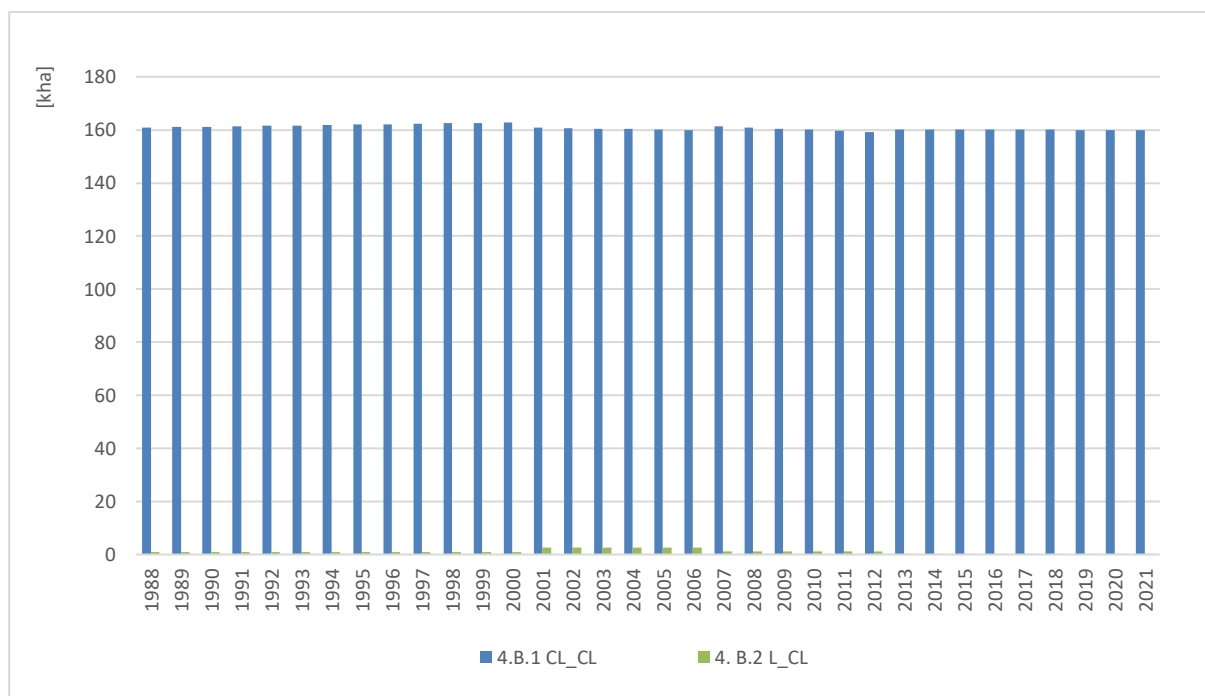


Figure 6.13. Organic soils area changes on cropland in the period 1988-2021

Table 6.28. CO₂ emission factor for drained organic soils

Name	Volume	Unit
EF _{drainage}	5.0	[tC/ha*y ⁻¹]

The same EF was applied for the estimation of CO₂ emissions on land subject to the categories 4.B.1 as well as for the land subject to the subcategory 4.B.2

N₂O emission from cultivation of histosols was estimated based on default emission factor for mid-latitude organic soils from [IPCC 2006]: 8 kg N₂O-N /ha. N₂O emission is reported in sector 4. *Agriculture* in subcategory 3.D.a.6.

6.3.4.6. CH₄, N₂O, CO and NO_x emissions from fires

CH₄, N₂O, CO and NO_x emissions from wildfires fires on croplands are reported in subcategory 4.C.1.

6.3.4.7. Mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices

This category deals with direct N₂O emissions from N mineralization resulting from change of land use or management of mineral soils. Tier 3 method was not applied to the estimation in this subcategory in Poland. Therefore, according to the 2006 IPCC Guidelines, N immobilization associated with gain of soil carbon on mineral soils is not considered. Consequently, only N₂O emissions from mineralization associated with loss of soil organic matter (SOM) were estimated.

For amount of N mineralized in mineral soil associated with land use change, annual loss of soil carbon in mineral soil for estimating carbon stock changes in mineral soils was used. The area of mineral soil

in land use change, which are calculated by subtracting the area of organic soil from the total area of land converted to cropland, were considered for the estimation as the activity data.

Estimation of the N release by mineralization was made according to the following steps:

- Step 1: Calculations of the average annual loss of soil C ($\Delta C_{\text{Mineral, LU}}$) for the land use change, over the inventory period, using equation 2.25.
- Step 2: Each land use change has been assessed by the single value of $\Delta C_{\text{Mineral, LU}}$. As a consequence of this loss of soil C (FSOM), equation 11.8 was applied to estimate N potentially mineralized.

Losses of soil organic matter were accounted for land-use change activity occurring when grassland is converted to cropland. Additionally, nitrogen mineralisation was estimated by dividing the carbon loss on grasslands converted to croplands with a C/N-ratio of 15 (default value from IPCC 2006).

6.3.5. Uncertainties and time-series consistency

With ongoing project to derive new activity data for all land categories the uncertainty is not yet estimated. Estimates for the uncertainty of the activity data would be derived as soon as data processing will be finalized. The advantage of the new land classification and area estimation method is that it provides sampling error for the area estimates for each land category and subcategory.

6.3.6. Category-specific QA/QC and verification

For the estimation of C stock changes in soils of land “remaining croplands” there is an improvement plan available, related to the development of national system to respond accounting requirements set in EU Regulation 2018/841. According to this regulation a reporting to European Union on the national estimating system for cropland management and grazing land management is due annually for 2017-2018 while provide preliminary estimates before 2022 and final estimates in the final submission in 2022.

6.3.7. Recalculations

Detailed information contain chapter 6.6.7.

6.3.8. Planned improvements

Detailed information contain chapter 6.6.8. Nevertheless, one of the main plans is to conduct an uncertainty analysis in the future.

6.4. Grassland (CRF sector 4.C)

6.4.1. Source category description

Calculation for category 4.C based on IPCC methodology described in the chapter 6 of IPCC 2006 guidelines of the Volume 4.

Activity data used to calculate GHG emissions for the land included in the *Grassland* category is provided by the land use change matrix, both for the 4.C.1 – *Grassland remaining Grassland* and 4.C.2 *Land converted to Grassland* category. Estimation of carbon stock change in the *Grassland* category corresponds to Tier 1, with country specific data on reference C stock in soils. Overall trend in the reporting period is presented on graph below.

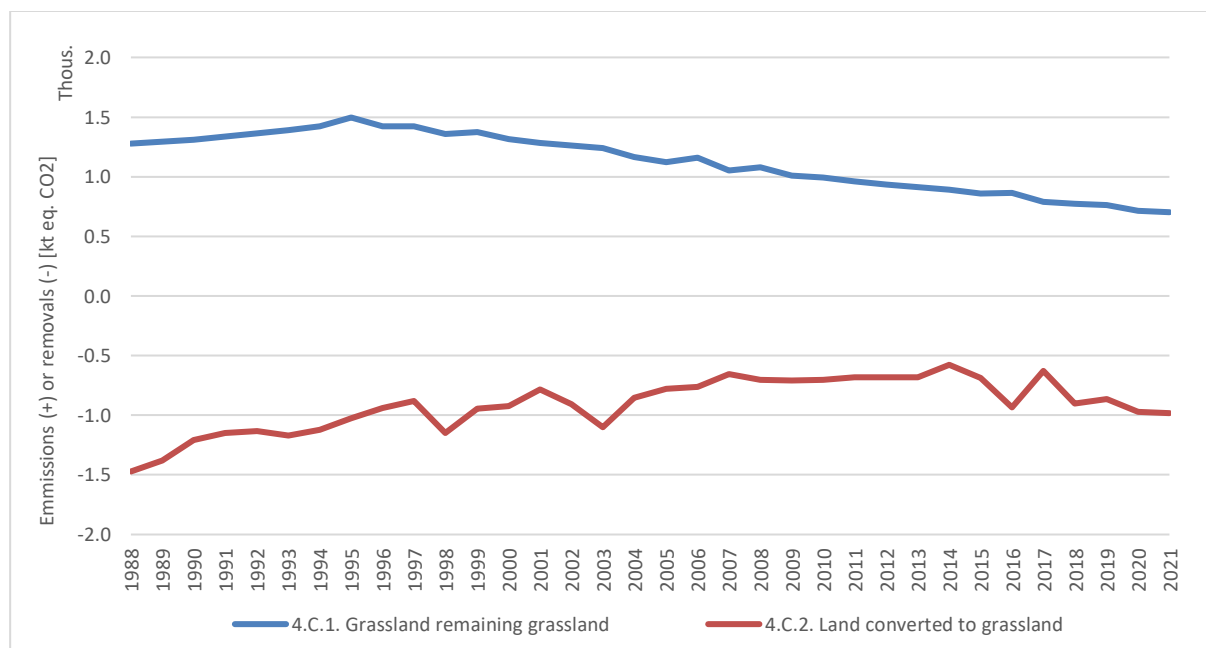


Figure 6.14. Trends in emissions/removals for the category 4.C *Grassland*

6.4.1.1. *Grassland remaining Grassland (CRF sector 4.C.1)*

GHG balance in this was identified as a net CO₂ source. Net CO₂ balance was equal to 702 kt of CO₂ emissions.

6.4.1.2. *Land converted to Grassland (CRF sector 4.C.2)*

GHG balance in this was identified as a net CO₂ sink. Net CO₂ balance was equal to 985 kt of CO₂ removals.

6.4.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

According to the description suggested in the chapter 3.3.1. of IPCC 2006 Guidelines of the Volume 4, Poland has selected Approach 2, considering the set of information's available in the register of land and buildings.

6.4.3. Land-use definitions and classification system used and their correspondence to the LULUCF categories

According to the Regulation of the Minister of Administration and Digitization of 29 November 2013 amending the regulation on the registration of land and buildings. (Journal of Laws 2013 pos. 1551), agricultural land considered as grassland consists of:

- permanent meadows and pastures include land permanently covered with grass, but it does not include arable land sown with grass as part of crop rotation; permanent meadows are understood as the land permanently covered with grass and mown in principle and in mountain area also the area of mown mountain pastures and meadows.
- permanent pastures are understood as the land permanently covered with grass not mown but grazed in principle and in mountain area – also the area of grazed pastures and meadows.

Permanent meadows and pastures classified to this category must be maintained in good agricultural condition.

6.4.4. Methodological issues

6.4.4.1. Subcategory area

Land use change matrix is provided in the annex 6.

6.4.4.2. Living organic matter

Estimates of the change of C stocks vary by type of land included in this land category:

- *Land remaining under the same use.* In the case of grasslands where there are no changes in usage it was considered that there are no changes in the C stocks of any pool (aboveground, belowground).
- *Land in conversion to grassland.* A default biomass value for the cold temperate wet eco-region (Table 6.4 of 2006 Guidelines) of 13.6 t d.m./ha was used in calculations. Estimates are calculated using equation 2.15 from 2006 Guidelines. Initial C stock changes in biomass are calculated under Tier 1 ($\Delta C_{\text{conversions}}$), assuming a default biomass C stock for annual crops (Table 5.9 of 2006 Guidelines).

6.4.4.3. Change of C stock in dead organic matter and soil

For the estimation of C stock changes in dead organic matter of land “remaining grasslands” there is an improvement plan available, related to the development of national system to respond accounting requirements set in EU Regulation 2018/841. Current approach is that there no change in dead organic matter C pool since there is no management change (reference soil C stock and values of C stock change factors would practically no change in time).

For the estimation of C stock changes in soil organic matter in land remaining the same category following assumptions were applied. Estimation of area of different soil types (high activity soils, low activity soils, sandy and wetland) is based on area of soil valuation classes. The percentage fraction of all soil types in grassland was calculated based on available data sets.

Table 6.29. Area of soil valuation classes

Valuation classes	1976	1979	1985	1990	2000	2021
	thous. ha					
grassland						
Total	4175.7	4127.1	4126.9	4122	4085.8	4154.6
I	2.0	2.2	2.6	2.2	2.8	1.6
II	67.6	67.3	65.3	61.9	56.8	47.2
III	531.7	533.2	555.4	550.9	537.3	521.4

Valuation classes	1976	1979	1985	1990	2000	2021
	thous. ha					
grassland						
IV	1666.5	1687.6	1738	1750	1762.7	1795.5
V	1370.2	1326.5	1292	1291	1288.9	1336.4
VI	537.7	510.3	473.6	466	432.3	452.4
land not classified	0.0	0.0	0.0	0.0	5.0	0

Due to limited data availability, linear interpolation was applied between the subsequent years

Table 6.30. Interpolated results for the area of cropland under different soil types in a percentage of the total area (1/5)

Soil type	1988	1989	1990	1991	1992	1993	1994
high activity	15.00	14.97	14.92	14.89	14.86	14.84	14.82
low activity	42.32	42.38	42.46	42.53	42.61	42.68	42.75
sandy	31.31	31.31	31.32	31.34	31.37	31.39	31.41
wetland	11.37	11.34	11.31	11.23	11.16	11.09	11.02

Table 6.30. Interpolated results for the area of cropland under different soil types in a percentage of the total area (2/5)

Soil type	1995	1996	1997	1998	1999	2000	2001
high activity	14.80	14.78	14.76	14.74	14.73	14.73	14.57
low activity	42.83	42.90	42.97	43.04	43.11	43.14	43.26
sandy	31.43	31.45	31.47	31.49	31.51	31.55	31.58
wetland	10.94	10.87	10.80	10.72	10.65	10.58	10.60

Table 6.30. Interpolated results for the area of cropland under different soil types in a percentage of the total area (3/5)

Soil type	2002	2003	2004	2005	2006	2007	2008
high activity	14.52	14.48	14.44	14.40	14.35	14.31	14.27
low activity	43.26	43.26	43.26	43.25	43.25	43.25	43.25
sandy	31.61	31.64	31.67	31.70	31.73	31.76	31.79
wetland	10.61	10.63	10.64	10.65	10.67	10.68	10.70

Table 6.30. Interpolated results for the area of cropland under different soil types in a percentage of the total area (4/5)

Soil type	2009	2010	2011	2012	2013	2014	2015
high activity	14.23	14.18	14.14	14.10	14.06	14.02	13.98
low activity	43.24	43.24	43.24	43.24	43.24	43.23	43.23
sandy	31.81	31.84	31.87	31.90	31.93	31.96	31.99
wetland	10.71	10.73	10.74	10.76	10.77	10.79	10.80

Table 6.30. Interpolated results for the area of cropland under different soil types in a percentage of the total area (5/5)

Soil type	2016	2017	2018	2019	2020	2021
high activity	13.93	13.89	13.85	13.81	13.77	13.73
low activity	43.23	43.23	43.22	43.22	43.22	43.22
sandy	32.02	32.05	32.08	32.11	32.14	32.17
wetland	10.82	10.83	10.85	10.86	10.87	10.89

Table 6.31. Valuation classes of agricultural land with the SOC_{ref} assignment

Soil type	Soil valuation classes
high activity	I, II, III
low activity	IV
sandy	V
wetland	other

Valuation classes of agricultural land describe the quality of land in terms of value to agricultural production. Class I corresponds to the highest agricultural value and class VI to the lowest.

Table 6.32. Soil organic carbon by land use system and soil types

Land-use/ management system	Soil types by IPCC	Carbon in soils [Mg C/ha]
		Default IPCC
Permanent meadows and pastures	high activity	50
	low activity	33
	sandy	34
	wetland	87

For calculations there were used default factors as below:

- stock change factor for land use or land-use change type in the beginning of inventory year - $F_{LU}(0-T) = 1.00$ [IPCC 2006 tab. 6.2 page 6.16]
- stock change factor for management regime in the beginning of inventory year - $F_{MG}(0-T)=1.14$ [IPCC 2006 tab. 6.2 page 6.16]
- Stock change factor for input of organic matter in the beginning of inventory year - $F_i(0-T)=1.11$ [IPCC 2006 tab. 6.2 page 6.16]
- Stock change factor for land use or land-use change type in current inventory year - $F_{LU}(0)=1.00$ [IPCC 2006 tab. 6.2 page 6.16]
- Stock change factor for management regime in current inventory year - $F_{MG}(0)=1.14$ [IPCC 2006 tab. 6.2 page 6.16]
- Stock change factor for input of organic matter in current inventory year - $F_i(0) = 1.11$ [IPCC 2006 tab. 6.2 page 6.16]

In terms of factors related to input (F_i), Poland has chosen the value for 'high level' of 1.11 rather than the value for 'medium level' 1.0 corresponding to the input factor volume of improved grassland where limited management inputs have been considered.

Improved grasslands with medium input are managed with a single improvement, such as fertilization, irrigation, or seeding legumes. These management activities increased SOC storage by a factor of 1.14 (+/- 0.06) and 1.17 (+/- 0.05) in temperate and tropical grasslands, respectively, which represented an increase of 14% and 17% over the storage typical of nominally managed grasslands. Furthermore, improved grasslands with high input, which are managed with multiple improvements, increased SOC storage by an additional factor of 1.11 (+/-0.04) or 11% beyond the change storage for improved grasslands with medium input. We assume improved grasslands with medium input have a single management improvement, which is represented by a coefficient of 1 (thus, the change in SOC storage may be determined solely by the factor of 1.0). In contrast, high input grasslands receive multiple improvements (e.g., fertilization plus irrigation), and SOC storage is estimated based on a coefficient quantifying the additional increase in storage beyond the amount found under medium-input conditions. We did not set a specific forage utilization rate for overgrazing owing to a lack of information in many studies about these thresholds, but rather relied on the classifications provided in the publications assuming reasonable assessments of grazing intensity taking into account increased productivity by using simultaneously irrigation, fertilization, lime additions, seeding legumes, or planting more productive varieties of grasses.

6.4.4.4. Organic soils

Following recommendation A.19 from the review report FCCC/ARR/2018/POL the area of cultivated organic soils was updated and unified [Walęzak et al, 2020]. The main basis for establishing histosols area under this Submission was the project *Spatial Information System on Wetlands in Poland* elaborated in 2004-2006 by the Institute of Technology and Life Sciences. Here available vector layers were compared with Corine land cover data, used as a proxy. Recent approach utilises Corine Land Cover maps published for: 1990, 2000, 2006, 2012 and 2018. The land cover classes were divided into IPCC classification where particular land uses were taken into account. Data between years covered by CLC were interpolated, data for 1988-1989 were extrapolated based on changes between 1990 -2000.

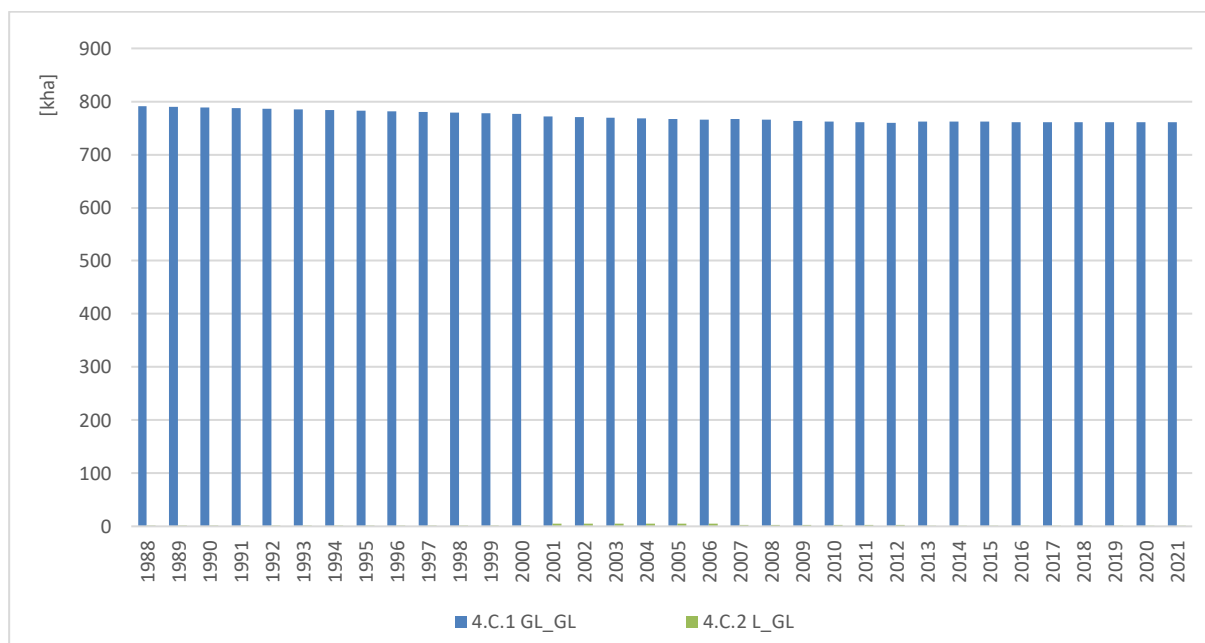


Figure 6.15. Organic soils area changes on grassland in the period 1988-2021

Table 6.33. CO₂ emission factor for drained organic soils

Name	Volume	Unit
EF _{drainage}	0.25	[tC/ha*y ⁻¹]

The same EF was applied for the estimation of CO₂ emissions on land subject to the categories 4.C.1 as well as for the land subject to the subcategory 4.C.2. To estimate CO₂ emission from cultivated organic soils the default emission factor was used for cold temperate – 0.25 tC/ha*year [IPCC 2006 tab. 6.3 page 6.17].

6.4.4.5. Biomass burning

CH₄, N₂O, CO and NO_x emissions from fires were calculated using following equation (IPCC 2006, page 2.429, equation 2.27). This subcategory is covering the non-CO₂ emission from crop area, meadows and stubbles fires.

Estimated non-CO₂ emissions include those from burning of slash on-site and, for more than a decade, those from wildfires. Non-CO₂ emissions from the mentioned sources are not significant, and are only reported for the sake of completeness and that of time series consistency with previous years. Note that CO₂ emissions from these sources are accounted for in the biomass pool, because we apply the stock-change method. Non-CO₂ emissions include the carbon of CO and CH₄, however, these gases are nevertheless reported because of their high global warming potential, because the double counting of the carbon is negligible, and also in order to comply with the IPCC 2006 GL.

Table 6.34. Emissions ratios for calculation CH₄, N₂O, CO and NO_x emissions from grassland fires [table 2.5 p. 2.47 of IPCC 2006 Guidelines, Volume 4]

Compound	Ratio [g/kg d.m burnt]		
CH ₄	2.3	default	[IPCC 2006]
CO	65	default	[IPCC 2006]
N ₂ O	0.21	default	[IPCC 2006]
NO _x	3.9	default	[IPCC 2006]

Table 6.35. Fraction of biomass combusted

Compound	Ratio		
C _f	0.9	Country specific	Łoboda (1994)

Table 6.36. Mass of available fuel

Year	Unit	Compound (M _b)	Year	Unit	Compound (M _b)
1988	[t. d.m./ha ⁻¹]	3.6	2005	[t. d.m./ha ⁻¹]	3.6
1989	[t. d.m./ha ⁻¹]	3.6	2006	[t. d.m./ha ⁻¹]	3.6
1990	[t. d.m./ha ⁻¹]	3.6	2007	[t. d.m./ha ⁻¹]	3.6
1991	[t. d.m./ha ⁻¹]	3.6	2008	[t. d.m./ha ⁻¹]	3.6
1992	[t. d.m./ha ⁻¹]	3.6	2009	[t. d.m./ha ⁻¹]	3.6
1993	[t. d.m./ha ⁻¹]	3.6	2010	[t. d.m./ha ⁻¹]	3.6
1994	[t. d.m./ha ⁻¹]	3.6	2011	[t. d.m./ha ⁻¹]	3.6
1995	[t. d.m./ha ⁻¹]	3.6	2012	[t. d.m./ha ⁻¹]	3.6
1996	[t. d.m./ha ⁻¹]	3.6	2013	[t. d.m./ha ⁻¹]	3.6
1997	[t. d.m./ha ⁻¹]	3.6	2014	[t. d.m./ha ⁻¹]	3.6
1998	[t. d.m./ha ⁻¹]	3.6	2015	[t. d.m./ha ⁻¹]	3.6
1999	[t. d.m./ha ⁻¹]	3.6	2016	[t. d.m./ha ⁻¹]	3.6
2000	[t. d.m./ha ⁻¹]	3.6	2017	[t. d.m./ha ⁻¹]	3.6
2001	[t. d.m./ha ⁻¹]	3.6	2018	[t. d.m./ha ⁻¹]	3.6
2002	[t. d.m./ha ⁻¹]	3.6	2019	[t. d.m./ha ⁻¹]	3.6
2003	[t. d.m./ha ⁻¹]	3.6	2020	[t. d.m./ha ⁻¹]	3.6
2004	[t. d.m./ha ⁻¹]	3.6	2021	[t. d.m./ha ⁻¹]	3.6

The estimation of the amount of emissions is done according to section 6.2.4.11. Although, the default amount of biomass burned was applied based on country research (Cenowski, 1996) with its amount equal to 3.6 [t d.m.]. Relevant data became possible based on additional capacity to improve accuracy. Although the new estimates are also based on expert solicitation, they are considered more accurate than the expert judgment applied before.

6.4.5. Uncertainties and time-series consistency

Detailed information contain chapter 6.6.5.

6.4.6. Category-specific QA/QC and verification

Detailed information contain chapter 6.6.6.

6.4.7. Recalculations

Detailed information contain chapter 6.6.7.

6.4.8. Planned improvements

For the estimation of C stock changes in soils of land “remaining grasslands” there is an improvement plan available, related to the development of national system to respond accounting requirements set in EU Regulation 2018/841. According to this regulation a reporting to European Union on the national estimating system for cropland management and grazing land management is due annually for 2017-2018 while provide preliminary estimates before 2022 and final estimates in the final submission in 2022.

6.5. Wetlands (CRF sector 4.D)

6.5.1. Source category description

Calculation for category 4.D is based on IPCC methodology described in the chapter 7 of IPCC 2006 guidelines of the Volume 4. Overall trend in the reporting period is presented on graph below.

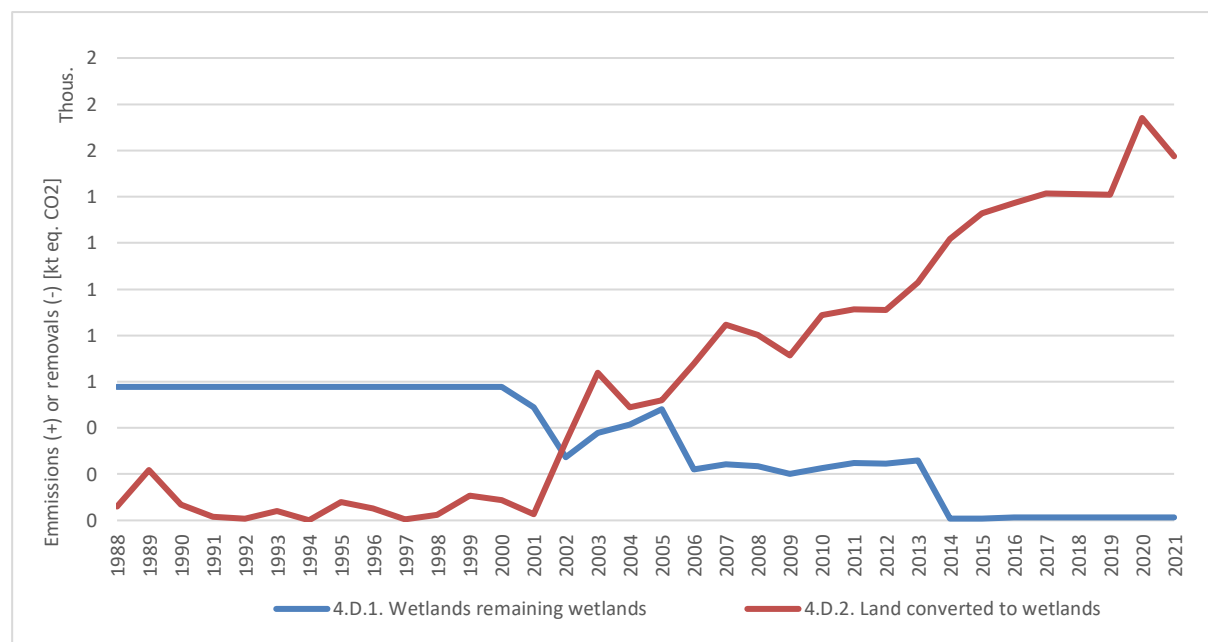


Figure 6.16. Trends in emissions/removals for the category 4.D. *Wetland*

Emissions/removals observed above are triggered by two major drivers. Firstly, significant increase of land area conversion to wetlands occurred, which in particular is done by clearing the grassland. Furthermore, area of 2226 hectares in 2002 and 1477 hectares in 2016 was converted for peat extraction. Since, the carbon stock change in living biomass for the lands converted for peat extraction to the CSC in biomass were estimated with the application of default factors available for grassland ($B_{\text{before}} = 2.4$ IPCC default tab 6.4. p. 6.27), the emissions associated to this activity were reported under 4D.2.2.2. Additionally, it is also assumed that when peat is removed in a new milling in a given extraction season, any potential living biomass should be also removed to provide and access to the available peat layers. In this particular case emissions as reported and refers to any potential emissions linked to the carbon stock change in living biomass. It is, therefore, assumed that any peat excavation in existing peatlands is preceded by the biomass removal. In this case the amount of biomass removed was also assigned to the default factors available for grassland ($B_{\text{before}} = 2.4$ IPCC default tab 6.4. p. 6.27). Principle of conservativeness has been taken into consideration in this case.

6.5.1.1. Wetlands remaining wetlands

GHG balance in this was identified as a net CO₂ source. Net CO₂ balance was equal to 12 kt of CO₂ eq. emissions.

6.5.1.2. Lands converted to Wetlands

GHG balance in this was identified as a net CO₂ source. Net CO₂ balance was equal to 1 574 kt of CO₂ eq. emissions.

6.5.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

According to the description suggested in the chapter 3.3.1. of IPCC 2006 Guidelines of the Volume 4, Poland has selected Approach 2, considering the set of information's available in the register of land and buildings.

6.5.3. Land-use definitions and classification system used and their correspondence to the LULUCF categories

According to the Regulation of the Minister of Administration and Digitization of 29 November 2013 amending the regulation on the registration of land and buildings. (Journal of Laws 2013 pos. 1551), agricultural land considered as wetland consists of:

1. land under waters
 - marine internal;
 - surface flowing waters, which covers land under waters flowing in rivers, mountain streams, channels, and other water courses, permanently or seasonally and their sources as well as land under lakes and artificial water reservoirs. from or to which the water course flow;
 - land under surface lentic water which covers land under water in lakes and reservoirs other than those described above;
2. land under ponds including water reservoirs (excluding lakes and dam reservoirs for water level adjustment) including ditches and areas adjacent and related to ponds;
3. land under ditches including open ditches acting as land improvement facilities for land used.

CO₂ and N₂O emissions are estimated from organic soils managed for peat extraction. Since 1999 national statistics contain data on area of organic soils managed for peat extraction It need to be highlighted that data from national statistics are consistent with the previously estimated values of organic soils managed for peat extraction. For the period 1988-1998 the latest available data was applied.

Table 6.37. Open drained area used for peat excavation in Poland (1/3)

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Area	5178	5178	5178	5178	5178	5178	5178	5178	5178	5178	5178

Table 6.37. Open drained area used for peat excavation in Poland (2/3)

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Area	5178	5178	2912	5138	5141	5508	5107	3429	3433	3410	3317

Table 6.37. Open drained area used for peat excavation in Poland (3/3)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Area	3314	3312	3283	3275	1960	3437	3485	3485	3451	3434	3423	2918

Data source: Statistics Poland - Environmental Protection 1990-2022

6.5.4. Methodological issues

6.5.4.1. Wetlands remaining wetlands

Since emissions from peatlands undergoing extraction differ substantially in scale and type from emissions from land being converted for peat extraction, countries with an active peat industry should separate their managed peatlands accordingly. Estimating CO₂ emissions from lands undergoing peat extraction has two basic elements: on-site emissions from peat deposits during the extraction phase, and off-site emissions from the horticultural (non-energy) use of peat. It is also assumed that when peat is removed in a new milling in a given extraction season, any potential living biomass should be

also removed to provide and access to the available peat layers. In this particular case emissions as reported refers to any potential emissions linked to the carbon stock change in living biomass. It is, therefore, assumed that any peat excavation in existing peatlands is preceded by the biomass removal. In this case the amount of biomass removed was also assigned to the default factors available for grassland (B_{before} = 2.4 IPCC default tab 6.4. p. 6.27). Principle of conservativeness has been taken into consideration in this case. On site emission calculations are based on equation 7.6 of IPCC 2006 guidelines of the Volume 4. page 7.9.

Table 6.38. On site emission factors for CO₂-C

Symbol	Unit	Emission factor	Source
EF _{peatNrich}	[t C/ha* y ⁻¹]	1.1	table 7.4. page 7.13 IPCC 2006
EF _{peatNpoor}	[t C/ha*yy ⁻¹]	0.2	

N₂O emission calculations are based on equation 7.7 of IPCC 2006 guidelines of the Volume 4.

Table 6.39. On site emission factors for N₂O emissions from managed peatlands

Symbol	Unit	Emission factor	Source
EF _{peatNrich}	[kgN ₂ O/ha*y ⁻¹]	1.8	table 7.6. page 7.16 IPCC 2006
EF _{peatNpoor}	[kgN ₂ O/ha*y ⁻¹]	0.1	

CO₂ emission calculations are based on equation 7.5 of IPCC 2006 guidelines of the Volume 4. For calculations default emission factors for cold climate were used.

6.5.4.3. Peatlands

A peatland is a wetland ecosystem with a relatively thick (>40 cm) soil layer of organic matter above a mineral substrate (Trettin et al., 2005). The utilization of peatland for peat production (peat harvesting) is not common but these emissions, mainly from dead organic matter may have significant impact on overall sectoral GHG's balance. Peat from the uppermost and deeper peatland layers are used for different purposes. The uppermost peat layers of peatland are not as well decomposed and are suitable for environmental protection, gardening and agricultural purposes because of their physical, chemical and biological properties. The structure of low decomposed surface peat results in a great water storage capability. In addition, it can absorb nutrients, metals and gases.

Poland reports emissions (on-site and off-site) associated with industrial peat extraction in this category. Off-site CO₂-C emissions are associated to the horticultural (non-energy) use of peat extracted and removed. Off-site emissions from peat used for energy are reported in the Energy Sector (1.A.1. Energy industries, 1.A.2. Manufacturing industries and construction and 1.A.4. Other sectors), and is therefore not included here.

Off-site emission estimates from peatlands were derived by converting the annual peat production data (air-dry weight) to the weight of carbon (Equation 7.5 page 7.11 of the IPCC 2006). All carbon in horticultural peat is assumed to be emitted during the extraction year.

The rest of the area of wetlands is not managed (undrained) and CO₂ emissions are not calculated. Off-site CO₂-C emissions associated to the horticultural (non-energy) use of peat extracted and removed are reported using instant oxidation method (Tier 2 method). Data on peat extraction for horticulture purposes is taken directly from statistics using extrapolation method for the periods, when official data are not available. Carbon content in peat is considered 40% according to IPCC 2006 Guidelines, with its relative moisture content of air-dry peat of 40%.

Off-site emission estimates from peatlands were derived by converting the annual peat production data (air-dry weight) to the weight of carbon (Equation 7.5 page 7.11 of the IPCC 2006). Since all carbon in extracted horticultural peat is assumed to be emitted during the extraction year, peat production (extraction) data is considered as major factor of DOM emissions.

Table 6.40. Emission factors for the subcategory peatland remaining peatland

Symbol	Unit	Emission factor	Source
Cfraction wt_peat	[t C/t air-dry peat ⁻¹]	0.4	table 7.5. page 7.13 IPCC 2006

N₂O emissions from peatlands during peat extraction

Equation 7.7 of Section 7.2.1 of the IPCC2006 describes the default approach to estimate N₂O emissions in this section.

6.5.4.3. Organic soils

Following recommendation A.19 from the review report FCCC/ARR/2018/POL the area of cultivated organic soils was updated and unified [Walęzak et al, 2020]. The main basis for establishing histosols area under this Submission was the project *Spatial Information System on Wetlands in Poland* elaborated in 2004-2006 by the Institute of Technology and Life Sciences. Here available vector layers were compared with Corine land cover data, used as a proxy. Recent approach utilises Corine Land Cover maps published for: 1990, 2000, 2006, 2012 and 2018. The land cover classes were divided into IPCC classification where particular land uses were taken into account. Data between years covered by CLC were interpolated, data for 1988-1989 were extrapolated based on changes between 1990-2000.

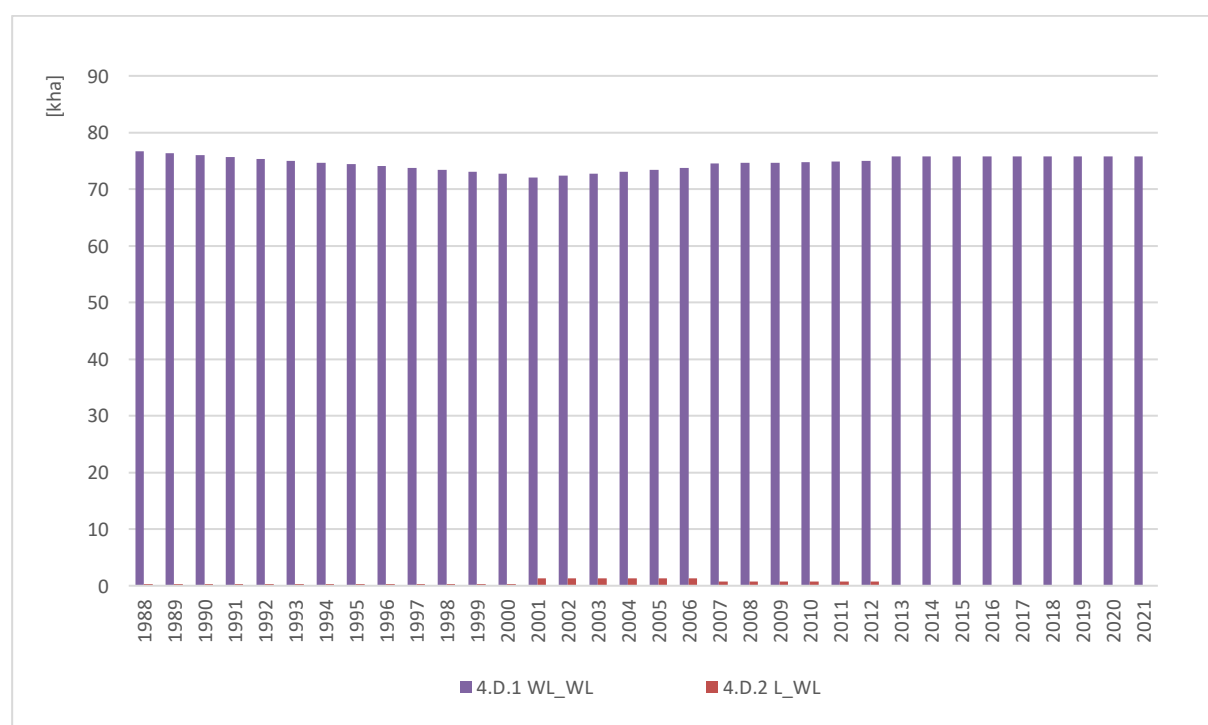


Figure 6.17. Organic soils area changes on wetlands (1988-2021)

Table 6.41. CO₂ emission factor for drained organic soils

Name	Volume	Unit
EF _{drainage}	1.1	[tC/ha*y-1]

The same EF was applied for the estimation of CO₂ emissions on land subject to the categories 4.D.1 as well as for the land subject to the subcategory 4.D.2.

6.5.4.3. Land converted to Wetlands (CRF sector 4.D.2)

The Tier 1 methodology considers only emissions from biomass clearing. When the total area of managed peatlands increases, conversion to peatland is occurring. The conversion of peatlands for peat extraction involves clearing and removal of vegetation. The term $\Delta C_{WW \text{ peat } B}$ of Equation 7.4 is estimated as $\Delta C_{\text{conversion}}$, using Equation 2.16 (Chapter 2 of Volume 4 of the IPCC 2006). Other changes in C stocks in living biomass on managed peat lands are assumed to be zero. For calculations default emission factors were used as presented below:

- carbon fraction of dry matter CF = 0.5 [IPCC 2006],
- living biomass in land immediately before conversion to flooded land $B_{\text{Before}} = 13.6 \text{ t d.m./ha}$ [IPCC 2006, page 6.8], living biomass immediately following conversion to flooded land $B_{\text{After}} = 0 \text{ t d.m./ha}$ [IPCC 2006, page 7.20].

Table 6.42. Emission factors

Emission factor	unit	value	Source
EF _{peatNrich}	[t C/ha*yr]	1.1	table 7.4. page 7.13 IPCC 2006

As described in the introduction of Section 7.2, the peat extraction cycle has three phases, the first one of which being the development or conversion for peat extraction, characterized by extensive drainage work (if the area was not already drained for other purposes), but little peat extraction. This conversion phase typically lasts for 2 to 5 years. In contrast with other land-use conversions and in accordance with the IPCC 2006 Guidelines, the recommended default transition period for land being converted for peat extraction is five years.

6.5.5. Uncertainties and time-series consistency

Detailed information contain chapter 6.6.5.

6.5.6. Category-specific QA/QC and verification

Detailed information contain chapter 6.5.6.

6.5.7. Recalculations

Detailed information contain chapter 6.6.7.

6.5.8. Planned improvements

Detailed information contain chapter 6.6.8.

6.6. Settlements (CRF sector 4.E)

6.6.1. Source category description

Calculation for category 4.E is based on IPCC methodology described in the chapter 8. of IPCC 2006 guidelines of the Volume 4. GHG balance for this subcategory was identified as a net CO₂ source. Net CO₂ balance was equal to 2 269 kt of CO₂ eq. Overall trend in the reporting period is presented on graph below.

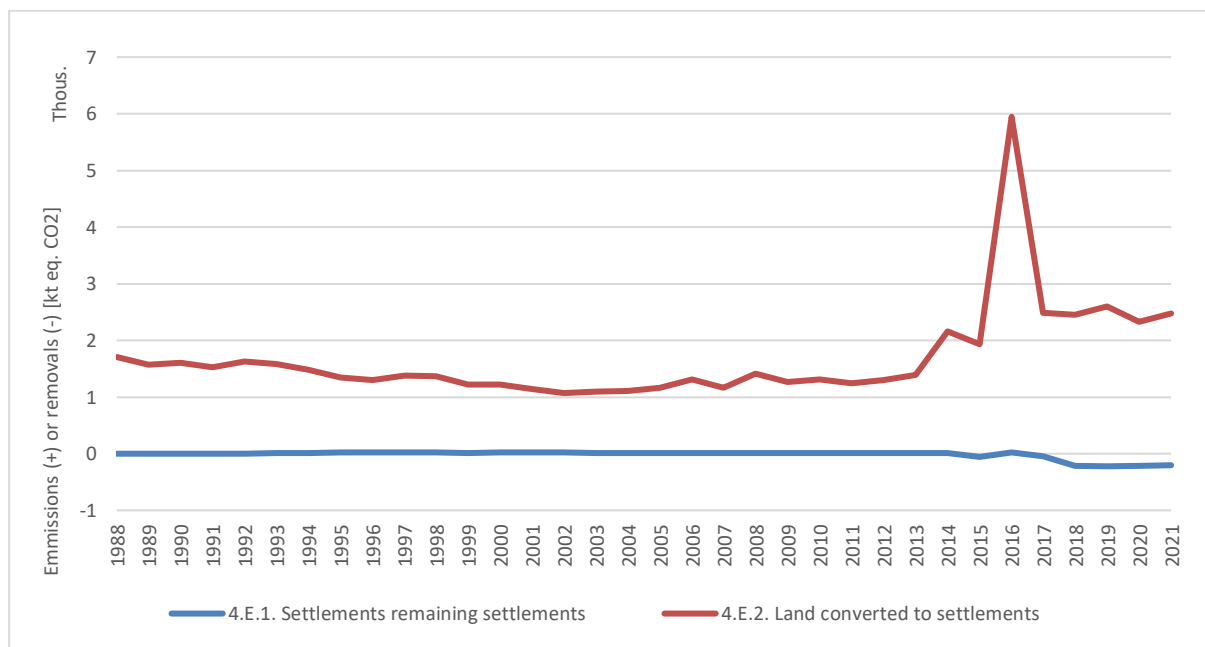


Figure 6.18. Trends in emissions/removals for the category 4.E. *Settlements*

Emissions/removals observed above are triggered by two major drivers. Firstly, significant increase of forest land area conversion occurred linked to expanding infrastructure requiring land necessary to support growing population, which in particular is done by clearing the forests. The construction of roads, railways, bridges, and airports opens up the land to development and brings increasing numbers of people to the forest frontier. Whether supported or not by the governmental programmes, these settlers have usually colonized the forest by using logging trails or new roads to access the forest for subsistence land. Poland continues to devote sizeable resources to the development of its transport infrastructure. Having stated that, Poland is also willing to highlight that the recent rather unique increase of deforestation in 2016 might be seen in light of implications of operationalization of programs set up to assess the complementarity of development interventions implemented in the years 2014-2020 for the macroregion under OP EP 2014-2020, Regional Operational Programmes of five Eastern Poland voivodships and central Operational Programmes (primarily OP Smart Growth and OP Infrastructure and Environment) Secondly, since the method follows the approach in the IPCC Guidelines (Section 8.3, Forest and Grassland Conversion) where the amount of living aboveground biomass that is cleared for expanding settlements is estimated by multiplying the forest area converted annually to settlements by the difference in carbon stocks between biomass in the forest prior to conversion (C_{Before}) and that in the settlements after conversion (C_{After}), the rationale for the increasing emissions in short term is directly linked to the increasing percentage of strata's of land within a land use category with the high carbon content.

6.6.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

According to the description suggested in the chapter 3.3.1. of IPCC 2006 Guidelines of the Volume 4, Poland has selected Approach 2, considering the set of information's available in the register of land and buildings.

6.6.3. Land-use definitions and classification system used and their correspondence to the LULUCF categories

According to the Regulation of the Minister of Administration and Digitization of 29 November 2013 amending the regulation on the registration of land and buildings (Journal of Laws 2013 pos. 1551), agricultural land considered as settlements consists of:

- residential areas include land not used for agricultural and forest production, put under dwelling buildings, devices functionally related to dwelling buildings (yards, drives, passages, playgrounds adjacent to houses), as well as gardens adjacent to houses;
- industrial areas include land put under buildings and devices serving the purpose of industrial production;
- other built-up areas include land put under buildings and devices related to administration. not listed under residential and industrial areas;
- undeveloped urbanised areas include land that is not built over, allocated in spatial management plans to building development and excluded from agricultural and forest production;
- recreational and resting areas comprise the following types of land not put under buildings;
- areas of recreational centres,. children playgrounds, beaches, arranged parks, squares, lawns (outside street lanes);
- areas of historical significance: ruins of castles, strongholds, etc.;
- sport grounds: stadiums, football fields, ski-jumping take-offs, toboggan-run, sports rifle-ranges, public baths etc.;
- area for entertainment purposes: amusement, grounds, funfairs etc.;
- zoological and botanical gardens;
- areas of non-arranged greenery, not listed under woodlands or land planted with trees or shrubbery;
- transport areas including land put under:
 1. roads: national roads; voivodship roads; poviast roads; communal roads; roads within housing estates; access roads to agricultural land and woodlands and to facilities of public utility; stopping and manoeuvring yards next to railway stations, bus stations and airports, maritime and river ports and other ports, as well as universal accesses to unloading platforms and storage yards;
 2. railway grounds;
 3. other transport grounds.

6.6.4. Methodological issues

6.6.4.1. Settlements remaining Settlements

GHG balance for this subcategory was identified as a net CO₂ sink. Net CO₂ balance was equal to 205 kt of CO₂ eq. removals.

Living biomass

Calculations for carbon stock changes in living biomass were based on crown cover area method (urban green area – Statistics Poland 2022 Environmental Protection). Carbon stock changes in living biomass were calculated based on equation 8.2. page 8.7 [IPCC 2006]. Default accumulation rate $C_{RF}=2.9 \text{ t C/ha}$ was used for calculations [IPCC 2006, page 8.9].

Organic soils

Following recommendation A.19 from the review report FCCC/ARR/2018/POL the area of cultivated organic soils was updated and unified [Walęzak et al, 2020]. The main basis for establishing histosols area under this Submission was the project *Spatial Information System on Wetlands in Poland*

elaborated in 2004-2006 by the Institute of Technology and Life Sciences. Here available vector layers were compared with Corine land cover data, used as a proxy. Recent approach utilises Corine Land Cover maps published for: 1990, 2000, 2006, 2012 and 2018. The land cover classes were divided into IPCC classification where particular land uses were taken into account. Data between years covered by CLC were interpolated, data for 1988-1989 were extrapolated based on changes between 1990-2000.

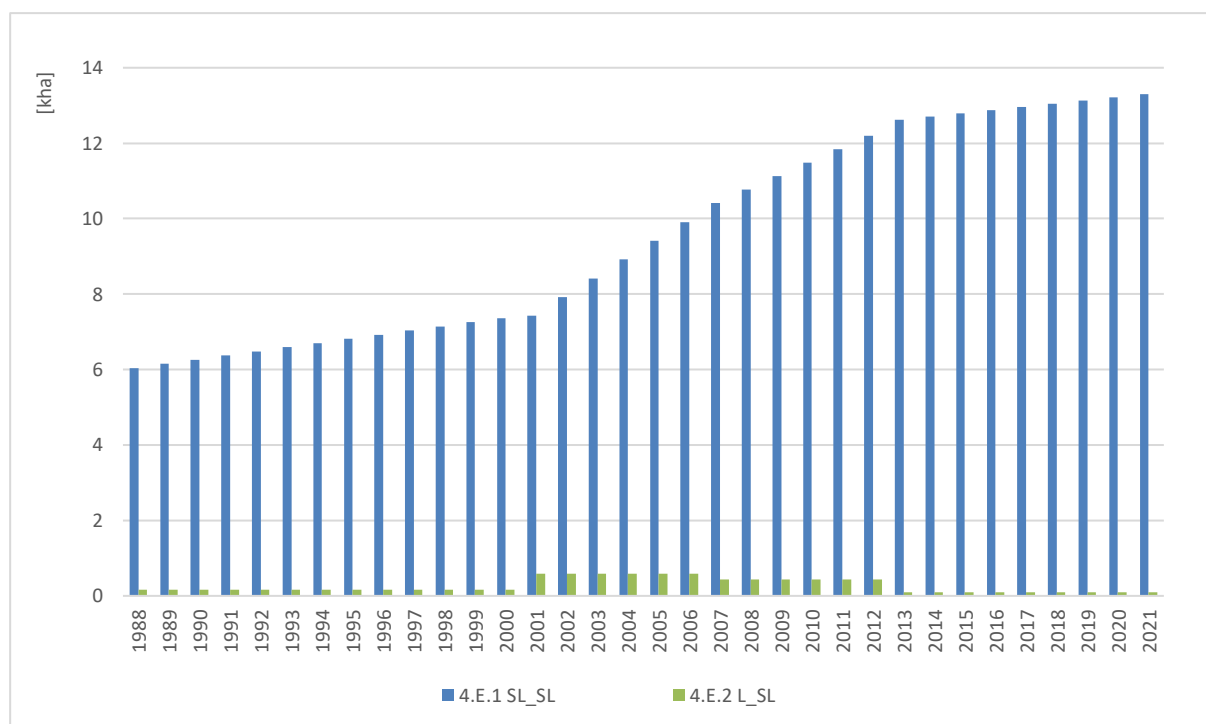


Figure 6.19. Organic soils area changes on settlements (1988-2021)

Table 6.43. CO₂ emission factor for drained organic soils

Name	Volume	Unit
EF _{drainage}	5.0	[tC/ha*y ⁻¹]

The same EF was applied for the estimation of CO₂ emissions on land subject to the categories 4.E.1 as well as for the land subject to the subcategory 4.E.2.

N₂O emission from cultivation of histosols was estimated based on default emission factor for mid-latitude organic soils from [IPCC 2006]: 8 kg N₂O-N/ha. N₂O emission is reported in sector 4. *Agriculture* in subcategory 3.D.a.6.

To estimate CO₂ emission from cultivated organic soils default emission factor for cropland was used (5 tC/ha*year). The principle of conservativeness was taken into account in this particular case.

6.6.4.2. Land converted to Settlements (CRF sector 4.E.2)

Forest land converted to Settlements (CRF sector 4.E.2.1)

Net emissions in this subcategory are equal to 336 kt of CO₂ emissions. The fundamental equation for estimating change in carbon stocks associated with land-use conversions has been explained in other sections covering conversions of land converted to forest land, cropland and grassland, respectively. The same decision tree and the same basic method were applied to estimate change in carbon stocks in forest land converted to settlements.

Since limited remote sensing technology is directly involved in the recent emission inventory, there is no issue related to distinguishing harvesting or forest disturbance from deforestation. Harvesting and

forest disturbance always occur on forest land, while deforestation is a cadastral change of land use from forest land to other land use categories.

The forest disturbance alone cannot trigger land conversions from forestland, i.e. land is subject to further forest management. Thus distinction between harvested and disturbance affected areas, on the one hand, and deforestation, on the other, is made as follows: for the former, there is legal obligation for the forest owner/administrator to maintain the land under forests category and forestry regime (including tree harvest based on permit), to apply the forest management plans specifications and regenerate it within a given timeframe (maximum 5 years); for the latter, following legal procedure with the issuance of the approval, a new land use category is assigned to that land, and the forestry regime is no longer applicable.

Any deforestation in terms of land use change in the in-country land use scheme requires an official decision. Hence, no permanent loss of forest cover may occur prior to this approval, which is reflected in cadastral land use. A temporary loss of forest cover up to an area of 2 [ha] ha may occur as part of forest management operations on forest land (units of land subject to managed forests or afforested land), which is not qualified as deforestation in terms of LULUCF Reg. Nevertheless, forest owners (according to art. 13.1 of the *Act on forests* of September 28th, 1991 (*Journal of Laws of 1991 No. 101, item. 444, as amended*)) shall be obliged to ensure the permanent maintenance of forest cover, as well as continuity of utilization, and in particular:

- 1) to preserve forest vegetation (plantations) in forests, as well as natural marshlands and peatlands;
- 2) to reintroduce forest vegetation (plantations) in forest areas within five years of a stand being cleared;
- 3) to tend and protect forest, including against fire;
- 4) to convert and rebuild stands, where these are not in a condition to ensure achievement of the objectives of forest management set out in the Forest Management Plan, Simplified Forest Management Plan or Decision;
- 5) to make rational use of forests in a manner permanently ensuring optimal discharge of all the functions thereof, by means of:
 - a) the harvesting of wood within limits not exceeding a forest's productive capabilities,
 - b) the harvesting of raw materials and by-products of forest use, in a manner providing for biological renewal, and also ensuring protection of forest-floor vegetation.

A basic requirement of the forest regime is that an area has to be restocked in maximum 5 years, without reference to a minimum area. In practice, such lands can regenerate either by plantations (usually followed by state forests) or by assisted natural regeneration), or by mixed ways. Its implementation is observed by public authority responsible for forestry. These areas cannot be confounded with deforested areas as far as they are subject to continuous planning and management (i.e. planting/gap filling, maintenance etc.).

In Poland, all forests must be regenerated after clearing mature stands by law (as defined by Forestry Act. Regeneration usually means that a cut-and-regeneration sequence of operations is applied, which involves that most of the area that is cut in a year is void of mature trees for many years.

Harvests on afforested area have so far mainly been final cuttings in stands that have reached their rotation age. In case an area is regenerated that was afforested or reforested earlier but after 1989, the same rules apply by law than for all other forests. These rules require that harvested forests must be regenerated at least in fifth year from the disturbance. All areas under regeneration are continuously surveyed by the Forest Authorities, and tough penalties are applied to those that violate relevant provisions.

Living biomass

Annual change in carbon stocks in living biomass reservoir was estimated considering the changes in carbon stocks between biomass in the forest prior to conversion (B_{Before}) and that in the settlements after

conversion (B_{After}). Estimations are based on the equation 2.16 contained in IPCC 2006 guidelines of the Volume 4.

Average gross merchantable volume used in the above mentioned equation is estimated on the basis of data from the most recent 5-year cycle of large-scale inventory and is published in the form of official statistics by the Statistics Poland. This method follows the approach in the IPCC Guidelines where the amount of living aboveground biomass that is cleared for expanding settlements is estimated by multiplying the forest area converted annually to settlements by the difference in carbon stocks between biomass in the forest prior to conversion (B_{Before}) and that in the settlements after conversion (B_{After}) which is equal to zero.

To estimate LB carbon stock change in Forest Land converted to Settlements, we have considered instant oxidation of carbon stock in living biomass and litter and dead wood.

Dead organic matter

Annual change in carbon stocks in dead wood reservoir was estimated considering the changes in dead wood resources on forest land all forms of ownership, using the information contained in the statistical yearbooks "Forestry". Estimations are based on the equation 2.19 contained in IPCC 2006 guidelines of the Volume 4.

Dead wood thickness used in the above mentioned equation is estimated on the basis of data from the most recent 5-year cycle of large-scale inventory and is published in the form of official statistics by the Statistics Poland.

This method follows the approach in the IPCC guidelines where the amount of living aboveground biomass dead organic matter that is cleared for expanding settlements is estimated by multiplying the forest area converted annually to settlements by the difference in carbon stocks between biomass in the forest prior to conversion (DOM_{t1}) and that in the settlements after conversion (DOM_{t2}) which is assumed to be equal to zero.

Soils

Annual change in carbon stocks in the litter reservoir was estimated using equation 2.25 as contained in the chapter 2 of the Volume 4 of the IPC 2006. For the needs of equation application, default reference values of SOC_{ref} were considered to be used linked with the dominant tree habitats.

Table 6.44. Forest habitat types in Poland with the SOC_{ref} assignment

SOC_{ref}	Forest habitat types
high active SOC_{ref} (50 [MgC/ha])	Fresh mixed forest, moist mixed forest, mixed upland forest, mountain mixed forest, fresh broadleaved forest, moist broadleaved forest upland forest, mountain forest
low active SOC_{ref} (33 [MgC/ha])	Moist coniferous forest, mountain coniferous forest, high- mountain coniferous forest, 0.5*fresh mixed coniferous forest, moist mixed coniferous forest, upland mixed coniferous forest, mountain mixed coniferous forest
sandy SOC_{ref} (34 [MgC/ha])	Dry coniferous forest, fresh coniferous forest 0.5*fresh mixed coniferous forest
wetland SOC_{ref} (87 [MgC/ha])	Marshy coniferous forest, boggy mountain coniferous forest, boggy mixed coniferous forest, boggy mixed forest, alder forest, ash- alder swamp forest, mountain alder forest, floodplain forest, mountain floodplain forest

Carbon stock changes in mineral soils were estimated based on following references contained in of IPCC 2006 Guidelines of the Volume 4 [IPCC, 2006]:

- transition period – 20 years,
- $f_{man\ intensity}$ – 1.0,
- $f_{dist\ regime}$ – 1.0,
- $f_{forest\ type}$ – 1.0.

Cropland converted to Settlements (CRF sector 4.E.2.2)

Net emissions in this subcategory are equal to 1 082 kt of CO₂ emissions. The fundamental equation for estimating change in carbon stocks associated with land-use conversions has been explained in other sections covering conversions of land converted to forest land, cropland and grassland, respectively. The same decision tree and the same basic method were applied to estimate change in carbon stocks in forest land converted to settlements.

Living biomass

Annual change in carbon stocks in living biomass reservoir was estimated considering the changes in carbon stocks between biomass in the forest prior to conversion (B_{Before}) and that in the settlements after conversion (B_{After}). Estimations are based on the equation 2.16 contained in IPCC 2006 guidelines of the Volume 4. Recent application of notation key "IE", in terms of biomass losses in this particular case is triggered by estimation assumptions for living biomass losses, considering the changes in carbon stocks between biomass in the land prior to conversion (B_{Before}) and that in the settlements after conversion (B_{After}). Estimations are based on the equation 2.16 contained in IPCC 2006 guidelines of the Volume 4. Default approach considering cropland biomass stock peaks has been utilised in the above mentioned equation reflecting any potential net changes of carbon stocks over the inventory year (considered relevant as of the end of the year (as of 31 Dec.).

This method follows the approach in the IPCC Guidelines where the amount of living aboveground biomass that is cleared for expanding settlements is estimated by multiplying the area converted annually to settlements by the difference in carbon stocks between biomass in the forest prior to conversion (B_{Before}) and that in the settlements after conversion (B_{After}) which is equal to zero.

To estimate LB carbon stock change in Forest Land converted to Settlements, we have considered instant oxidation of carbon stock in living biomass and litter and dead wood.

Soils

Annual change in carbon stocks in the litter reservoir was estimated using equation 2.25 as contained in the chapter 2 of the Volume 4 of the IPC 2006. For the needs of equation application, default reference values of SOC_{ref} were considered to be used linked with Estimation of area of different soil types (high activity soils, low activity soils, sandy and wetland) were based on area of soil valuation classes. The percentage fraction of all soil types in croplands was calculated based on available data sets.

Carbon stock changes in mineral soils were estimated based on following references contained in of IPCC 2006 Guidelines of the Volume 4 [IPCC, 2006]:

- transition period – 20 years
- $f_{\text{man intensity}} = 0.62$,
- $f_{\text{dist regime}} = 1.0$,
- $f_{\text{forest type}} = 0.92$.

Grassland converted to Settlements (CRF sector 4.E.2.3)

Net emissions in this subcategory are equal to 1 052 kt of CO₂ emissions. The fundamental equation for estimating change in carbon stocks associated with land-use conversions has been explained in other sections covering conversions of land converted to forest land, cropland and grassland, respectively. The same decision tree and the same basic method were applied to estimate change in carbon stocks in forest land converted to settlements.

Living biomass

Annual change in carbon stocks in living biomass reservoir was estimated considering the changes in carbon stocks between biomass in the forest prior to conversion (B_{Before}) and that in the settlements

after conversion (B_{After}). Estimations are based on the equation 2.16 contained in IPCC 2006 guidelines of the Volume 4. Recent application of notation key “IE” in terms of biomass losses in this particular case is triggered by estimation of living biomass losses, considering the changes in carbon stocks between biomass in the land prior to conversion (B_{Before}) and that in the settlements after conversion (B_{After}). Estimations are based on the equation 2.16 contained in IPCC 2006 guidelines of the Volume 4. Default approach considering grassland biomass stock peaks has been utilised in the above mentioned equation reflecting any potential net changes of carbon stocks over the inventory year (considered relevant as of the end of the year (as of 31 Dec).

This method follows the approach in the IPCC Guidelines where the amount of living aboveground biomass that is cleared for expanding settlements is estimated by multiplying the area converted annually to settlements by the difference in carbon stocks between biomass in the forest prior to conversion (B_{Before}) and that in the settlements after conversion (B_{After}) which is equal to zero.

To estimate LB carbon stock change in Forest Land converted to Settlements, we have considered instant oxidation of carbon stock in living biomass and litter and dead wood.

Soils

Annual change in carbon stocks in the litter reservoir was estimated using equation 2.25 as contained in the chapter 2 of the Volume 4 of the IPC 2006. For the needs of equation application, default reference values of SOC_{ref} were considered to be used linked with Estimation of area of different soil types (high activity soils, low activity soils, sandy and wetland) were based on area of soil valuation classes. The percentage fraction of all soil types in grassland was calculated based on available data sets.

Carbon stock changes in mineral soils were estimated based on following references contained in of IPCC 2006 Guidelines of the Volume 4 [IPCC, 2006]:

- transition period – 20 years,
- $f_{man\ intensity} = 1.00$,
- $f_{dist\ regime} = 1.14$,
- $f_{forest\ type} = 1.11$.

6.6.5. Uncertainties and time-series consistency

The reference dataset is actually a combination of heterogeneous underlying sources offering indirect guarantee for complete and consistent land use capturing in time and space. Land registry is a major source of data, usually locally implemented cadastral database as ownership information, complemented by operational data in forestry, both backed by ground measurements. Additional information is provided by sectorial statistics in agriculture mostly based on municipality or owners/farmers' declarations. Notably, for the agricultural lands reported under agricultural statistics, errors can be particularly high when “activity area” is taken as a proxy for “land use”, or when subjective methods are involved (e.g. non-rigorous implementation of land definition on owner declaration) or lack of rigorous checks and quality assurance/control procedures. Using such data for emissions reduction commitments on land is further strongly limited by non-spatially explicit nature of information and impossibility to be processed as a unique national database. The most significant weakness of reference dataset related to forest land is that it implements an exclusive forest definition, which is ‘land administration oriented’ thus focusing on forest administrated by the State Forests Holding, instead of one based on quantitative thresholds which would be able to capture all forests and change no matter of their cadastral status.

Uncertainty of inventory annual estimate is dominated by forest sink, and apparently influenced by uncertainties of C pool changes. Our sensitivity analysis did not reveal uncertainty of land areas as a significant input, nor for stable land uses and for conversions.

For estimating the contribution of land datasets uncertainty to the overall uncertainty of the CO₂ emissions and removals, a Approach 1 (IPCC 2006) was applied to the inputs for year 2021 within the LUM spreadsheet. An input was defined as the mean value and its relative standard deviation of the mean CSC. Where data was available, standard error of the mean was used (e.g. C stock change in litter or biomass on lands in conversion to forests), otherwise a probability range of the mean as defined by the reference or based on expert assumption (assuming mean is normally distributed).

Uncertainty analysis for the year 2021 for IPCC sector 4. *Land-Use Change and Forestry* was estimated with use of approach 1 described in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Simplified approach was based on the assumptions that every value is independent and probability distribution is symmetric. In this submission uncertainty assumptions were applied directly to on activities and emission factors, instead of emission as in previous years. Results of the sectoral uncertainty analysis are given below. More details on uncertainty assessment of whole inventory are given in annex 8.

Recalculation of data for years 1988-2021 ensured consistency for whole time-series.

Table 6.45. Results of the sectoral uncertainty analysis in 2021

2021	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ Emission uncertainty [%]	CH ₄ Emission uncertainty [%]	N ₂ O Emission uncertainty [%]
4. Land use, land-use change and forestry	-21844.52	0.28	6.57	34.1%	59.4%	91.1%
A. Forest land	-22240.28	0.23	0.56	30.4%	70.2%	70.2%
B. Cropland	1699.99			75.2%		
C. Grassland	-282.60	0.05	0.00	75.2%	70.2%	100.1%
D. Wetlands	1585.91	0.00	0.00	75.2%	0.0%	100.1%
E. Settlements	2269.49			30.4%		
F. Other land						
G. Other	-4877.03			50.2%		

6.6.6. Category-specific QA/QC and verification

Basing on the current recommendations from the IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories, following elements of quality assurance and control were defined for the inventory of national activities in this area:

- performing an inventory of institutions. is responsible for coordinating QA/QC,
- general procedures for quality control inventory QA/QC (using Tier 1),
- a detailed set for the category of sources. quality control procedures (using Tier 2).

Most of the input data used in the inventory process comes from official national statistics in the statistical studies of Statistics Poland, reports of Forest Management and Geodesy Bureau. In case of deviations from the trend, more detailed checks are carried out concerning data input. This situation has occurred in the year 2009 for the studies presented in the official statistical volume of forest resources as a result of changes in methodology for their estimation. Presented data as a result of using National of State Forest Inventory of all forms of ownership become an official source of national statistics. In addition, for the annually calculated emissions are compared with the corresponding values from the previous years (trend of emissions), and in the event of any unexpected changes they are examined in more detail. For the detailed information see chapter QA/QC.

6.6.7. Recalculations

It has be noted, the approach applied by Poland to calculate the percentage change as well as the net effect (in the CO₂ eq.) of changes in methodologies, changes in the manner in which EFs and AD, or the inclusion of new sources or sinks which have existed since the base year, allows to maintain TACCC

principle in relatively simple way. Despite the fact that recalculations of reported data, driven mainly by the ERT recommendations are frequent and sometimes substantial (see Annex I) but as long as the whole time series of data is updated this is not an issue for time consistency. Since the recalculations always affects all reported time series, we consider the recalculated values consistent with the trends in the activity data, and thus more accurate and comparable than before. Main reasons leading to recalculations in the LULUCF sector for the whole time-series are as follows:

- LUC matrix revision (update of historical soil AD, by replacing extrapolated AD data (distribution of soil valuation classes under different LU) with historical data);
- factors related adjustment of carbon stocks calculation in categories 4.B, 4E (update of emission factors for organic soils);
- comprehensive implementation of methods and factors provided in IPCC 2006 guidelines while updating of HWP production data (including historical production data for FAO codes: 1875, 1876, 1874, 1872).

Recalculation of data for years 1988-2020 ensured consistency for whole time-series. Net effect of recalculations on emissions/removals is provided in the tables 6.46; 6.47; 6.48.

Table 6.46. Net effect of recalculations on CO₂ emissions/removals (1/2)

Category	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
4. Total LULUCF	[kt]	901.48	584.09	574.83	548.61	527.46	520.30	524.65	529.89	483.28	468.03	467.36	393.36	376.22	361.06	382.28	395.09	363.76
	[%]	4.89	2.52	1.94	2.44	32.49	5.81	6.21	2.85	1.34	1.30	1.13	1.01	1.06	1.31	1.06	1.03	0.74
A. Forest land	[kt]	-0.45	-27.16	-25.72	-23.96	-23.63	-22.27	-21.98	-22.54	-20.81	-21.10	-23.85	-32.05	-37.13	-41.27	-46.21	-53.91	-54.43
	[%]	0.00	-0.10	-0.08	-0.09	-0.44	-0.18	-0.19	-0.10	-0.05	-0.05	-0.05	-0.08	-0.10	-0.14	-0.12	-0.14	-0.11
1. Forest land remaining forest land	[kt]	-0.45	-0.46	-0.59	-0.58	-0.59	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	0.00	0.00	0.00	0.00	-0.01	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to forest land	[kt]	negligible	-26.70	-25.13	-23.38	-23.04	-22.27	-21.98	-22.54	-20.81	-21.10	-23.85	-32.05	-37.13	-41.27	-46.21	-53.91	-54.43
	[%]	negligible	-2.13	-2.07	-1.86	-1.79	-1.47	-1.58	-1.70	-1.79	-1.52	-2.07	-1.72	-2.09	-1.90	-2.81	-3.22	-3.49
B. Cropland	[kt]	274.22	0.66	0.66	0.65	0.65	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.53	1.04	1.04	1.04	1.04
	[%]	-14.22	-0.04	-0.04	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.03	-0.07	-0.07	-0.07	-0.07
1. Cropland remaining cropland	[kt]	-0.02	-0.02	-0.02	-0.02	-0.03	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	0.00	0.00	0.00	0.00	0.00	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to cropland	[kt]	274.24	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.53	1.04	1.04	1.04	1.04
	[%]	-61.17	-0.39	-0.25	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33	-0.18	-1.00	-1.00	-1.00	-1.00
C. Grassland	[kt]	114.29	102.61	94.43	94.01	97.87	105.98	103.03	95.43	90.04	88.98	125.95	96.75	98.07	98.71	129.47	160.93	139.15
	[%]	144.10	-611.38	-48.23	-33.49	-29.82	-32.53	-25.85	-16.78	-15.64	-14.14	-37.85	-18.42	-20.01	-16.55	-26.79	-53.38	-30.81
1. Grassland remaining grassland	[kt]	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	negligible	0.72	1.44	2.15	2.87
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	-0.06	-0.11	-0.17	-0.25
2. Land converted to grassland	[kt]	114.29	102.62	94.44	94.02	97.88	105.98	103.04	95.43	90.05	88.99	125.96	96.75	98.07	97.99	128.03	158.78	136.29
	[%]	8.42	8.04	8.49	8.91	9.45	9.95	10.09	10.29	10.62	11.24	12.29	11.43	11.90	14.23	16.42	16.84	18.97
D. Wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Wetlands remaining wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
E. Settlements	[kt]	513.44	507.98	505.46	477.91	452.57	435.91	442.92	456.32	413.37	399.47	364.59	327.98	314.75	302.59	297.99	287.03	278.00
	[%]	-23.18	-24.41	-23.91	-23.85	-21.72	-21.58	-22.93	-25.05	-23.90	-22.24	-20.83	-21.01	-20.31	-20.78	-21.49	-20.53	-19.87
1. Settlements remaining settlements	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to settlements	[kt]	513.44	507.98	505.46	477.91	452.57	435.91	442.92	456.32	413.37	399.47	364.59	327.98	314.75	302.59	297.99	287.03	278.00
	[%]	-23.14	-24.39	-23.92	-23.88	-21.77	-21.65	-23.03	-25.35	-24.21	-22.50	-21.04	-21.23	-20.58	-21.03	-21.78	-20.78	-20.06
F. Other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Other land remaining other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible

Table 6.46. Net effect of recalculations on CO₂ emissions/removals (2/2)

Category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
4. Total LULUCF	[kt]	349.58	345.92	281.78	285.43	217.78	216.50	226.65	450.15	281.62	605.29	789.78	646.27	324.29	461.00	410.03	688.55
	[%]	0.72	0.81	0.79	0.81	0.61	0.64	0.58	1.15	0.68	1.79	2.62	1.72	0.84	1.21	2.09	3.43
A. Forest land	[kt]	-58.81	-65.14	-70.24	-71.89	-80.62	-83.36	-80.08	-68.35	-64.64	-51.78	-38.39	-35.76	-53.95	-60.90	-10.10	-3.24
	[%]	-0.12	-0.15	-0.19	-0.20	-0.22	-0.24	-0.20	-0.17	-0.15	-0.14	-0.12	-0.08	-0.13	-0.16	-0.05	-0.01
1. Forest land remaining forest land	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	0.00	-0.12	-0.12	-0.12	-0.38	-0.35	36.62	39.61
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	0.19	0.20
2. Land converted to forest land	[kt]	-58.81	-65.14	-70.24	-71.89	-80.62	-83.36	-80.08	-68.35	-64.64	-51.66	-38.26	-35.64	-53.56	-60.55	-46.72	-42.85
	[%]	-2.76	-2.32	-3.36	-2.70	-2.98	-3.18	-2.98	-2.56	-2.31	-1.87	-1.44	-1.32	-2.94	-2.71	-2.21	-2.24
B. Cropland	[kt]	1.04	1.04	1.45	1.45	1.45	1.45	1.45	1.45	0.39	0.39	0.37	0.37	-5.48	-1.37	-1.35	-1.28
	[%]	-0.07	-0.06	-0.09	-0.08	-0.09	-0.09	-0.09	-0.09	-0.02	-0.02	-0.02	-0.02	0.31	0.08	0.08	0.07
1. Cropland remaining cropland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	-0.02	-0.02	-0.01	-0.01	0.01	0.08
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	0.00	0.00	negligible	negligible	negligible	-0.01
2. Land converted to cropland	[kt]	1.04	1.04	1.45	1.45	1.45	1.45	1.45	1.45	0.39	0.39	0.39	0.39	-5.47	-1.36	-1.36	-1.36
	[%]	-0.78	-0.92	-1.71	-0.62	-1.14	-1.14	-1.47	-1.47	-0.49	-0.49	-0.49	-0.49	2.70	1.14	1.16	1.16
C. Grassland	[kt]	144.31	160.34	159.41	174.30	180.25	183.05	182.81	185.31	183.11	173.27	171.00	201.98	166.41	192.25	197.63	220.07
	[%]	-29.89	-28.79	-28.81	-31.58	-37.44	-38.53	-39.64	-42.36	-43.84	-35.42	-49.95	-154.34	-50.47	-285.69	-207.38	553.94
1. Grassland remaining grassland	[kt]	3.59	4.29	4.99	5.69	6.36	7.04	7.71	8.41	9.10	9.80	10.51	11.16	11.73	12.48	13.11	13.73
	[%]	-0.32	-0.37	-0.47	-0.52	-0.63	-0.70	-0.80	-0.89	-0.99	-1.09	-1.21	-1.28	-1.46	-1.58	-1.69	-1.89
2. Land converted to grassland	[kt]	140.73	156.05	154.42	168.62	173.89	176.01	175.10	176.91	174.01	163.47	160.49	190.82	154.68	179.77	184.51	206.33
	[%]	21.98	25.76	30.73	31.63	32.53	33.52	34.42	35.00	34.41	39.50	30.51	25.64	32.80	24.95	27.14	26.96
D. Wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	83.78	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	-5.90	negligible	negligible	negligible	negligible	negligible
1. Wetlands remaining wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	83.78	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	-5.93	negligible	negligible	negligible	negligible	negligible
E. Settlements	[kt]	263.05	249.69	191.17	181.57	116.70	115.36	122.47	331.74	162.77	483.40	573.01	479.68	217.31	331.02	223.86	452.61
	[%]	-18.33	-15.86	-13.98	-11.29	-8.37	-8.02	-8.92	-20.29	-10.39	-18.18	-23.34	-7.44	-8.17	-12.93	-8.61	-17.61
1. Settlements remaining settlements	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to settlements	[kt]	263.05	249.69	191.17	181.57	116.70	115.36	122.47	331.74	162.77	483.40	573.01	479.68	217.31	331.02	223.86	452.61
	[%]	-18.51	-15.99	-14.14	-11.38	-8.46	-8.09	-8.98	-20.37	-10.45	-18.26	-22.84	-7.47	-8.03	-11.91	-7.93	-16.27
F. Other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Other land remaining other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	20.40
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	0.46

Table 6.47. Net effect of recalculations on CH₄ emissions (1/2)

Category	1988	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
4. Total LULUCF	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
A. Forest land	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Forest land remaining forest land	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to forest land	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
B. Cropland	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Cropland remaining cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Grassland	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Grassland remaining grassland	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Wetlands remaining wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Settlements remaining settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Other land remaining other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 6.47. Net effect of recalculations on CH₄ emissions (2/2)

Category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
4. Total LULUCF	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
A. Forest land	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Forest land remaining forest land	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to forest land	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
B. Cropland	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Cropland remaining cropland	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to cropland	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Grassland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Grassland remaining grassland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to grassland	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Wetlands remaining wetlands	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to wetlands	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Settlements remaining settlements	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to settlements	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Other land remaining other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 6.48. Net effect of recalculations on N₂O emissions (1/2)

Category	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
4. Total LULUCF	[kt]	0.24	0.23	0.23	0.22	0.21	0.20	0.19	0.18	0.18	0.17	0.16	0.14	0.13	0.12	0.12	0.12	0.12
	[%]	3.59	3.56	3.62	3.55	3.23	3.37	3.39	3.40	3.39	3.45	3.35	2.96	2.85	2.92	2.96	2.78	3.11
A. Forest land	[kt]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04	0.05
	[%]	6.64	6.66	6.81	7.95	3.06	6.60	6.51	7.37	6.32	7.67	8.50	7.33	7.56	8.20	8.31	6.22	8.80
1. Forest land remaining forest land	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to forest land	[kt]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04	0.05
	[%]	8.73	8.73	8.85	8.82	8.25	8.75	8.76	8.82	9.20	9.22	9.45	9.02	9.20	9.07	9.46	9.30	9.49
B. Cropland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Cropland remaining cropland	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to cropland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
C. Grassland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Grassland remaining grassland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to grassland	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Wetlands remaining wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
E. Settlements	[kt]	0.21	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.12	0.10	0.09	0.09	0.08	0.07	0.07
	[%]	3.47	3.47	3.48	3.36	3.31	3.21	3.21	3.20	3.15	3.11	2.89	2.54	2.42	2.38	2.30	2.21	2.17
1. Settlements remaining settlements	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to settlements	[kt]	0.21	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.12	0.10	0.09	0.09	0.08	0.07	0.07
	[%]	3.47	3.47	3.48	3.36	3.31	3.21	3.21	3.20	3.15	3.11	2.89	2.54	2.42	2.38	2.30	2.21	2.17
F. Other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Other land remaining other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 6.48. Net effect of recalculations on N₂O emissions (2/2)

Category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
4. Total LULUCF	[kt]	0.11	0.09	0.08	0.07	0.04	0.04	0.05	0.08	0.02	0.18	0.22	0.04	0.02	-0.01	-0.03	-0.13
	[%]	3.01	2.75	2.38	2.01	1.14	1.26	1.38	2.18	0.67	4.63	3.27	0.65	0.35	-0.12	-0.50	-1.96
A. Forest land	[kt]	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.02
	[%]	8.23	7.92	8.65	8.47	8.23	8.54	8.39	7.78	8.49	8.21	7.82	8.25	8.45	7.91	7.71	2.30
1. Forest land remaining forest land	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	-0.07
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	-183.17
2. Land converted to forest land	[kt]	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.09
	[%]	9.17	8.86	9.19	8.91	8.85	8.86	8.79	8.71	8.70	8.59	8.55	8.48	8.61	8.33	8.27	13.23
B. Cropland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	-1.52	-1.51	-1.51	-1.51
1. Cropland remaining cropland	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to cropland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	-1.52	-1.51	-1.51	-1.51
C. Grassland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
1. Grassland remaining grassland	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to grassland	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	0.04	negligible	negligible	negligible	0.00	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	99.98	negligible	negligible	negligible	62.89	negligible
1. Wetlands remaining wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
2. Land converted to wetlands	[kt]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	NO	0.04	negligible	negligible	negligible	0.00	negligible
	[%]	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	NO	99.99	negligible	negligible	negligible	63.02	negligible
E. Settlements	[kt]	0.06	0.05	0.02	0.01	-0.02	-0.01	-0.01	0.02	-0.04	0.12	0.12	-0.01	-0.04	-0.06	-0.09	-0.14
	[%]	1.98	1.70	0.92	0.47	-0.72	-0.57	-0.45	0.61	-1.42	3.83	2.09	-0.22	-0.62	-1.02	-1.48	-2.48
1. Settlements remaining settlements	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to settlements	[kt]	0.06	0.05	0.02	0.01	-0.02	-0.01	-0.01	0.02	-0.04	0.12	0.12	-0.01	-0.04	-0.06	-0.09	-0.14
	[%]	1.98	1.70	0.92	0.47	-0.72	-0.57	-0.45	0.61	-1.42	3.83	2.09	-0.22	-0.62	-1.02	-1.48	-2.48
F. Other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1. Other land remaining other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to other land	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Harvested wood products	[kt]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	[%]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

6.6.8. Planned improvements

Recent focus in terms of the inventory related developments is focused on improving monitoring capacities allowing to assess natural resources and land use and land use cover over the particular time frames with the required levels of data accuracy. The scope of those activities requires detailed, and up-to-date geospatial information on land cover (LC), land use (LU) and their changes over time. The LCLU information is essential for a broad range of inventory applications. It is crucial for land management, monitoring of sustainable development of agriculture, forestry, rural areas, assessment of biodiversity status and losses, urban planning and land uptake. LCLU is also essential for various reporting obligations, for example, for counting greenhouse gas (GHG) emissions and removal from the Land Use, Land Use Change and Forestry (LULUCF) sector, a long-term climate mitigation, greening of Common Agricultural Policy (CAP), Biodiversity Conservation, Urban Agenda and plans for the upcoming Energy Union. Each of these regulations requires different level of details on land cover, land use and changes. The products of the Copernicus Land Monitoring Service are to some extent used in national research projects, but rarely in national mapping, reporting and monitoring programs carried out by national and regional authorities.

Scope of above mentioned assessment is partially covered by the goals of InCoNaDa projects allowing to improve the user uptake of land cover and land use information derived from the integration of Copernicus Land Monitoring Services (CLMS) and national databases.

The project goal is to address the request for more detailed information on LCLU and its changes (in respect to spatial, temporal and thematic content), than is currently provided in Corine Land Cover (CLC) databases. Furthermore, the assessment of usefulness of enhanced LCLU database and CLMS products for decision makers, reporting obligations in natural resources monitoring, urban and spatial planning, agricultural management and reporting greenhouse gases emissions and removals from LULUCF in Poland and Norway.

Furthermore, the project is aiming to address the following objectives:

- 1) to determine the most accurate land cover map based on a time series of Sentinel-2 data using machine learning approaches;
- 2) to verify the EAGLE concept by developing and testing an approach for integration and population of land use information and delivering the enhanced LCLU database;
- 3) to design and develop web-based application enabling to query the enhanced LCLU database as well as to integrate and extract statistics from the CLMS adjusted to the user needs;
- 4) to proof if and how enhanced LCLU database and CLMS can be used in spatial planning;
- 5) to proof if and how the enhanced LCLU database and CLMS can be used in the agricultural management and environmental monitoring;
- 6) to demonstrate the usefulness of the enhanced LCLU database and CLMS for reporting GHG emissions and removals from LULUCF.

Furthermore, the available information on forest management practices, their characteristics, including the rules on forest use and the species-age structure of forests, is being analysed. The division of forests in Poland is being applied taking into account two stratification layers justified by: the differences in the intensity and structure of the harvest, as well as in the availability and reliability of data on the condition and management of forests.

Based on the NFI results as well as on available more detailed data on national forests, a division into two stratification layers (strata) is being analysed for the inventory related purposes:

- forests under management of the State Forests National Forest Holding - covering most of the area and wood resources of Poland (ca. 77%) and carried out according to uniform practices

applied based on methods contained in the instructions and internal regulations concerning forest management in force in the State Forests National Forest Holding;

- forests outside the management of the State Forests National Forest Holding (so called - other forests) - including forests of other forms of ownership, whose total area and volume of resources is approximately 23%. Other forests include forests under private ownership, forests managed by national parks, the Agricultural Property Stock of the State Treasury, other forests of the State Treasury and municipalities forests. Forests under private ownership dominate in this group, while other properties account for a small percentage of Poland's forest area. This group is characterized by a different way of forest management, e.g by significantly lower ratios of harvest relation to forests managed by the State Forests National Forest Holding.

As matter for relevant data preparation for subcategory 4.A.1, tables of volume stock based on the forest area (without forest area used for forest management) as of 1 January have been prepared, by reducing volume stock tables of total forests - namely in Ia and Ib age subclasses – assuming they representing the relevant area resources. It is worth to note that the national forest inventory does not provide any official information on annual increment data exclusively from age class I (1-20 years) available for inventory compilation. However, alternative solutions are being investigated.

Nevertheless, while working on implementation of the CBM CFS model into GHG inventory this issue will be covered by the utilisation of growth curves based on forest inventory data (namely WISL). Since the CBM CFS implementation is a part of overall inventory improvement plan containing issues that require further analysis in relation to lack of activity data, emission factors, changing / increasing the Tier in methodology, issue will be fully covered by the time of obtaining the modelling results. The scope of the modelling framework considers following activities:

- preparation of CSC data for 4A.1 and 4.A.2 and 4.E.2.1 subcategories;
- preparation of potential technical correction of forest reference level.

Indicated improvement is considered as a matter of inventory improvement plan, taking into account utilisation of carbon modelling framework (mainly by introducing CBM CFS) and incorporation of subsequent results into GHG inventory. The modelling of carbon emission and removal balances to be carried out using CBM-CFS3 software. Recent activities are focused on preparation of missing historical model library defining gross standing volume by age class for each species. Activities currently completed covers the following:

- 1) adaptation of biomass expansion factors (BEFs) to Polish conditions;
- 2) adaptation wood densities to Polish conditions;
- 3) consideration of domestic division of forests into nature and forest regions in place in Poland;
- 4) preparation of growth curves based on WISL data.

The other subject of inventory improvement are agricultural peat soils which represents around 3% of the total agricultural land in Poland but still have a significant effect on total national greenhouse gas emissions. While current estimations of greenhouse gas emissions from managed peat soils look reasonably accurate for today's conditions, the changing rules and regulations governing agriculture in Europe together with new energy policies can affect both the acreage and the cultivation intensity of organic soils quite dramatically. Climate change, with its associated predicted higher temperatures in Poland, will certainly have a major effect on emission rates for this source.

Taking into consideration the necessity of further improvement in the precision in the estimation of acreage and cultivation intensity necessary for an accurate estimation of greenhouse gas emissions from peat soils under agriculture. forestry and other land related use it is desirable that future estimations will take into account following issues under recent consideration:

- the relevant decisions of the UNFCCC and EU legislation;
- strive for best possible activity (area) data that comply with IPCC land use categories. preferably in a spatial ('wall-to-wall') approach:
 - use proxy sources (high resolution data, data on drainage networks) to identify possible occurrences of organic soils;
 - conduct peatland surveys as has been done e.g. in Estonia (cf. Paal & Leibak 2011);
- use country-specific. higher tier emission factors if available whenever emissions from organic soils are key sources;
- develop appropriate emission factors when developing and implementing new land use options on rewetted organic soils (such as 'paludiculture').

Furthermore, current approach is to build capacity to cover soil organic carbon related aspects, to better understand the estimation methodologies and requirements, as well as available data.

6.7. Other land (CRF sector 4.F)

Emissions/removals from this subcategory were not estimated. It is included to match overall consistency of country land area.

6.8. Harvested wood products (CRF sector 4.G)

This chapter provides information on how the framework for calculating the carbon substitution effect in harvested wood products based on changes in the carbon pool and some historical information on assumptions related to the principle of instantaneous oxidation. was implemented. Calculation for category 4.G is based on IPCC methodology described in the chapter 8 of IPCC 2006 guidelines of the Volume 4. GHG balance for this subcategory was identified as a net CO₂ sink. Net CO₂ sink was equal to 4 877 kt of CO₂. Overall trend in the reporting period is presented on graph below.

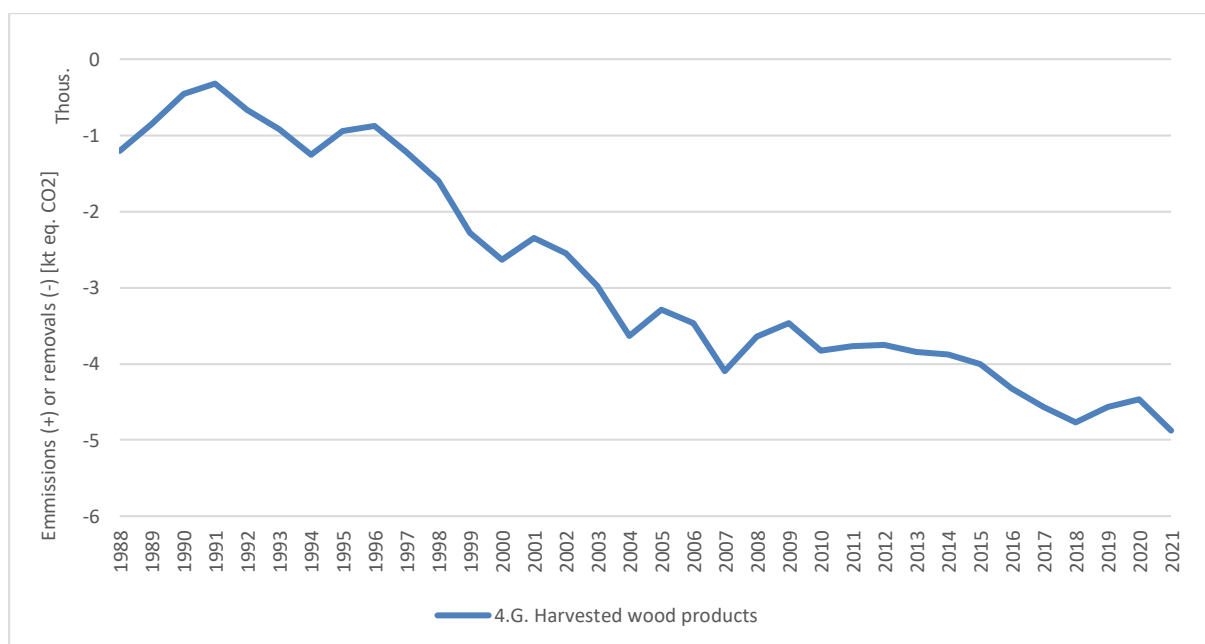


Figure 6.20. Trends in emissions/removals for the category 4.G. *Harvested wood products*

According to the relevant provisions (Regulation 2018/841), only carbon contained in wood products harvested from managed forest land should be included in the estimation. However, if it is not possible to differentiate between harvested wood products subject to Afforestation and Managed forests EU Member State may choose to account for harvested wood products assuming that all emissions and removals occurred on land subject to Managed forests. As a consequence, time series of data reflecting the annual production of wood products have been allocated to the corresponding national forest land activity. This process consisted of three intermediate stages:

- estimation of the share of carbon in harvested wood products from domestic forests. For this purpose, the share of the relevant categories of raw materials (which also originate from domestic forests) of harvested wood products, such as "industrial round wood", "wood pulp" and "recovered paper" used (i.e. consumed) in the production process of the relevant wood products, such as "sawn timber", "wood-based panels" and "paper and board", was determined.
- an estimate of the annual fraction of raw materials for the wood products categories 'sawn timber', 'wood-based panels' and 'paper and board' originating in land category 4.A.1 *forest land remaining forest land*. Importantly, in accordance with the relevant requirements, harvested wood from deforested areas (in accordance with EU Reg. 2018/841) has been treated according to the principle of "instantaneous oxidation".

- c) in order to obtain annual fractions of harvested wood products derived from the reporting category/activity, the information obtained in steps a and b has been combined.

The estimation process itself uses the methodological guidelines contained in section 2.8.1.2 of the IPCC (2014)⁶. Following coefficients from Table 12.4 of 2006 Guidelines (default factors to convert from product units to carbon) were applied taking into account the conditions of our country and resulting the following factors for conversion to carbon:

Table 6.49. Factors for conversion to carbon

Item	Value
Sawn wood	0.225
Wood panel	0.269
Paper and paper board	0.386

The half-live time parameters

According to the 2006 Guidelines, the half-live time parameters are: 35 years – sawn wood (decay rate $k=0.020$), 25 years – wood panels (decay rate $k=0.028$) and 2 years- paper products (decay rate $k=0.347$).

Data sources (FAO database)

When determining CO₂ emission balance, we resorted to consulting the FAO database (available at the following address: <http://faostat.fao.org>). Based on FAO classification, we retrieved data regarding the production and export of the following wood products: sawn wood, wood-based panels, paper and paperboard, wood pulp and recovered paper. Wood products import data has been excluded while assessing input data.

Estimating data for the period between 1900 and 1960

Due to the fact that FAO only supplies data beginning with 1961, we resorted to estimate production and export of wood products between 1900 and 1960 by equation 12.6, which takes into account the production and exports values for 1961 and U (the exchange rate in Europe, which amounts to 0.0151).

The variables (1.A, 1.B, 2.A, 2.B, 3, 4, 5) were determined in conformity with the provisions of the *IPCC Guidelines for National Greenhouse Gas Inventories Volume 4. Agriculture, Forestry and Other Land Use. Chapter 12 Harvested Wood Products 2006*. Calculation were run through all of the mentioned stages, and also by using the modified inventory worksheet as provided by the IPCC at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_12_Ch12_HWP_Worksheet.zip

Calculation

Step 1: Calculating variable 1.A (i.e. Annual change in carbon stock in “products in use”). It was calculated using formulas 12.1 and 12.2, for each product category (sawn wood, wood panels and paper products), inflow, k (decay rate), and the carbon stock at the beginning of the year ($C_{(i)}$).

Step 2: Calculating variable 2.A (Annual change in carbon stock in “products in use” where wood came from harvest in the reporting country (includes exports)). It was calculated using formulas 12.1 and 12.3, accounting for the product category (solid wood or paper products), inflow, k (decay rate) and the stock of carbon at the beginning of the year ($C_{(i)}$).

⁶ The same information as provided in section 12.5.2.1 (“Compilation of activity data on the production approach”) of the IPCC 2019 Refinement.

Step 3: Calculating variable 1.B (Annual Change in stock of HWP in SWDS from consumption) and 2.B (annual Change in stock of HWP in SWDS produced from domestic harvest). When calculating the 1.B and 2.B variables, we didn't take into account the Waste Sector Tier 1 estimates, as laid out in the IPCC 2006 Guidelines.

In the interest of transparency, pursuant to CRF Table 4.Gs1. wood products for material use are divided into products that, following their production, are used in Poland, and products that are exported following their production. The carbon stored in wood in landfills is not taken into account.

The biomass of short-rotation plantations in Poland is used exclusively for energy purposes and thus that biomass is not reported under "harvested wood products" (HWP).

6.8.1 Uncertainties and time series consistency

Estimation of C stock change in HWP is under further refining. Estimate of uncertainty is going to be done with future submissions.

6.8.2 Category-specific QA/QC and verification. if applicable

Comparable order of magnitude of currently submitted estimates with those submitted by Poland in the past (NFAP for forest reference level).

6.8.3 Recalculations

No recalculations were performed in relation to the HWP estimates.

6.8.4 Planned improvements

Current approach is to build capacity to cover HWP, to better understand the estimation methodologies and requirements, as well as available data.

7. WASTE

7.1. Overview of sector

The GHG emission sources in waste sector involve: methane emission from 5.A *Solid Waste Disposal*, CH₄ and N₂O emissions from 5.B *Biological Treatment of Solid Waste*; CO₂, CH₄ and N₂O emissions from 5.C *Incineration and Open Burning of Waste* and CH₄ and N₂O emissions from 5.D *Wastewater Treatment and Discharge*.

Following subcategories from sector 5 have been identified as key source (excluding LULUCF):

IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)		
5.A Solid Waste Disposal	CH ₄		T	
5.D Wastewater Treatment and Discharge	CH ₄	L		

Share of these subcategories in total Poland's GHG emissions amounts ca. 0.84%.

Total emission of GHG amounted to 4 752 kt of CO₂ equivalent in 2021 and decreased since 1988 by 74.40% (figure 7.1).

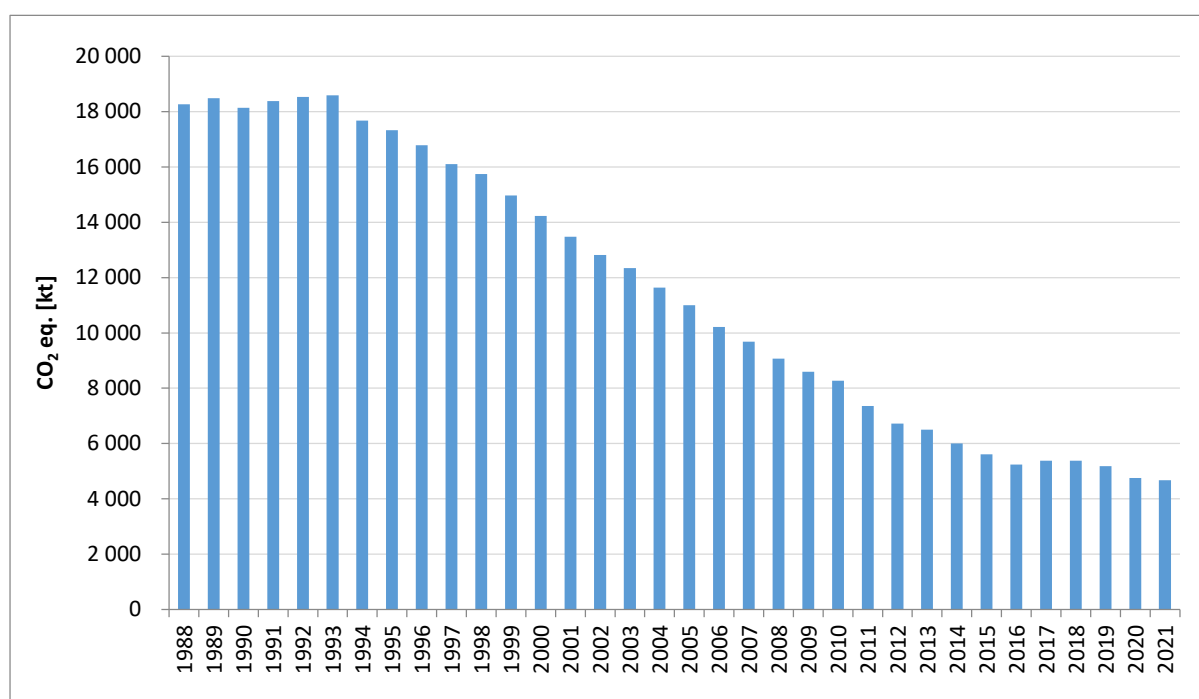


Figure 7.1. GHG emissions from waste sector in 1988-2021

Between years 1988 and 2021 decrease of GHG emissions appeared in subcategory 5.A (by 91.0 %) and 5.D (by 15.8 %) while emissions from sources gathered in subcategories 5.B and 5.C decreased since 1988 by 1 058.7 % (5.B) and 37.5 % (5.C). The main reason of decrease of emissions from sector 5 is decrease of GHG emissions in subsector 5.A *Solid Waste Disposal on Land* and subsector 5.D *Wastewater Treatment and Discharge* (figure 7.2), the biggest (27.9% and 59.0% of emission respectively) contributors to emission from *Waste* sector.

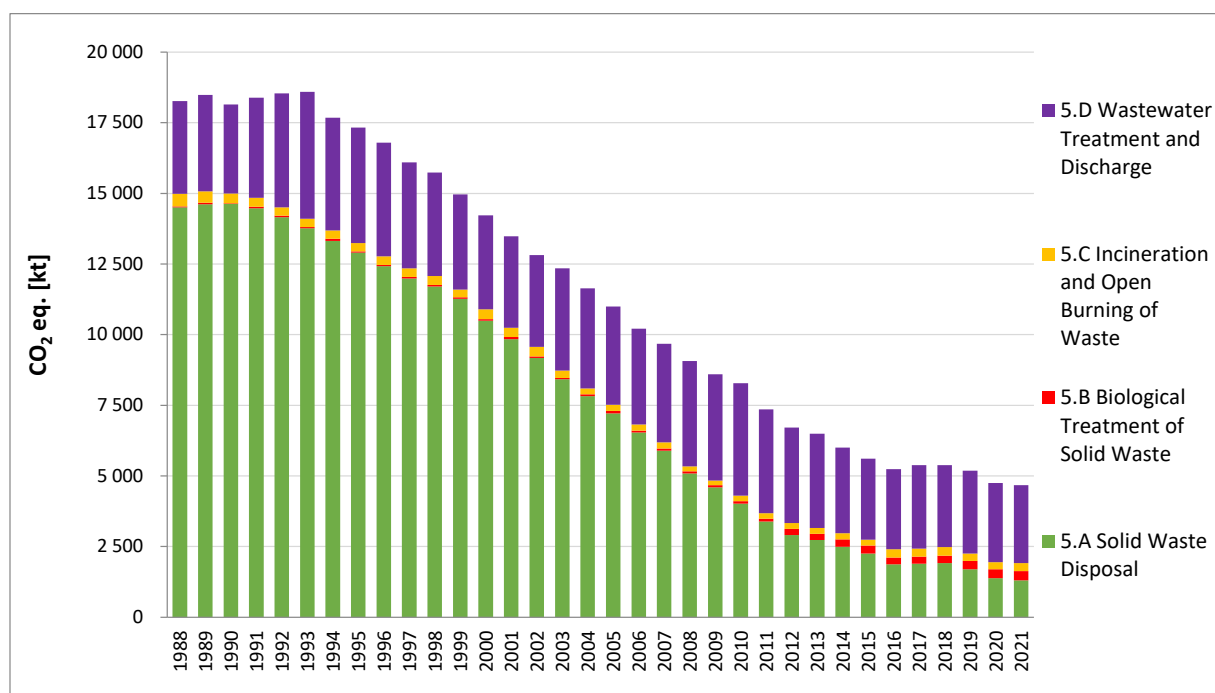


Figure 7.2. GHG emissions from waste sector divided to subsectors in 1988-2021

According to statistical data [GUS (2022d)] in 2021 collected municipal solid wastes go to four different treatment pathways: incineration with energy recovery (21.0%), biological treatment (13.3%), recycling (26.9%) and landfilling (38.7%).

The changes in shares of municipal solid waste treatment pathways since 2007 are presented in figure 7.3.

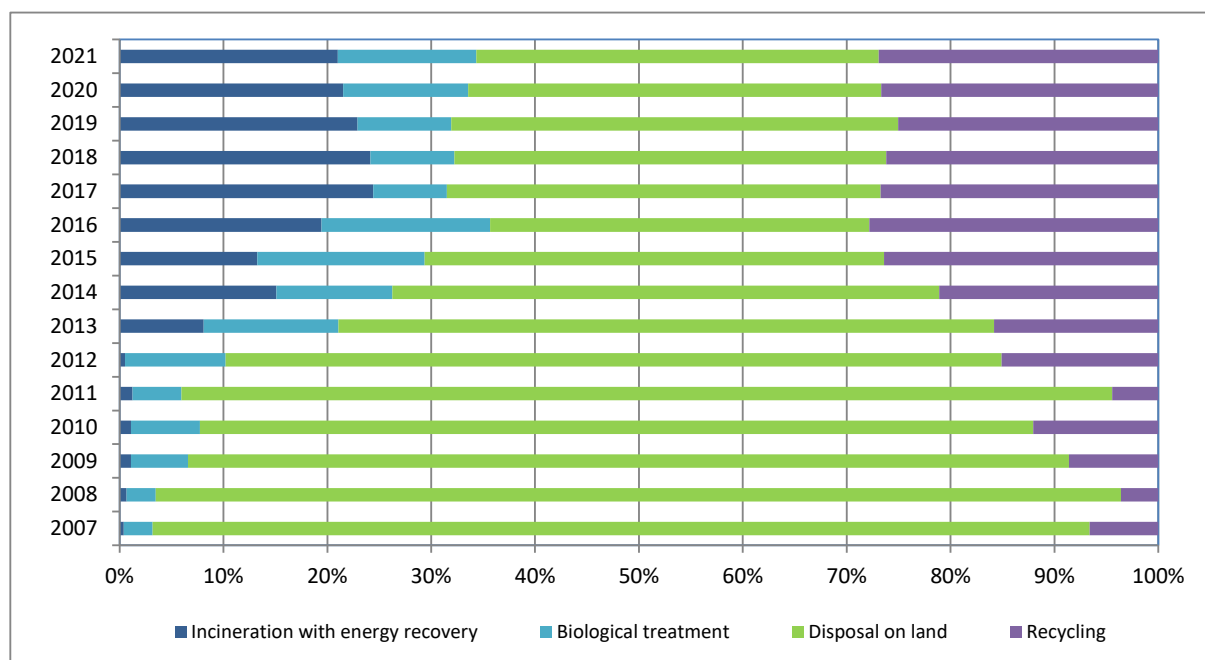


Figure 7.3. Municipal solid waste treatment pathways

7.2. Solid Waste Disposal (CRF sector 5.A)

7.2.1. Source category description

The 5.A *Solid Waste Disposal on Land* subcategory share in total waste sector amounts ca. 27.9% and it involves methane emissions from Managed Waste Disposal on Land (21.8% share of 5.A), Unmanaged Waste Disposal on Land deep (0.9% share of 5.A) and Uncategorized MSW Disposal on Land (5.2% share of 5.A). Managed Waste Disposal on Land includes methane emissions from disposal of sewage sludge (described in chapter 7.2.2.1) and industrial solid waste (described in chapter 7.2.2.2).

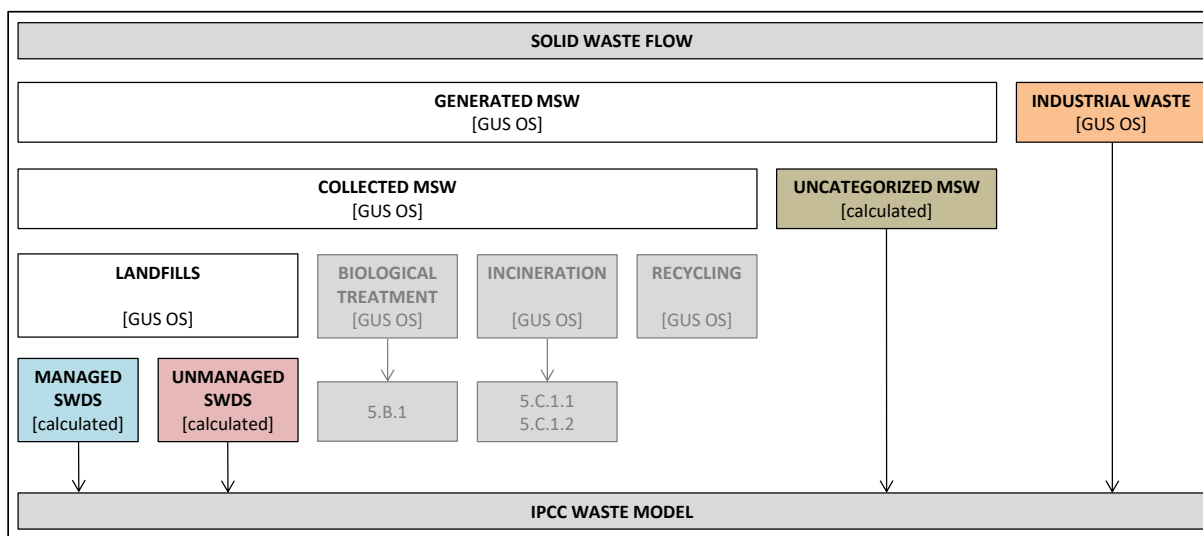


Figure 7.4. Solid waste flow scheme

The trend of emissions from sector 5.A is mostly conditioned by activity data – amounts of waste generated, collected and landfilled – which reached highest values around the year 1990 and the year 1999. The first peak in the trend (Fig. 7.5) is a result of high waste generation and poorly developed waste collection and recycling system in the early '90. The post-communist economy was generating big amounts of municipal and industrial waste, the most common way of treatment was landfilling, and the significant amount of disposal sites were unmanaged. Increase of emission resulting in second peak, which appeared around the year 1999, is related to highest share of utilization in unmanaged waste disposal sites coinciding with the highest peak in collected MSW trend.

Since 1999 the trend of methane emission is decreasing, mostly due to development of collection, segregation and landfilling system (what is the result of implementing recommendations of Landfill Directive 1999/31/EC, among others). During this period waste recycling was popularized and the recycling system was developed, what resulted in decrease of landfilled municipal waste. Moreover, new technologies were introduced on disposal sites what caused the decrease in amount of waste landfilled in unmanaged disposal sites.

Basic legal regulatory

The basic legal regulatory for waste management in Poland is the Act on waste (Dz.U. 2013/0/21 with later changes) describing the ways of waste treatment leading to human and environment protection.

Imported waste

Poland is importing solid waste but according to information from Chief Inspectorate of Environment Protection it is mostly hazardous waste for incineration (no municipal waste is imported) and it's amount is included in data on incinerated waste used by Party for estimates from subsector 5.C.

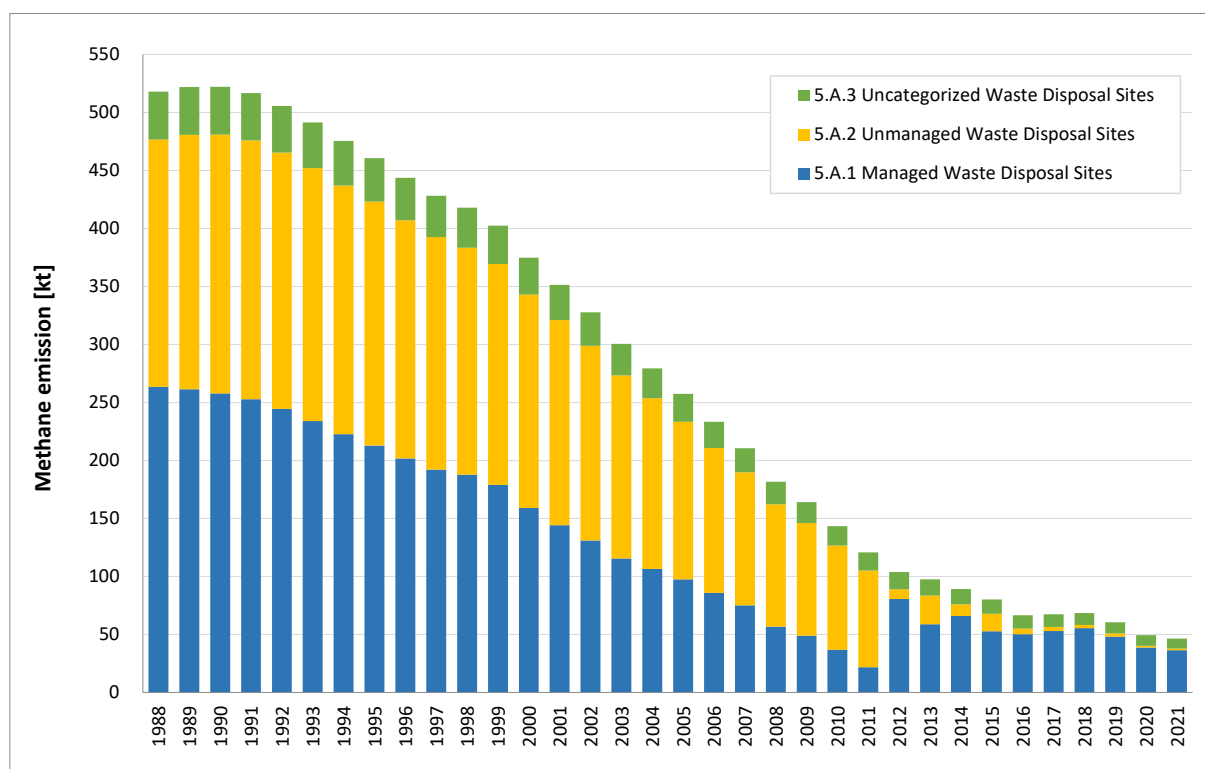


Figure 7.5. Methane emission from 5.A subsector divided to subcategories

7.2.2. Methodological issues

7.2.2.1 Method and factors applied

The methane emission estimates from waste disposal sites were calculated using IPCC 2006 *Tier 2* method. The choice of the method was supported by good quality country-specific historical and current activity data on waste disposal at SWDSs provided by Statistics Poland and The Ministry of Environment.

The methane emissions estimates were calculated with application the IPCC Waste Model published in [IPCC (2006)]. The model establishes multiyear series when methane is generated from organic matter decomposition in anaerobic conditions. The emission of CH₄ is diminished by recapturing of this gas for energy purposes.

The following factors were used for estimation of CH₄ emissions:

- DOC – degradable organic carbon in the year of deposition,
- DOC_f – fraction of DOC that can decompose,
- MCF – CH₄ correction factor for aerobic decomposition in the year of deposition,
- k – reaction constant,
- F – fraction of CH₄ by volume, in generated landfill gas,
- OX – Oxidation Factor reflecting the amount of CH₄ from solid waste disposal sites that is oxidized in the soil or other material covering the waste.

Table 7.1. MCF indicators of organic carbon in disposed municipal and industrial waste

Unmanaged, shallow	Unmanaged, deep	Managed	Managed, semiaerobic	Uncategorised
0.4	0.8	1	0.5	0.6

Estimation of unmanaged landfill depth based on area and amount of landfilled allowed to categorize unmanaged SWDSs to “shallow” in years 1950-1963 and since 1964 to “deep” group.

Table 7.2. DOC and DOC_f indicators

DOC	Municipal Waste			Industrial Waste	
	Range	Default	Adopted Value	Default	Adopted Value
Food	0.08-0.20	0.15	0.15	0.15	0.15
Garden	0.18-0.22	0.2	0.2	NO	NO
Paper	0.36-0.45	0.4	0.4	0.4	0.4
Wood and straw	0.39-0.46	0.43	0.43	0.43	0.43
Textiles	0.20-0.40	0.24	0.24	0.24	0.24
Nappies	0.18-0.32	0.24	IE	NO	NO
Rubber (and leather)	0.39	0.39	IE	0.39	0.39
DOC_f	0.5	0.5	0.5	0.5	0.5

Table 7.3. Methane generation rate (k) assumed for calculations

Methane generation rate constant (k)	Municipal Waste			Industrial Waste		
	Range	Default	Adopted Value	Range	Default	Adopted Value
Food waste	0.1–0.2	0.185	0.185	0.1–0.2	0.185	0.185
Garden	0.06–0.1	0.1	0.1	NO	NO	NO
Paper	0.05–0.07	0.06	0.06	0.05–0.07	0.06	0.06
Wood and straw	0.02–0.04	0.03	0.03	0.02–0.04	0.03	0.03
Textiles	0.05–0.07	0.06	0.06	0.05–0.07	0.06	0.06
Nappies	0.06-0.1	0.1	IE	0.06-0.1	0.1	NO
Rubber	IE	IE	IE	0.02–0.04	0.03	0.03

No data on shares of nappies, rubber and leather in municipal solid waste are available - reported under “textile” category.

Table 7.4. Factors F, OX and delay time assumed for calculations

Factor	Municipal Waste		Industrial Waste	
	Default	Value	Default	Value
Delay time (months)	6	6	6	6
Fraction of methane in developed gas (F)	0.5	0.5	0.5	0.5
Oxidation factor (OX)	0	0-0.1*	0	0

* since 2001 managed SWDSs fulfill requirements of [IPCC (2006)] to be treated as “well-managed” SWDSs for which the 0.1 value of oxidation factor is default

Fraction of degradable organic carbon in bulk waste (DOC) was calculated with application of default IPCC 2006 method and country specific data on waste composition.

Sewage sludge

Emission from sewage sludge was estimated on the basis of [IPCC (2006)] methodology, using IPCC Waste Model. Emission factors are default [IPCC (2006)] (table 7.6). Other parameters were assumed as for municipal solid waste landfilled in managed waste disposal sites.

Table 7.6. Sewage sludge emission factors

DOC	Reaction constant (k)
0.05	0.185

Climatic zone

Party is applying IPCC 2006 values of methane generation rate (k) and half-life ($t_{1/2}$) default for cold temperate wet climatic zone, according to IPCC Good Practice Guidance for LULUCF, Chapter 3 (IPCC 2003).

7.2.2.2 Activity data

Activity data applied in IPCC Waste Model to estimate emissions of CH₄ from solid waste disposal are calculated on basis of following data:

- **generated MSW** – data for the years 1950-2004 were extrapolated according to amount of collected MSW, since 2005 – data published in [GUS (2006-2022d)] (table 7.7);
- **collected MSW** – data for the years 1970-2021 were taken from National Statistics, data for the years 1950-1970 were extrapolated according to amount of landfilled MSW. Data for 1971-1973 and 1976 were interpolated (table 7.7);
- **landfilled MSW** – data for the years 1970-2005 were taken from National Statistics, data for the years 1950-1970 was extrapolated according to data on average monthly salary per capita published in National Statistics (table 7.7), data for years 2006-2021 were taken from facility reports from Central Waste Management System and KOBIZE Waste Database;
- **managed SWDS** – data provided by Waste Management Department of Ministry of the Environment – MSW deposited on landfills fulfilling requirements of Landfill Directive 1999/31/EC (table 7.8);
- **landfilled sewage sludge** – data for the years 1995-2010 were published in [GUS (1996d-2011d)], data for years 2011-2021 were taken from facility reports from Central Waste Management System and KOBIZE Waste Database (table 7.10);
- **landfilled ISW** – data for the years 1975-2005 were published in [GUS (1976d-2006d)] (table 7.12), data for years 1950-1974 were extrapolated separately for each component on basis of oldest trend tendencies, data for years 2006-2021 were taken from facility reports from Central Waste Management System and KOBIZE Waste Database;
- **composition of landfilled MSW** – data calculated on basis of facility reports from Central Waste System and Waste Database for years 2006-2021, Rosik-Dulewska Cz. (2000) for year 1985 and extrapolated for periods 1950-1984 and 1986-2005 (table 7.9);
- **composition of landfilled ISW** – data for years 1975-1985 calculated on basis of data on landfilled waste from industries published in [GUS (1976d-1986d)], facility reports from Central Waste Management System and KOBIZE Waste Database for years 2006-2021, and extrapolated for 1950-1974 and 1986-2005 periods (table 7.13);
- **methane recovery** – calculated on basis of data on amounts of recovered landfill gas published in [GUS OZE (2001-2022)] (table 7.11).

Municipal Waste

Table 7.7. Generated, collected and landfilled municipal solid waste

Years	Generated MSW [kt]	Data source	Collected MSW [kt]	Data source	Landfilled MSW [kt]	Data source
1950	3 403.63	extrapolation	1 151.67	extrapolation	973.50	extrapolation
1955	4 211.05	extrapolation	1 959.10	extrapolation	1 780.92	extrapolation
1960	5 186.37	extrapolation	2 934.42	extrapolation	2 756.18	extrapolation
1965	5 728.46	extrapolation	3 476.51	extrapolation	3 298.59	extrapolation
1970	6 365.93	extrapolation	4 113.98	GUS (1987d)	3 949.42	GUS (1987d)
1975	9 040.92	extrapolation	6 788.96	GUS (1986d)	6 517.41	GUS (1986d)
1980	12 120.67	extrapolation	9 868.72	GUS (1986d)	9 861.54	GUS (1986d)
1985	13 338.90	extrapolation	11 086.95	GUS (1986d)	11 075.86	GUS (1986d)
1988	14 336.13	extrapolation	12 084.18	GUS (1989d)	12 072.09	GUS (1989d)

Years	Generated MSW [kt]	Data source	Collected MSW [kt]	Data source	Landfilled MSW [kt]	Data source
1989	14 252.90	extrapolation	12 000.95	GUS (1990d)	11 988.95	GUS (1990d)
1990	13 350.23	extrapolation	11 098.28	GUS (1996d)	11 087.18	GUS (1996d)
1991	12 889.93	extrapolation	10 637.98	GUS (1996d)	10 627.34	GUS (1996d)
1992	12 872.95	extrapolation	10 621.00	GUS (1996d)	10 610.38	GUS (1996d)
1993	12 896.61	extrapolation	10 644.66	GUS (1996d)	10 551.85	GUS (1996d)
1994	13 266.59	extrapolation	11 014.64	GUS (1996d)	10 899.98	GUS (1996d)
1995	13 236.95	extrapolation	10 985.00	GUS (2005d)	10 783.84	GUS (2005d)
1996	13 873.17	extrapolation	11 621.22	GUS (1997d)	11 402.00	GUS (1997d)
1997	14 435.40	extrapolation	12 183.44	GUS (1998d)	11 964.00	GUS (1998d)
1998	14 527.72	extrapolation	12 275.77	GUS (1999d)	11 988.00	GUS (1999d)
1999	14 568.85	extrapolation	12 316.90	GUS (2000d)	12 035.00	GUS (2000d)
2000	14 477.95	extrapolation	12 226.00	GUS (2005d)	11 888.04	GUS (2005d)
2001	13 360.95	extrapolation	11 109.00	GUS (2005d)	10 637.57	GUS (2005d)
2002	12 760.65	extrapolation	10 508.70	GUS (2005d)	10 161.93	GUS (2005d)
2003	12 176.56	extrapolation	9 924.61	GUS (2005d)	9 609.10	GUS (2005d)
2004	12 011.26	extrapolation	9 759.31	GUS (2005d)	9 193.60	GUS (2005d)
2005	12 169.00	GUS (2012d)	9 352.12	GUS (2006d)	8 623.10	GUS (2006d)
2006	12 235.00	GUS (2009d)	9 876.59	GUS (2007d)	7989.42	CSO
2007	12 264.00	GUS (2010d)	10 082.58	GUS (2011d)	7815.95	CSO
2008	12 194.00	GUS (2011d)	10 036.41	GUS (2011d)	7881.77	CSO
2009	12 053.00	GUS (2012d)	10 053.50	GUS (2012d)	7274.77	CSO
2010	12 038.00	GUS (2012d)	10 040.11	GUS (2012d)	7184.30	CSO
2011	12 128.80	GUS (2012d)	9 827.64	GUS (2012d)	5742.69	CSO
2012	12 085.00	GUS (2013d)	9 580.87	GUS (2013d)	5207.30	CSO
2013	11 295.00	GUS (2014d)	9 473.83	GUS (2014d)	3833.25	CSO
2014	10 330.40	GUS (2015d)	10 330.40	GUS (2015d)	3621.65	CSO
2015	10 863.50	GUS (2016d)	10 863.50	GUS (2016d)	3123.29	CSO
2016	11 654.00	GUS (2017d)	11 654.00	GUS (2017d)	2983.47	CSO
2017	11969.00	GUS (2018d)	11969.00	GUS (2018d)	2843.65	CSO
2018	12485.42	GUS (2019d)	12485.42	GUS (2019d)	2703.83	CSO
2019	12752.78	GUS (2020d)	12752.78	GUS (2020d)	2564.01	BDO
2020	13116.90	GUS (2021d)	13116.90	GUS (2021d)	2381.48	BDO
2021	13674.58	GUS (2022d)	13674.58	GUS (2022d)	2647.88	BDO

Data on landfilled municipal solid waste for the years 1950-1970 was extrapolated according to data on average monthly salary per capita published in national statistics [GUS W (2016)]. Correlation of those factors is acknowledged by researches and described in papers, eg. Gellynck (2011).

Shares of managed and unmanaged SWDSs for years 1970-2001 was calculated in accordance to elaboration [Gworek (2003)]. Since 2001, Poland was implementing the Landfill Directive (1999/31/EC), and gathering data on amounts of SDWSs which are fulfilling its requirements and are considered to be managed solid waste disposal sites. For years 2003-2011, it was provided for inventory purposes by Waste Management Department of Ministry of Environment (table 7.8). Since 2012 all solid waste disposal sites in Poland fulfill requirements of the Directive.

Table 7.8. Amount and share of waste landfilled on managed SWDS

Year	Landfilled MSW [kt]	MSW landfilled on managed SWDS [kt]	Share of managed SDWS
2001	data unavailable	data unavailable	20%*
2002	data unavailable	data unavailable	26%*
2003	10 753.0	3 414.0	32%
2004	9 029.3	5 207.5	58%
2005	8 623.1	5 210.0	60%

Year	Landfilled MSW [kt]	MSW landfilled on managed SDWS [kt]	Share of managed SDWS
2006	7 824.4	5 903.3	75%
2007	9 227.8	7 411.4	80%
2008	8 947.2	7 584.8	85%
2009	8 543.6	7 379.9	86%
2010	8 577.6	7 885.3	92%
2011	7 649.8	6 979.1	91%

* interpolated values

Composition of municipal waste was calculated on the basis of publication [Rosik-Dulewska Cz. (2000)] and on the basis of publication by [Rzeczyński B. (1996)]. From the first publication composition of waste in 1985 was taken. From the second publication, information on change in composition of metals and plastics during 20 years was taken (11.8% decrease from 1992 to 1972), and interpolation for the years until 2005 was made (table 7.10). Data for 2006-2021 are based on facility reports from Central Waste Management System (CSO) and KOBIZE Waste Database (BDO).

The data on recovered methane are plant specific, based on responses to questionnaires of Statistics Poland on energy combustion. Recovered gas is combusted for energy purposes or flared (no data on amounts available).

Table 7.9. Composition of municipal solid waste

Year	Food	Garden	Paper	Wood	Textile	Plastics, and other inert
1950	19.03%	4.52%	15.32%	6.12%	3.32%	51.67%
1955	19.03%	4.52%	15.32%	6.12%	3.32%	51.67%
1960	19.03%	4.52%	15.32%	6.12%	3.32%	51.67%
1965	19.03%	4.52%	15.32%	6.12%	3.32%	51.67%
1970	19.03%	4.52%	15.32%	6.12%	3.32%	51.67%
1975	21.51%	4.23%	15.03%	5.83%	3.03%	50.36%
1980	25.71%	3.73%	14.53%	5.33%	2.53%	48.18%
1985	30.00%	3.20%	14.00%	4.80%	2.00%	46.00%
1988	25.75%	2.84%	12.00%	4.12%	1.72%	53.57%
1989	24.33%	2.73%	11.34%	3.89%	1.62%	56.10%
1990	22.91%	2.61%	10.67%	3.66%	1.53%	58.62%
1991	21.49%	2.49%	10.01%	3.43%	1.43%	61.15%
1992	20.08%	2.37%	9.34%	3.20%	1.34%	63.67%
1993	18.66%	2.25%	8.68%	2.97%	1.24%	66.20%
1994	17.24%	2.13%	8.01%	2.75%	1.15%	68.72%
1995	15.82%	2.01%	7.35%	2.52%	1.06%	71.24%
1996	14.41%	1.89%	6.68%	2.29%	0.96%	73.77%
1997	12.99%	1.78%	6.01%	2.06%	0.87%	76.29%
1998	11.57%	1.66%	5.35%	1.83%	0.77%	78.82%
1999	10.15%	1.54%	4.68%	1.60%	0.68%	81.34%
2000	8.74%	1.42%	4.02%	1.38%	0.58%	83.87%
2001	7.32%	1.30%	3.35%	1.15%	0.49%	86.39%
2002	5.90%	1.18%	2.69%	0.92%	0.40%	88.92%
2003	4.48%	1.06%	2.02%	0.69%	0.30%	91.44%
2004	3.07%	0.94%	1.36%	0.46%	0.21%	93.96%
2005	1.65%	0.83%	0.69%	0.23%	0.11%	96.49%
2006	0.23%	0.71%	0.03%	0.01%	0.02%	99.01%
2007	0.22%	0.73%	0.02%	0.01%	0.02%	99.00%
2008	0.19%	1.03%	0.01%	0.00%	0.01%	98.75%
2009	0.12%	1.27%	0.01%	0.00%	0.01%	98.59%
2010	0.11%	1.41%	0.00%	0.00%	0.00%	98.47%
2011	0.11%	1.80%	0.00%	0.00%	0.00%	98.08%
2012	0.08%	2.05%	0.00%	0.00%	0.00%	97.86%
2013	0.10%	2.63%	0.00%	0.00%	0.00%	97.27%
2014	0.07%	2.82%	0.00%	0.00%	0.00%	97.11%
2015	0.09%	3.47%	0.00%	0.00%	0.00%	96.44%

Year	Food	Garden	Paper	Wood	Textile	Plastics, and other inert
2016	0.08%	3.15%	0.00%	0.00%	0.01%	96.77%
2017	0.05%	3.39%	0.00%	0.00%	0.01%	96.55%
2018	0.04%	3.87%	0.00%	0.00%	0.01%	96.08%
2019	0.00%	3.51%	0.00%	0.00%	0.02%	96.47%
2020	0.03%	4.62%	0.00%	0.00%	0.01%	95.34%
2021	0.03%	3.96%	0.00%	0.00%	0.24%	95.77%

Composition of municipal solid waste is used in IPCC Waste Model to calculate weight of each fraction of waste deposited at SWDSs, and amounts of CH₄ generated by each fraction.

Sewage sludge

The data on amounts of landfilled sewage sludge for the years 1998-2010 was taken from Statistics Poland *Environment* annuals, data for years 2011-2021 were taken from facility reports from Central Waste Management System and KOBIZE Waste Database, and data for the years 1950-1997 were extrapolated with application of linear regression in correlation with trend of landfilled MSW.

Table 7.10. Sewage sludge activity data (dry basis)

Year	Amount of sewage sludge disposed on landfills [kt]			Data source
	Municipal - Managed	Municipal - Unmanaged	Industrial	
1950	14.04	86.27	267.74	extrapolation
1955	26.21	161.01	499.72	extrapolation
1960	38.10	234.03	726.34	extrapolation
1965	45.34	278.53	864.46	extrapolation
1970	58.91	361.89	1123.19	extrapolation
1975	84.77	520.75	1616.25	extrapolation
1980	129.04	792.66	2460.15	extrapolation
1985	121.04	743.50	2307.59	extrapolation
1988	138.96	853.60	2649.30	extrapolation
1989	134.36	825.38	2561.71	extrapolation
1990	135.90	834.79	2590.90	extrapolation
1991	120.73	741.61	2301.71	extrapolation
1992	105.29	646.77	2007.37	extrapolation
1993	89.38	549.05	1704.05	extrapolation
1994	96.01	589.76	1830.42	extrapolation
1995	90.57	556.37	1726.77	extrapolation
1996	88.93	546.28	1695.46	extrapolation
1997	91.51	562.15	1744.71	extrapolation
1998	89.42	549.27	1704.75	GUS (1999d)
1999	95.40	586.04	2057.99	GUS (2000d)
2000	94.05	577.72	1490.23	interpolation
2001	131.87	530.23	922.47	GUS (2005d)
2002	165.75	475.87	923.30	GUS (2005d)
2003	174.52	375.15	960.67	GUS (2005d)
2004	312.84	229.59	968.70	GUS (2005d)
2005	303.50	198.83	828.11	GUS (2006d)
2006	369.84	120.36	780.74	CSO
2007	333.41	81.71	575.40	CSO
2008	258.87	46.50	390.33	CSO
2009	235.02	37.06	332.58	CSO
2010	180.54	15.85	356.53	CSO
2011	183.57	17.64	384.09	CSO
2012	197.12	NO	404.43	CSO
2013	129.94	NO	339.18	CSO
2014	151.84	NO	383.17	CSO
2015	167.75	NO	356.71	CSO
2016	138.38	NO	345.08	CSO

Year	Amount of sewage sludge disposed on landfills [kt]			Data source
	Municipal - Managed	Municipal - Unmanaged	Industrial	
2017	97.01	NO	428.60	CSO
2018	101.68	NO	378.15	CSO
2019	93.81	NO	380.79	BDO
2020	93.72	NO	377.19	BDO
2021	93.72	NO	384.76	BDO

Methane recovery

Data on amounts of recovered landfill gas are published in elaboration *Energy from renewable sources* [GUS OZE (2001-2022)]. Amount of recovered methane is calculated with application of [IPCC (2006)] default net calorific value (50.4 MJ/m³).

Table 7.11. Methane recovery data

Year	Recovered landfill gas [TJ]	Data source	Recovered methane [kt]
2000	423.00	GUS OZE (2001)	4.62
2001	544.00	GUS OZE (2002)	5.94
2002	628.00	GUS OZE (2003)	6.85
2003	704.00	GUS OZE (2004)	7.68
2004	636.00	GUS OZE (2005)	6.94
2005	649.10	GUS OZE (2006)	7.08
2006	791.32	GUS OZE (2007)	8.64
2007	879.00	GUS OZE (2008)	9.59
2008	1 432.00	GUS OZE (2009)	15.63
2009	1 487.00	GUS OZE (2010)	16.23
2010	1 811.00	GUS OZE (2011)	19.76
2011	2 323.00	GUS OZE (2012)	25.35
2012	2 249.00	GUS OZE (2013)	24.54
2013	2 157.00	GUS OZE (2014)	23.54
2014	2 051.00	GUS OZE (2015)	22.38
2015	2 125.00	GUS OZE (2016)	23.19
2016	2 412.00	GUS OZE (2017)	26.32
2017	2 010.61	GUS OZE (2018)	21.94
2018	1 626.64	GUS OZE (2019)	32.27
2019	1 756.00	GUS OZE (2020)	34.84
2020	2 078.51	GUS OZE (2021)	41.24
2021	1 992.00	GUS OZE (2022)	39.52

Industrial Waste

Activity data on landfilled industrial waste for the years 1975-2005 were taken from Statistics Poland (GUS) *Environment* annuals, and data for years 2006-2021 were taken from facility reports from Central Waste Management System (CSO) and KOBIZE Waste Database (BDO). Data for the years 1950-1974 were calculated on basis of correlation with historical data published by GUS.

Table 7.12. Landfilled industrial waste

Years	Landfilled industrial waste [kt]	Data source
1950	6245.75	extrapolation
1955	9494.29	extrapolation
1960	12748.19	extrapolation
1965	18004.65	extrapolation
1970	23140.50	extrapolation
1975	30589.32	GUS (1976d)
1980	37687.30	GUS (1981d)

Years	Landfilled industrial waste [kt]	Data source
1985	37239.94	GUS (1986d)
1988	36538.27	GUS (1989d)
1989	36505.88	GUS (1990d)
1990	36356.70	GUS (1996d)
1991	32794.89	GUS (1996d)
1992	29523.23	GUS (1996d)
1993	28114.55	GUS (1996d)
1994	29491.88	GUS (1996d)
1995	26887.83	GUS (2005d)
1996	28962.04	GUS (1997d)
1997	42299.09	GUS (1998d)
1998	34101.75	GUS (1999d)
1999	25682.11	GUS (2000d)
2000	20856.47	GUS (2005d)
2001	19584.23	GUS (2005d)
2002	16128.60	GUS (2005d)
2003	15104.03	GUS (2005d)
2004	16164.60	GUS (2005d)
2005	15884.59	GUS (2006d)
2006	15146.11	CSO
2007	18891.50	CSO
2008	20060.08	CSO
2009	21573.64	CSO
2010	22828.20	CSO
2011	20468.34	CSO
2012	19789.34	CSO
2013	22045.94	CSO
2014	23117.99	CSO
2015	23545.09	CSO
2016	24127.05	CSO
2017	22089.52	CSO
2018	22074.98	CSO
2019	26956.57	BDO
2020	27780.18	BDO
2021	26242.37	BDO

According to IPCC Guidelines [IPCC (2006)] only following types of industrial waste generate CH₄ emission:

- paper and cardboard,
- food,
- wood,
- tobacco,
- textiles and rubber and leather (only synthetic).

Data on composition of landfilled industrial waste for the years 1975-1985 are calculated on basis of data on landfilled waste from industries published in [GUS (1976d-1986d)], facility reports from Central Waste Management System and KOBIZE Waste Database for years 2006-2021, and extrapolated for 1950-1974 and 1986-2005 periods. Waste from manufacturing of furniture is not included in the inventory due to lack of information on content of wood, plastic, metal and other materials in disposed furniture. On the basis of waste amount from each industry sector the composition of waste was calculated.

Table 7.13. Composition of industrial waste

Year	Food	Paper	Wood	Textile	Rubber	Plastics, other inert
1950	9.76%	1.15%	0.78%	0.49%	0.24%	87.57%
1955	9.13%	0.96%	0.73%	0.37%	0.39%	88.43%
1960	9.40%	0.92%	0.49%	0.35%	0.49%	88.35%
1965	8.81%	0.81%	0.35%	0.29%	0.50%	89.23%
1970	8.07%	0.76%	0.29%	0.26%	0.57%	90.05%
1975	8.73%	0.74%	0.25%	0.22%	0.63%	89.43%
1980	9.89%	0.53%	0.23%	0.25%	0.51%	88.59%
1985	9.36%	0.79%	0.17%	0.22%	0.49%	88.98%
1988	8.03%	0.68%	0.14%	0.20%	0.42%	90.53%
1989	7.58%	0.64%	0.13%	0.20%	0.40%	91.05%
1990	7.14%	0.61%	0.13%	0.19%	0.37%	91.56%
1991	6.69%	0.57%	0.12%	0.19%	0.35%	92.08%
1992	6.25%	0.53%	0.11%	0.18%	0.33%	92.60%
1993	5.81%	0.49%	0.10%	0.18%	0.31%	93.11%
1994	5.36%	0.45%	0.10%	0.17%	0.28%	93.63%
1995	4.92%	0.42%	0.09%	0.17%	0.26%	94.15%
1996	4.48%	0.38%	0.08%	0.16%	0.24%	94.66%
1997	4.03%	0.34%	0.07%	0.16%	0.22%	95.18%
1998	3.59%	0.30%	0.07%	0.15%	0.19%	95.70%
1999	3.15%	0.27%	0.06%	0.15%	0.17%	96.21%
2000	2.70%	0.23%	0.05%	0.14%	0.15%	96.73%
2001	2.26%	0.19%	0.04%	0.13%	0.13%	97.25%
2002	1.81%	0.15%	0.04%	0.13%	0.10%	97.76%
2003	1.37%	0.11%	0.03%	0.12%	0.08%	98.28%
2004	0.93%	0.08%	0.02%	0.12%	0.06%	98.80%
2005	0.48%	0.04%	0.01%	0.11%	0.04%	99.31%
2006	0.04%	0.00%	0.00%	0.11%	0.01%	99.83%
2007	0.03%	0.00%	0.01%	0.10%	0.00%	99.86%
2008	0.04%	0.00%	0.01%	0.11%	0.00%	99.83%
2009	0.03%	0.00%	0.00%	0.05%	0.00%	99.92%
2010	0.03%	0.00%	0.00%	0.07%	0.00%	99.90%
2011	0.03%	0.00%	0.00%	0.05%	0.01%	99.91%
2012	0.03%	0.00%	0.00%	0.04%	0.00%	99.93%
2013	0.02%	0.00%	0.00%	0.02%	0.00%	99.96%
2014	0.02%	0.00%	0.00%	0.05%	0.01%	99.92%
2015	0.02%	0.00%	0.00%	0.04%	0.00%	99.94%
2016	0.02%	0.00%	0.00%	0.06%	0.00%	99.92%
2017	0.01%	0.00%	0.00%	0.09%	0.01%	99.88%
2018	0.00%	0.00%	0.00%	0.10%	0.01%	99.89%
2019	0.02%	0.00%	0.00%	0.14%	0.01%	99.84%
2020	0.00%	0.00%	0.00%	0.13%	0.02%	99.86%
2021	0.00%	0.00%	0.00%	0.13%	0.02%	99.86%

For years 1977 and 1978 no data on amount of industrial waste from separate industries are available, for this reason aggregated data on waste amount from resorts are used: in textile resort there were data for textiles and leather products, in forests and wood resort there were data on wood and on pulp and paper. Disaggregation of these data was made on the basis of adequate data from years 1976 and 1979. Also the percentages of food waste in a food resort were taken from 1976 and 1979.

7.2.2.3 Unmanaged Solid Waste Disposal Sites

Emission factors and activity data applied to estimate emissions from unmanaged SWDSs are described in the NIR in chapters 7.2.2.1 and 7.2.2.2. Since 2012 all solid waste disposal sites in Poland fulfill requirements of the Landfill Directive 1999/31/EC and are considered to be managed. Therefore Party

still estimates emissions from waste landfilled in unmanaged SWDSs before 2012. This is more restrictive approach that could lead to overestimation of the emissions, but also the best available. Basing on data on area of closed landfills and assumption, that all active unmanaged SWDSs became managed in 2012, amounts of additional waste on managed SWDSs since 2012 were calculated.

7.2.2.4 Uncategorized Solid Waste Disposal Sites

Emission factors and activity data applied to estimate emissions from uncategorized SWDSs are described in the NIR in chapters 7.2.2.1. Amount of municipal solid waste landfilled in Uncategorized SWDSs is calculated by subtracting amount of collected MSW from amount of generated MSW (fig. 7.4).

In Poland, disposal of waste outside Waste Management System (in Uncategorized Solid Waste Disposal Sites) is strictly prohibited by law and it is assumed that since 2014 no new waste is being landfilled in Uncategorized SWDSs. Still no data on treatment of waste disposed illegally before 2014 are available, therefore assumption that methane emissions from this source stopped is unjustifiable. For this reason emission of methane from waste landfilled before 2014 in Uncategorized Waste Disposal Sites is still estimated.

7.2.3. Uncertainties and time-series consistency

Uncertainty analysis for the revised year 2021 for IPCC sector 5. *Waste* was estimated with use of approach 1 described in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Simplified approach was based on the assumptions that every value is independent and probability distribution is symmetric. Results of the sectoral uncertainty analysis are given below. More details on uncertainty assessment of whole inventory are given in annex 8.

Recalculation of data for years 1988-2020 ensured consistency for whole time-series.

2021	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ Emission uncertainty [%]	CH ₄ Emission uncertainty [%]	N ₂ O Emission uncertainty [%]
5. Waste	274.56	128.04	3.08	33.5%	58.8%	129.2%
A. Solid waste disposal		46.55			82.6%	
B. Biological treatment of solid waste		7.55	0.45		104.4%	153.0%
C. Incineration and open burning of waste	274.56	0.00	0.02	33.5%	0.0%	150.7%
D. Wastewater treatment and discharge		73.95	2.60		86.8%	150.3%

7.2.4. Source-specific QA/QC and verification

Activity data concerning solid waste disposals and sewage sludge come from Statistics Poland (GUS). GUS is responsible for QA/QC of collected and published data. In some cases of solid waste comparison is made between national statistical data and National Waste Management Plan. Activity data on waste incineration is based on external expert's research involving questionnaires from individual entities. Country specific emission factors involved in estimation of GHG emissions from waste water treatment are based on external expert's analysis of questionnaires from individual entities.

The attempt has been undertaken to ensure internal consistency between different treatment pathways of waste and sewage sludge. Calculations in waste sector were examined with focus on formulas, units and trends consistency. Generally QC procedures follow QA/QC plan presented in Annex 7.

7.2.5. Source-specific recalculations

Recalculations details:

- new sources of data on landfilled MSW and ISW since 2006 – Central Waste Management System (CSO, 2006-2018) and KOBIZE Waste Database (BDO, 2019-2021);
- new source of data on landfilled sewage sludge since 2011 – Central Waste Management System (CSO, 2011-2018) and KOBIZE Waste Database (BDO, 2019-2021);
- new sources of data on morphology of landfilled MSW and ISW since 2006 – Central Waste Management System (CSO, 2006-2018) and KOBIZE Waste Database (BDO, 2019-2021);
- new data on amounts and on morphology of landfilled ISW for years 1975-2005 from Statistics Poland (GUS).

Table 7.14. Change in methane emissions in result of recalculations in sector 5.A

Change	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
kt CH ₄	-42.47	-40.98	-40.95	-42.80	-49.94	-55.79	-64.09	-71.75	-80.57	-91.69	-98.52
%	-8%	-7%	-7%	-8%	-9%	-10%	-12%	-13%	-15%	-18%	-19%

Change	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
kt CH ₄	-112.36	-132.08	-149.46	-162.89	-176.59	-192.58	-209.89	-227.38	-246.37	-264.02	-277.12
%	-22%	-26%	-30%	-33%	-37%	-41%	-45%	-49%	-54%	-59%	-63%

Change	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
kt CH ₄	-284.77	-290.38	-299.90	-301.24	-299.12	-289.39	-279.85	-268.10	-260.63	-255.39	-252.33
%	-66%	-71%	-74%	-76%	-77%	-78%	-81%	-80%	-79%	-81%	-84%

7.2.6. Source-specific planned improvements

No improvements are planned for the next submission.

7.3. Biological Treatment of Solid Waste (CRF sector 5.B)

7.3.1. Source category description

In the following section estimation of emissions of methane and N₂O from composting facilities is provided. Estimates of methane emissions from anaerobic digestion facilities are reported under category 1A, as analysis of facility data from Central Waste Management System (CSO), KOBIZE Waste Database (BDO) and National Support Centre for Agriculture (KOWR) confirmed that all methane is recovered for energy generation. Emissions of N₂O from anaerobic digestion are negligible according to IPCC 2006 GLs.

The 5.B subcategory share in total waste sector is 7.1%.

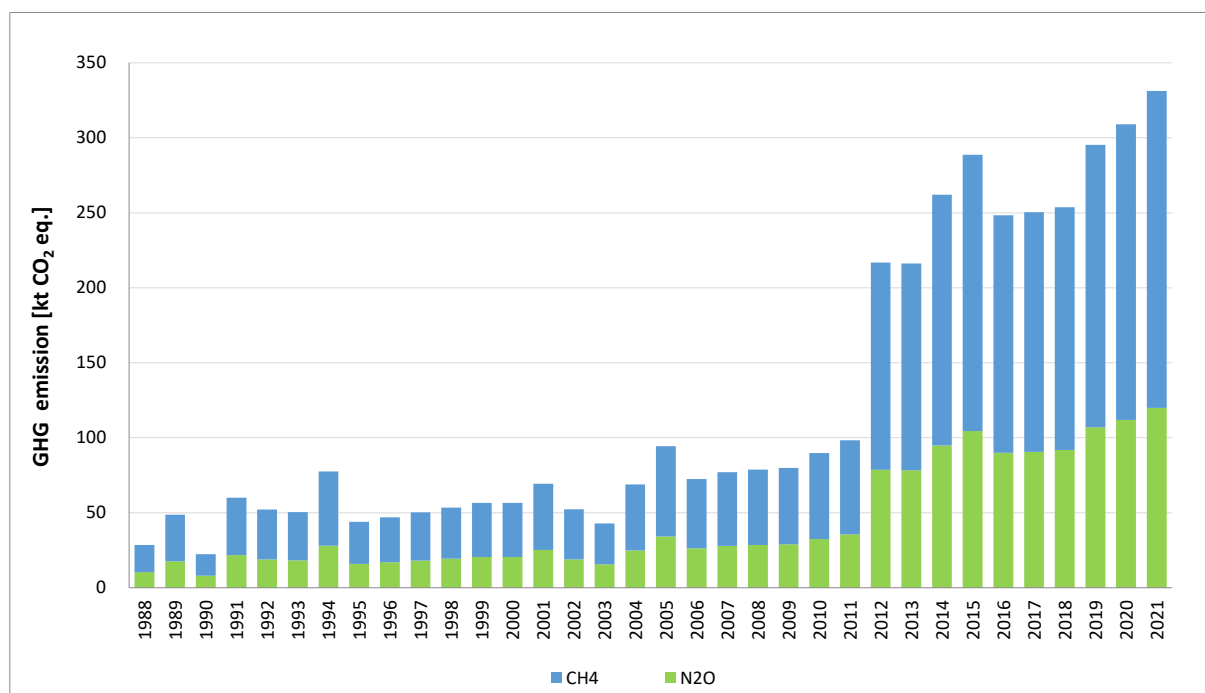


Figure 7.6. GHG emission from 5.B subsector

Increase of amounts of estimated GHG emissions in 2012 is result of increase of amount of operating composting facilities. Increase of the amount of waste composted in 2019 is result of 35% increase of amount of collected biogenic waste, caused by prohibition of biomass household burning, increase of waste treatment awareness, and enhanced monitoring of waste management.

7.3.2. Methodological issues

7.3.2.1 Method and factors applied

Calculations are based on IPCC 2006 Guidelines [IPCC (2006)] methodology, *Tier 1*, choice of which justifies lack of country-specific method of estimation and research.

Default emission factors applied by Party are: 4 g CH₄/kg treated waste and 0.24 g N₂O/kg treated waste (composting, wet weight basis).

7.3.2.2 Activity data

Activity data and its sources are presented in table 7.15. Data on amounts of waste composted in years 1993-2005 are taken from statistical yearbooks, apart from the year 1997 where, due to lack of data, interpolation was applied. For the years 1988-1992 activity data were estimated by extrapolation. Data on amounts of municipal waste composted in years 2006-2021 are taken from analysis of facility data from Central Waste Management System (CSO) and KOBIZE Waste Database (BDO).

Table 7.15. Amounts of composted waste and data sources (wet basis)

Year	Municipal waste [kt]	Data source	Other waste [kt]	Data source
1988	32.0	<i>extrapolation</i>	130.8	GUS (1989d)
1989	39.6	<i>extrapolation</i>	238.0	GUS (1990d)
1990	48.9	<i>extrapolation</i>	78.1	GUS (1996d)
1991	60.5	<i>extrapolation</i>	281.4	GUS (1996d)
1992	74.7	<i>extrapolation</i>	222.2	GUS (1996d)
1993	92.4	GUS (1994d)	194.3	GUS (1996d)
1994	114.2	GUS (1997d)	327.2	GUS (1996d)
1995	200.6	GUS (1997d)	49.6	GUS (2005d)
1996	218.6	GUS (1998d)	48.8	GUS (1997d)
1997	220.2	<i>interpolation</i>	65.7	<i>interpolation</i>
1998	221.7	GUS (2002d)	82.6	GUS (2002d)
1999	225.2	GUS (2003d)	96.8	GUS (2003d)
2000	248.3	GUS (2003d)	73.7	GUS (2003d)
2001	309.0	GUS (2004d)	86.1	GUS (2004d)
2002	214.8	GUS (2004d)	82.8	GUS (2004d)
2003	128.9	GUS (2004d)	115.3	GUS (2004d)
2004	234.1	GUS (2007d)	158.1	GUS (2007d)
2005	317.9	GUS (2007d)	219.6	GUS (2007d)
2006	289.4	CSO	123.4	CSO
2007	283.0	CSO	156.1	CSO
2008	214.0	CSO	234.3	CSO
2009	224.8	CSO	229.9	CSO
2010	274.4	CSO	236.7	CSO
2011	297.4	CSO	263.0	CSO
2012	451.9	CSO	783.4	CSO
2013	736.3	CSO	495.4	CSO
2014	1017.5	CSO	475.0	CSO
2015	1112.5	CSO	531.4	CSO
2016	975.1	CSO	439.2	CSO
2017	950.5	CSO	475.2	CSO
2018	1059.8	CSO	385.5	CSO
2019	1025.4	BDO	656.7	BDO
2020	1127.9	BDO	632.1	BDO
2021	1128.7	BDO	757.9	BDO

7.3.3. Uncertainties and time-series consistency

See chapter 7.2.3.

7.3.4. Source-specific QA/QC and verification

See chapter 7.2.4.

7.3.5. Source-specific recalculations

Recalculations details:

- new source of activity data since 2006;
- change of IPCC 2006 EF from dry to wet basis.

Table 7.16. Change in GHG emissions in result of recalculations in sector 5.B

Change	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
kt CO ₂ eq.	-	-	-	-	-	-	-	-	-	-	-
%	-	-	-	-	-	-	-	-	-	-	-

Change	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
kt CO ₂ eq.	-	-	-	-	-	-	-	-10.78	-10.30	-6.55	-37.47
%	-	-	-	-	-	-	-	-13%	-12%	-8%	-31%

Change	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
kt CO ₂ eq.	-44.31	12.42	27.97	-23.08	32.67	-31.37	-93.26	79.69	41.89	75.73	20.23
%	-32%	15%	15%	-10%	14%	-10%	-27%	48%	20%	35%	7%

7.3.6. Source-specific planned improvements

No improvements are planned.

7.4. Incineration and Open Burning of Waste (CRF sector 5.C)

7.4.1. Source category description

The 5.C subcategory share in total waste sector is 6.0% and it involves CO₂ and N₂O emissions from incineration of industrial (including hazardous) and medical waste. According to IPCC Guidelines biogenic emission of CO₂ (33.13 kt in 2021) is not included in total emission.

Estimates of GHG emissions from municipal waste and sewage sludge incineration are reported under category 1A, as analysis of facility data from Central Waste Management System (CSO) and KOBIZE Waste Database (BDO) confirmed that those facilities incinerate waste for energy purposes treated as a fuel. Information on used EFs is included in NIR report under the Annex 2.

Polish law strictly prohibits open burning of waste. Therefore no data on open burning are present in national statistics and no estimation of emissions of GHG from this subsector is calculated.

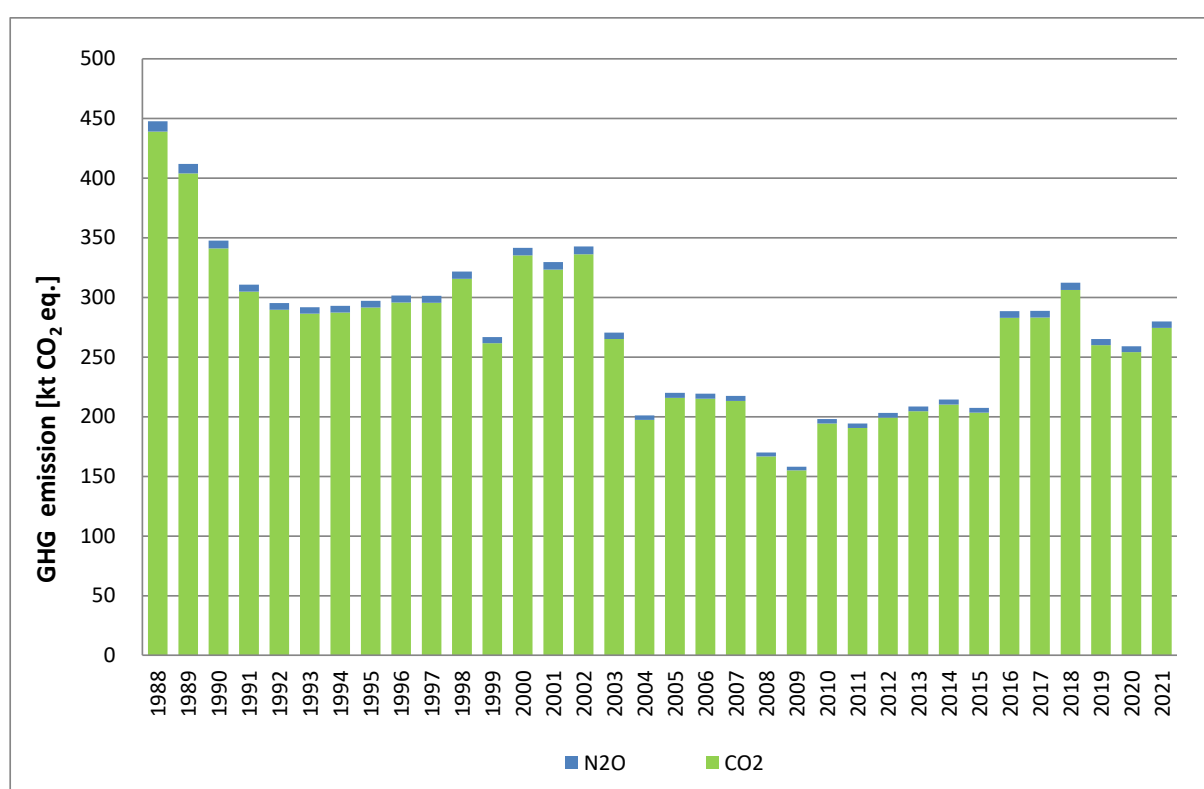


Figure 7.7. GHG emission from 5.C subsector

7.4.2. Methodological issues

7.4.2.1 Method and factors applied

Estimates of emissions of GHG from waste incineration are based on IPCC 2006 Guidelines [IPCC (2006)] *Tier 1* and domestic case study [Wielgosiński G. 2003].

Table 7.17. Emission factors

Incinerated waste	Factor	Data source
Industrial (including hazardous)	dry matter	default IPCC 2006
	fraction of carbon in the dry matter	default IPCC 2006

Incinerated waste	Factor	Data source
	fraction of fossil carbon	default IPCC 2006
	oxidation factor	default IPCC 2006
	N ₂ O emission factor	default IPCC 2006
medical	dry matter	default IPCC 2006
	fraction of carbon in the dry matter	default IPCC 2006
	fraction of fossil carbon	default IPCC 2006
	oxidation factor	default IPCC 2006

Biogenic and non-biogenic content fractions were taken from [IPCC 2000] – industrial and medical waste and are presented in table 7.18.

Table 7.18. Biogenic and non-biogenic content of waste in 2021

Type of waste	Biogenic waste fraction	Non-biogenic waste fraction
industrial (including hazardous)	0.1	0.9
medical	0.6	0.4

7.4.2.2 Activity data

The amounts of incinerated industrial (including hazardous) waste in years 1988-2008 are taken from Statistics Poland *Environment* yearbooks [GUS 2007d] and for years 2009-2021 are taken from analysis of facility data from Central Waste Management System (CSO) and KOBIZE Waste Database (BDO).

The amounts of incinerated medical waste in years 2004-2021 are taken from analysis of facility data from Central Waste Management System (CSO) and KOBIZE Waste Database (BDO), and for years 1988-2004 are extrapolated with correlation to amounts of beds in hospitals and hospitalised citizens taken from Statistics Poland [GUS].

Table 7.19. Activity data in 2021 [kt]

Type of waste	Amount of waste incinerated	Data source
industrial (including hazardous)	204.02	BDO
medical	4.29	BDO

Table 7.21. Composition of incinerated waste [kt]

Year	medical		industrial (including hazardous)	
	nonbiogenic	biogenic	nonbiogenic	biogenic
1988	9.08	13.62	291.68	32.41
1989	8.87	13.30	268.17	29.80
1990	8.67	13.00	225.77	25.09
1991	8.80	13.20	201.40	22.38
1992	8.66	12.99	191.25	21.25
1993	8.40	12.60	189.08	21.01
1994	8.52	12.78	189.72	21.08
1995	8.56	12.85	192.50	21.39
1996	8.42	12.63	195.46	21.72
1997	8.38	12.56	195.34	21.70
1998	8.20	12.30	208.89	23.21
1999	8.14	12.21	172.62	19.18
2000	7.82	11.73	222.21	24.69
2001	8.01	12.01	214.11	23.79
2002	6.86	10.28	223.29	24.81
2003	2.86	4.29	177.35	19.71
2004	3.22	4.83	131.40	14.60
2005	2.91	4.36	144.00	16.00

Year	medical		industrial (including hazardous)	
	nonbiogenic	biogenic	nonbiogenic	biogenic
2006	2.80	4.20	143.60	15.96
2007	2.69	4.03	142.38	15.82
2008	2.63	3.95	111.10	12.34
2009	2.36	3.54	103.34	11.48
2010	1.97	2.96	129.96	14.44
2011	2.47	3.70	127.19	14.13
2012	2.81	4.21	132.97	14.77
2013	2.38	3.57	136.65	15.18
2014	2.51	3.77	140.44	15.60
2015	2.14	3.21	136.08	15.12
2016	2.70	4.04	189.26	21.03
2017	2.54	3.80	189.51	21.06
2018	2.31	3.46	205.22	22.80
2019	2.39	3.58	174.00	19.33
2020	2.63	3.95	169.94	18.88
2021	2.86	4.29	183.62	20.40

7.4.3. Uncertainties and time-series consistency

See chapter 7.2.3.

7.4.4. Source-specific QA/QC and verification

See chapter 7.2.4.

7.4.5. Source-specific recalculations

Recalculations details:

- new source activity data on incinerated industrial and medical waste (CSO and BDO);
- submission of municipal waste and sewage sludge incineration in *Energy* sector.

Table 7.22. Change in GHG emissions in result of recalculations in sector 5.C

Change	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
kt CO ₂ eq.	-8.91	-8.71	-9.07	-8.74	-8.40	-8.77	-8.77	-8.50	-8.51	-8.25	-18.14
%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-5%

Change	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
kt CO ₂ eq.	-15.39	64.20	-25.21	-107.38	-307.39	-191.08	-202.01	-203.41	-267.17	-304.89	-306.05
%	-5%	23%	-7%	-24%	-53%	-49%	-48%	-48%	-55%	-64%	-66%

Change	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
kt CO ₂ eq.	-249.09	-275.66	-375.30	-408.38	-370.67	-322.70	-394.88	-404.46	-417.62	-254.47	-403.26
%	-56%	-59%	-65%	-66%	-63%	-61%	-58%	-58%	-57%	-49%	-61%

7.4.6. Source-specific planned improvements

No improvements are planned.

7.5. Waste Water Handling (CRF sector 5.D)

7.5.1. Source category description

The 5.D category share in emission of GHG from waste sector in 2021 is 59.0% and it involves methane emission from industrial wastewater (11.2% share of 5.D), methane emission from domestic wastewater (63.8% share of 5.D) and N₂O emission from human sewage (25.0% share of 5.D).

The emission from sector 5.D decreased ca. 15.8 % since the base year, mostly because of significant development of national wastewater collection and treatment system. The main contributor and driver of emission change in 5.D is the *Domestic Wastewater* subsector (5.D.1) – responsible of ca. 63.8% of emission of CH₄ from sector 5.D in 2021.

Emission of methane from subsector 5.D.2 *Industrial Wastewater* is ca. 11.2% of emission of GHG from sector 5.D in 2021 and it is constantly decreasing due to reduction of wastewater production by industries.

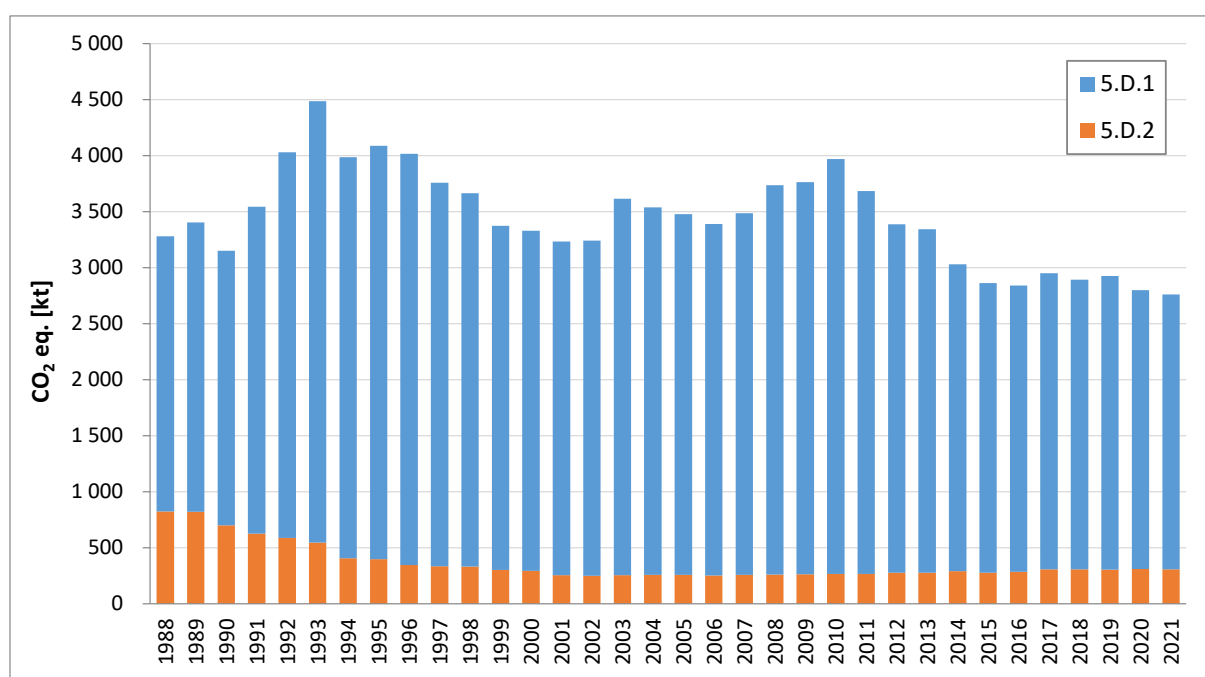


Figure 7.6. GHG emission from 5.D subsector

7.5.2. Methodological issues

7.5.2.1. Domestic Wastewater (CRF sector 5.D.1)

Methane emission

Estimation of CH₄ emissions from sector 5.D.1 *Domestic Wastewater* was based on methodology IPCC 2006 Guidelines [IPCC (2006)], *Tier 2* – which choice is justified by availability of country specific activity data. Amounts of degradable organic components were estimated basing on the data on population of Poland [GUS (2022)], and rural and urban population using different sewage treatment pathways [GUS (2022d)]. Activity data are presented in table 7.23.

Table 7.23. Rural and urban population using given sewage treatment pathways

Year	Urban population shares in treatment pathway				Rural population shares in treatment pathway			
	Well managed WWTP	Not well managed WWTP	Septic tanks	Latrines	Well managed WWTP	Not well managed WWTP	Septic tanks	Latrines
1988	14.3%	30.6%	55.1%	0.0%	0.7%	1.4%	50.6%	47.3%
1989	14.3%	30.7%	54.9%	0.0%	0.7%	1.4%	51.7%	46.2%
1990	14.4%	30.8%	54.9%	0.0%	0.7%	1.4%	53.0%	44.9%
1991	17.7%	38.0%	44.3%	0.0%	0.7%	1.4%	54.3%	43.6%
1992	18.2%	39.0%	42.7%	0.0%	0.7%	1.4%	56.2%	41.7%
1993	19.1%	41.0%	39.9%	0.0%	0.7%	1.4%	57.6%	40.3%
1994	20.0%	42.8%	37.2%	0.0%	0.7%	1.4%	59.0%	38.8%
1995	20.9%	44.8%	34.3%	0.0%	1.0%	2.1%	59.6%	37.3%
1996	21.3%	45.7%	33.0%	0.0%	1.3%	2.8%	60.0%	35.9%
1997	23.1%	49.4%	27.5%	0.0%	1.9%	4.0%	59.7%	34.4%
1998	24.2%	51.8%	24.1%	0.0%	2.3%	4.8%	59.9%	33.0%
1999	25.0%	53.7%	21.3%	0.0%	2.8%	5.9%	59.8%	31.6%
2000	25.4%	54.5%	20.0%	0.0%	3.4%	7.4%	59.1%	30.0%
2001	26.0%	55.7%	18.3%	0.0%	4.0%	8.6%	58.9%	28.5%
2002	26.4%	56.7%	16.8%	0.0%	4.5%	9.6%	59.0%	27.0%
2003	26.8%	57.4%	15.8%	0.0%	5.2%	11.2%	58.1%	25.5%
2004	26.9%	57.6%	15.5%	0.0%	5.9%	12.6%	57.6%	24.0%
2005	32.3%	52.9%	14.8%	0.0%	7.7%	12.7%	57.1%	22.5%
2006	37.9%	48.3%	13.8%	0.0%	9.7%	12.3%	57.0%	21.0%
2007	43.4%	43.2%	13.4%	0.0%	11.9%	11.9%	56.8%	19.5%
2008	48.8%	38.0%	13.1%	0.0%	14.5%	11.3%	56.3%	17.9%
2009	54.9%	33.2%	11.9%	0.0%	16.8%	10.1%	56.6%	16.5%
2010	60.2%	27.8%	12.0%	0.0%	19.5%	9.0%	56.7%	14.8%
2011	65.9%	22.5%	11.6%	0.0%	22.8%	7.8%	56.1%	13.3%
2012	74.0%	17.8%	8.3%	0.0%	26.7%	6.4%	55.0%	11.9%
2013	80.9%	12.4%	6.7%	0.0%	30.6%	4.7%	54.3%	10.4%
2014	87.2%	6.7%	6.1%	0.0%	34.7%	2.7%	53.6%	9.0%
2015	89.9%	4.6%	5.4%	0.0%	37.7%	1.9%	52.8%	7.6%
2016	92.3%	2.5%	5.2%	0.0%	40.1%	1.1%	52.6%	6.2%
2017	92.0%	2.5%	5.5%	0.0%	40.9%	1.1%	53.2%	4.8%
2018	92.1%	2.5%	5.4%	0.0%	41.8%	1.1%	52.5%	4.6%
2019	92.3%	2.5%	5.2%	0.0%	42.8%	1.2%	52.2%	3.8%
2020	92.2%	2.5%	5.3%	0.0%	44.0%	1.2%	52.1%	2.8%
2021	92.1%	2.5%	5.4%	0.0%	45.2%	1.2%	50.8%	2.7%

Default value of organic load in biochemical oxygen demand per person, which is equal to 60 g BOD/person/day [IPCC (2006)], was taken for the calculations.

Methane Correction Factors (MCF) for various treatment pathways are taken from [IPCC (2006)] and domestic study [Bernacka (2005)]. Their values are listed in table 7.24.

Bernacka study on MCF is based on year 2004 data from 334 municipal wastewater treatment facilities, treating 90% of domestic wastewater. Assumption that 5% of treated wastewater is converted to methane is based on results of study on treatment practises which indicated minor appearance of transporting from rotting pits to facilities, use of UASB reactors, preliminary settling tanks, and facility malfunctions.

Application of default IPCC 2006 MCF since 2005 is justified by significant development in domestic wastewater treatment forced by changes in Polish law: National Programme on Municipal Wastewater Treatment from 2003 with 2005 update, Ordinance of Minister of Environment on conditions of

treated wastewater (2004), Environmental Protection Act (2001), Act on on collective water supply and collective sewage disposal (2001).

Table 7.24. MCF values

Treatment pathway	Well managed WWTP	Not well managed WWTP	Septic tanks	Latrines
MCF	0.05/0 (since 2005)	0.3	0.5	0.7
Data source	Bernacka (2005)/IPCC 2006	IPCC 2006	IPCC 2006	IPCC 2006

Methane recovery

Data on amounts of recovered biogas are published in elaboration *Energy from renewable sources* [GUS OZE (2002-2022)]. Amount of recovered methane is calculated with application of [IPCC (2006)] default net calorific value.

Table 7.26. Methane recovery data

Year	Recovered biogas [TJ]	Data source	Recovered methane [kt]
1988	no data	-	-
1989	no data	-	-
1990	393.00	ARE database	7.80
1991	190.00	ARE database	3.77
1992	230.00	ARE database	4.56
1993	62.00	ARE database	1.23
1994	255.00	ARE database	5.06
1995	433.00	ARE database	8.59
1996	587.00	ARE database	11.65
1997	580.00	ARE database	11.51
1998	689.00	ARE database	13.67
1999	732.00	ARE database	14.52
2000	788.00	ARE database	15.63
2001	933.00	GUS OZE (2002)	18.51
2002	725.00	GUS OZE (2003)	14.38
2003	896.00	GUS OZE (2004)	17.78
2004	1 297.00	GUS OZE (2005)	25.73
2005	1 586.00	GUS OZE (2006)	31.47
2006	1 803.00	GUS OZE (2007)	35.77
2007	1 802.00	GUS OZE (2008)	35.75
2008	2 486.00	GUS OZE (2009)	49.33
2009	2 429.00	GUS OZE (2010)	48.19
2010	2 652.00	GUS OZE (2011)	52.62
2011	2 775.00	GUS OZE (2012)	55.06
2012	3 321.00	GUS OZE (2013)	65.89
2013	3 572.00	GUS OZE (2014)	70.87
2014	3 810.00	GUS OZE (2015)	75.60
2015	4 043.00	GUS OZE (2016)	80.22
2016	5 014.00	GUS OZE (2017)	99.48
2017	4 815.60	GUS OZE (2018)	95.55
2018	4 860.81	GUS OZE (2019)	96.44
2019	5 049.00	GUS OZE (2020)	100.18
2020	5 068.69	GUS OZE (2021)	100.57
2021	4 989.30	GUS OZE (2022)	98.99

Organic component removed as sludge

Amounts of organic component removed as sludge are calculated on basis of factor 0.8 kg dry matter/kg BOD supplied by ATV Germany and statistical data on amounts of sewage sludge incinerated, landfilled, applied in agriculture, applied in land reclamation (including reclamation of land for agricultural purposes) and applied in cultivation of plants intended for compost production.

Data for the years 1998-2021 are provided by [GUS (1999-2022d)], with exception of amounts of landfilled sludge in years 2006-2021 taken from facility reports from Central Waste Management System (CSO) and KOBIZE Waste Database (BDO). For the 1988-1997 period amount of removed sludge was calculated with application of extrapolation of last trend change of total amount of removed sludge.

Table 7.27. Removed sludge (dry matter)

Year	Removed sludge [kt]						
	landfilled	Data source	incinerated	applied in agriculture	applied in land reclamation	applied in cultivation of plants intended for compost production	Data source
1988	992.56	extrapolation	-	23.70			extrapolation
1989	959.75	extrapolation	-	34.73			extrapolation
1990	970.69	extrapolation	-	45.77			extrapolation
1991	862.34	extrapolation	-	56.80			extrapolation
1992	752.06	extrapolation	-	67.84			extrapolation
1993	638.43	extrapolation	-	78.87			extrapolation
1994	685.77	extrapolation	-	89.91			extrapolation
1995	646.94	extrapolation	-	100.94			extrapolation
1996	635.21	extrapolation	-	111.98			extrapolation
1997	653.66	extrapolation	-	123.01			extrapolation
1998	638.69	GUS (1999d)	14.39	134.05			GUS (1999d)
1999	681.44	GUS (2000d)	4.89	145.08			GUS (2000d)
2000	671.77	interpolation	5.90	44.75	83.75	25.50	GUS (2001d)
2001	662.10	GUS (2005d)	6.94	49.30	90.90	27.59	GUS (2002d)
2002	641.62	GUS (2005d)	6.80	54.60	97.50	26.50	GUS (2003d)
2003	549.67	GUS (2005d)	6.30	58.40	105.20	19.70	GUS (2004d)
2004	542.43	GUS (2005d)	1.40	66.90	110.70	29.70	GUS (2005d)
2005	502.33	GUS (2006d)	6.20	66.00	120.60	27.40	GUS (2006d)
2006	490.20	CSO	4.50	80.60	109.70	28.10	GUS (2007d)
2007	415.12	CSO	1.70	98.20	118.50	25.50	GUS (2008d)
2008	305.37	CSO	6.00	112.00	105.80	27.80	GUS (2009d)
2009	272.07	CSO	8.90	123.10	77.80	23.50	GUS (2010d)
2010	196.39	CSO	19.80	109.30	54.30	30.90	GUS (2011d)
2011	201.21	CSO	41.60	116.20	54.40	31.00	GUS (2012d)
2012	197.12	CSO	56.60	115.00	50.30	33.30	GUS (2013d)
2013	129.94	CSO	72.90	105.40	29.40	32.60	GUS (2014d)
2014	151.84	CSO	84.20	107.22	21.96	46.33	GUS (2015d)
2015	167.75	CSO	79.27	107.54	19.17	47.10	GUS (2016d)
2016	138.38	CSO	101.14	116.03	20.08	31.82	GUS (2017d)
2017	97.01	CSO	106.16	108.52	19.70	25.89	GUS (2018d)
2018	101.68	CSO	111.54	118.33	17.41	25.20	GUS (2019d)
2019	93.81	BDO	70.17	123.78	15.20	30.55	GUS (2020d)
2020	93.72	BDO	98.58	137.77	17.50	29.46	GUS (2021d)
2021	93.72	BDO	93.60	156.00	13.10	21.40	GUS (2022d)

N₂O emission

N₂O emission from human sewage was calculated according to default method [IPCC (2006)]. Population of Poland was provided by Statistics Poland [GUS (2022)] (table 7.29). Amounts of animal and vegetal protein consumption per capita per year was taken from FAO database. For years 2020-2021 protein consumption was assumed on the level of 2019 data, what is a result of delay in presenting data in FAO database.

Values and sources of emission factors are provided in table 7.28.

Table 7.28. Emission factors

Emission factor	F_{npr}	$EF_{effluent}$	EF_{plant}	$F_{non-con}$	$F_{ind-com}$
Value	0.16	0.005	3.2	1.1	1.25
Data source	default IPCC 2006				

Additionally, estimation of N_2O emissions from advanced wastewater treatment plants was performed. Degree of utilization of modern, centralized WWT plants (T_{plant}) is presented in table 7.29. Amount of nitrogen associated with these emissions (N_{WWT}) was subtracted from the $N_{EFFLUENT}$.

Table 7.29. Consumption of proteins, T_{plant} and population of Poland

Year	Protein consumption [kg/person]	Source	Population [in 1000s]	Source	T_{plant}
1988	38.57	FAOSTAT	37 885	GUS	0.0%
1989	38.19	FAOSTAT	37 988	GUS	0.0%
1990	36.85	FAOSTAT	38 073	GUS	0.0%
1991	37.37	FAOSTAT	38 144	GUS	0.0%
1992	37.28	FAOSTAT	38 203	GUS	0.0%
1993	36.78	FAOSTAT	38 239	GUS	0.0%
1994	35.51	FAOSTAT	38 265	GUS	0.0%
1995	35.91	FAOSTAT	38 284	GUS	3.0%
1996	36.02	FAOSTAT	38 294	GUS	4.8%
1997	35.45	FAOSTAT	38 290	GUS	8.3%
1998	36.26	FAOSTAT	38 277	GUS	13.1%
1999	36.39	FAOSTAT	38 263	GUS	15.4%
2000	36.43	FAOSTAT	38 254	GUS	20.1%
2001	36.36	FAOSTAT	38 242	GUS	22.9%
2002	36.72	FAOSTAT	38 219	GUS	26.8%
2003	36.88	FAOSTAT	38 191	GUS	30.5%
2004	36.17	FAOSTAT	38 174	GUS	33.5%
2005	36.03	FAOSTAT	38 157	GUS	37.3%
2006	36.03	FAOSTAT	38 125	GUS	39.0%
2007	36.35	FAOSTAT	38 116	GUS	41.1%
2008	35.76	FAOSTAT	38 136	GUS	46.6%
2009	36.74	FAOSTAT	38 167	GUS	48.6%
2010	36.96	FAOSTAT	38 530	GUS	49.6%
2011	37.34	FAOSTAT	38 538	GUS	52.2%
2012	37.06	FAOSTAT	38 533	GUS	54.6%
2013	37.04	FAOSTAT	38 496	GUS	56.0%
2014	36.65	FAOSTAT	38 479	GUS	57.6%
2015	36.82	FAOSTAT	38 437	GUS	58.9%
2016	37.94	FAOSTAT	38 432	GUS	59.7%
2017	38.43	FAOSTAT	38 434	GUS	59.5%
2018	38.67	FAOSTAT	38 411	GUS	60.0%
2019	38.31	FAOSTAT	38 383	GUS	60.3%
2020	38.31	missing data	38 089	GUS	60.7%
2021	38.31	missing data	37 908	GUS	60.9%

7.5.2.2. Industrial Wastewater (CRF sector 5.D.2)

Methane emission

Estimates of emissions of methane from industrial wastewater treatment sector are based on IPCC 2006 Guidelines [IPCC (2006)] *Tier 1* method and domestic case study [Przewłocki (2007)]. In the inventory COD default emission factors were applied. For branches, where the COD EF was not available country specific data were used [Rueffer (1998)]. Data on share of aerobic and anaerobic wastewater treatment method was taken from expert opinion [Przewłocki (2007)].

Data on amount of industrial wastewater from separate branches and on biological treatment of organic wastewater were taken from national statistics [GUS (2022d)].

Total organic product is derived from amount of wastewater from each industry, COD concentration in organic wastewater and wastewater produced per unit product by industry.

Data on employment in the mining, metal, fertilizer, machinery and equipment industries, as well as on production in the wood and paper industries were taken from the statistical yearbooks of the Statistics Poland for years 1989-2005. Information on the total amount of wastewater from individual industries and biologically treated organic wastewater was adopted on the basis of the studies of the Statistics Poland *Environment* yearbooks from the same period.

Due to the lack of reliable national information on the quality of raw industrial wastewater (BOD, COD and suspended solids) from the late 1980s, data for the period 1988 - 1990 was adopted on the basis of "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Workbook". In the absence of average values for some industries, incidentally averaged literature data were also taken into account.

The characteristics of wastewater from the food industry for the 1990s were adopted on the basis of Przewłocki survey data from the first half of the decade and a detailed inventory from 2001. The most reliable information in this regard concerns the first half of the current decade (2000-2004), for which there are detailed data from own inventories of water pollution loads from the food industry. The latter source also provided information on the methods of wastewater treatment as well as the parameters and conditions (overloads) of operation of the treatment plants.

Due to the fragmentation of this type of information for other industrial sectors from 1991 - 2004, the characteristics of wastewater from 1988 were extrapolated, with its possible correction according to development trends in the volume of production and water consumption and detailed industry studies. An exception in this regard is the wood and paper industry, for which pollutant loads in the entire period of 1988-2004 were analyzed in detail, based on the production volume and unit pollutant loads of raw sewage.

The source of information on the share of aerobic and anaerobic treatment methods and possible overloads (oxygen deficits) of the biological parts of the treatment plant for the food industry in the period 1988 - 1999 and for other industry sectors in the entire period under consideration (1988 - 2004) is the expert knowledge of the authors of [Przewłocki (2007)].

Decreasing trend of methane emissions in years 1988-2002 (ca. 230%) is driven by closing of industrial facilities after decline of communism in Poland. Increase of estimated methane emissions in years 2003 – 2017 is result of growth of Polish industries and slight decrease since 2018 is driven by development of sewage treatment practises and facilities.

Methane recovery

Data on recovery of methane in industrial wastewater treatment was taken from expert opinion [Przewłocki (2007)]. Recovered gas is combusted for energy purposes.

Organic component removed as sludge

The amount of sludge removed from industrial wastewater is zero in accordance with the default value from the 2006 IPCC Guidelines.

Table 7.30. Emission factors on wastewater and sludge

Industry sector	COD concentration in organic wastewater	Methane correction factor from wastewater	Maximum CH ₄ producing capacity form wastewater	Methane emission factor for wastewater	Methane correction factor from sludge	Maximum CH ₄ producing capacity form sludge	Methane emission factor for sludge
	kg/m ³		kg CH ₄ /kg ChZT	kg CH ₄ /kg ChZT		kg CH ₄ /kg ChZT	kg CH ₄ /kg ChZT
Mining and quarrying	0.60	0.10	0.25	0.030	0.32	0.25	0.080
Iron and steel	0.75	0.10	0.25	0.030	0.32	0.25	0.080
Non-iron metals	0.67	0.10	0.25	0.030	0.32	0.25	0.080
Synthetic fertilizers	0.82	0.10	0.25	0.030	0.32	0.25	0.080
Food products: Meat & Poultry	3.00	0.20	0.25	0.050	0.36	0.34	0.120
Food products: Fish Processing	2.50	0.15	0.25	0.040	0.68	0.34	0.231
Food products: Vegetables & Fruits	2.82	0.20	0.25	0.050	0.35	0.29	0.12
Food products: Vegetable Oils	0.79	0.34	0.25	0.090	0.65	0.34	0.221
Food products: Dairy Products	2.88	0.16	0.25	0.040	0.32	0.34	0.109
Food products: Sugar	2.51	0.52	0.25	0.130	0.38	0.34	0.129
Food products: Soft Drinks	1.49	0.10	0.25	0.030	0.2	0.34	0.068
Food products: Beer & Malt	3.81	0.10	0.25	0.030	0.20	0.34	0.068
Food products: Other	2.77	0.22	0.25	0.060	0.39	0.34	0.133
Textiles	0.90	0.12	0.25	0.030	0.24	0.25	0.060
Leathers	3.31	0.29	0.25	0.070	0.24	0.25	0.060
Wood and Paper	2.71	0.11	0.25	0.030	0.12	0.25	0.030
Petroleum Refineries	0.37	0.15	0.25	0.040	0.08	0.25	0.020
Organic Chemicals	3.00	0.15	0.25	0.040	0.08	0.25	0.020
Plastics & Resins	3.70	0.15	0.25	0.040	0.08	0.25	0.020
Other non-metallic	2.50	0.10	0.25	0.030	0.32	0.25	0.080
Manufacturing of Machinery and Transport Equipment	4.97	0.10	0.25	0.030	0.32	0.25	0.080
Other	0.77	0.10	0.25	0.030	0.32	0.25	0.080

Table 7.31. Amount of industrial wastewater by industry [million m³]

Year	Mining and quarrying	Iron and steel	Non-iron metals	Synthetic fertilizers	Food products: Meat & Poultry	Food products: Fish Processing	Food products: Vegetables & Fruits	Food products: Vegetable Oils	Food products: Dairy Products	Food products: Sugar	Food products: Soft Drinks	Food products: Beer & Malt	Food products: Other	Textiles	Leathers	Wood and Paper	Petroleum Refineries	Organic Chemicals	Plastics & Resins	Other non-metallic	Manufacturing of machinery and transport equipment	Other
1988	548.0	94.2	48.7	123.0	3.3	1.6	14.2	3.7	19.5	23.7	4.1	4.0	2.7	14.2	6.3	195.0	43.2	126.0	17.4	58.2	53.6	90.9
1989	426.5	119.6	86.1	118.3	3.0	1.5	12.0	2.5	20.6	21.0	4.2	4.0	5.7	13.9	5.7	199.1	43.4	224.1	0.0	59.6	54.6	91.3
1990	519.0	99.8	39.7	92.5	2.7	1.3	10.0	1.5	19.7	20.4	4.3	4.3	3.7	11.1	4.7	184.0	38.7	107.0	17.6	53.3	50.3	95.2
1991	470.0	73.1	67.8	58.4	3.2	1.2	8.5	1.0	17.7	13.9	5.0	4.0	2.6	8.2	4.2	168.0	40.0	120.0	15.8	43.9	42.1	89.8
1992	453.0	51.4	66.2	53.5	5.4	1.1	7.4	0.5	16.2	10.0	5.8	4.0	0.6	9.0	3.0	146.0	36.6	108.0	15.7	31.0	32.6	79.8
1993	392.0	47.0	59.7	48.5	4.6	0.9	8.0	2.1	15.3	11.0	2.3	3.6	1.5	7.8	2.6	132.0	33.6	97.7	15.1	28.0	30.7	82.7
1994	382.0	45.8	128.0	51.3	3.9	0.8	7.4	1.2	14.2	7.9	2.6	2.7	1.6	7.3	1.7	129.0	32.6	101.0	14.6	29.6	29.5	104.0
1995	378.0	44.4	134.0	41.5	4.0	0.3	8.3	1.0	13.2	7.7	2.4	2.1	1.5	6.4	1.6	121.0	33.2	98.6	12.6	29.3	27.0	94.5
1996	362.0	43.0	142.0	48.5	4.2	0.4	7.8	3.6	12.5	6.5	2.6	1.7	0.9	5.7	1.3	117.0	28.1	94.3	6.7	28.8	25.9	115.0
1997	340.0	43.9	172.0	51.9	4.2	0.2	7.7	4.8	12.2	5.7	2.9	1.7	1.1	5.2	1.1	114.0	25.1	81.5	9.2	32.9	26.5	110.0
1998	336.0	25.3	188.0	52.3	3.9	0.1	9.4	2.5	12.3	6.1	2.7	1.6	2.5	4.7	0.7	106.0	24.3	63.1	10.3	27.9	25.1	161.0
1999	362.3	13.2	184.8	52.6	4.0	0.1	7.5	3.2	11.4	4.9	2.6	1.4	0.5	3.1	0.7	90.3	20.3	55.9	8.4	29.8	22.0	116.7
2000	350.0	14.2	184.0	51.7	3.6	0.1	7.5	2.4	11.3	4.0	2.5	1.3	0.8	2.6	1.1	81.7	17.8	47.7	7.8	32.3	12.0	121.0
2001	332.0	14.8	187.0	49.7	3.4	0.1	7.2	0.7	11.7	2.9	2.1	1.3	0.7	2.1	1.2	76.9	18.1	42.4	4.7	34.2	10.4	130.0
2002	293.0	13.3	184.0	50.3	3.4	0.1	6.4	0.3	11.3	2.7	2.2	1.4	0.7	1.7	0.9	77.1	16.8	42.0	2.7	38.0	9.1	126.0
2003	272.0	9.6	155.0	46.0	3.5	0.1	7.8	0.2	11.5	2.7	3.1	1.2	0.8	1.6	0.8	71.5	17.4	38.3	2.5	31.9	8.1	120.0
2004	261.0	8.2	135.0	49.4	4.1	0.1	6.8	0.3	13.0	2.2	2.0	1.2	3.3	1.5	0.6	70.9	19.6	36.0	2.5	37.4	6.8	129.0
2005	267.0	6.5	132.0	48.6	4.3	0.0	6.6	0.3	13.5	1.8	2.1	1.3	2.8	1.6	0.7	68.9	19.3	38.4	2.4	36.3	7.0	128.0
2006	272.0	7.4	132.0	50.7	4.6	0.0	7.0	0.4	13.8	1.4	2.1	1.7	2.3	1.3	0.6	69.7	20.7	38.6	2.2	43.2	4.4	128.0
2007	271.0	10.8	133.0	52.6	4.8	0.0	6.8	0.4	14.4	1.9	1.9	1.4	2.4	0.7	0.6	67.6	23.0	39.1	2.3	39.4	4.2	148.0
2008	242.6	8.3	130.8	176.3	5.0	0.0	6.0	0.6	14.2	2.7	1.6	1.4	2.6	0.6	0.4	64.7	20.9	35.5	1.9	46.1	3.7	141.7
2009	252.9	12.8	128.4	121.3	5.8	0.0	6.1	0.8	14.2	3.2	1.8	1.1	2.1	0.4	0.5	66.8	21.3	29.4	1.8	39.9	2.1	168.4
2010	283.2	16.5	147.3	49.8	6.6	0.0	5.8	0.7	14.5	2.6	1.6	2.4	36.1	0.3	0.4	64.2	23.1	35.6	2.1	46.8	2.8	183.2
2011	286.2	13.2	166.4	48.1	6.5	0.0	5.8	0.6	13.8	3.1	2.2	10.3	35.3	0.0	0.3	66.3	23.1	38.0	2.4	48.0	2.7	164.9
2012	286.0	12.4	133.5	53.8	6.6	0.0	7.1	0.7	13.9	3.6	3.1	1.3	39.2	0.0	0.2	69.4	23.8	35.4	2.2	40.2	2.2	136.1

Year	Mining and quarrying	Iron and steel	Non-iron metals	Synthetic fertilizers	Food products: Meat & Poultry	Food products: Fish Processing	Food products: Vegetables & Fruits	Food products: Vegetable Oils	Food products: Dairy Products	Food products: Sugar	Food products: Soft Drinks	Food products: Beer & Malt	Food products: Other	Textiles	Leathers	Wood and Paper	Petroleum Refineries	Organic Chemicals	Plastics & Resins	Other non-metallic	Manufacturing of machinery and transport equipment	Other
2013	320.9	13.4	134.6	51.1	6.9	0.0	6.8	0.8	14.7	3.5	3.0	1.3	39.2	0.0	0.2	71.4	24.0	37.2	1.8	19.9	1.7	79.3
2014	312.1	12.2	128.6	52.0	7.6	0.0	7.3	0.8	14.8	3.5	3.3	1.3	42.5	0.0	0.3	71.1	22.5	38.8	2.5	40.4	2.1	160.8
2015	247.7	13.8	124.5	84.6	8.2	0.0	7.3	0.8	15.8	4.5	4.1	0.0	43.1	0.1	0.2	73.3	22.1	1.6	2.3	38.5	1.9	229.5
2016	320.0	15.9	115.4	80.0	9.3	0.0	7.5	0.6	16.4	4.2	4.3	0.0	45.4	0.3	0.2	77.4	21.0	1.7	3.3	41.5	1.8	152.2
2017	307.8	17.6	116.0	52.2	9.6	0.0	7.4	0.8	17.6	4.0	2.4	1.1	46.9	0.3	0.2	80.0	24.0	31.6	3.5	41.9	1.9	157.5
2018	294.3	16.4	121.7	79.3	10.0	0.0	7.9	0.7	18.3	5.6	4.3	0.0	49.3	0.4	0.2	79.6	23.8	1.8	4.2	41.0	2.1	147.2
2019	268.3	19.2	133.7	81.9	10.2	0.0	7.1	0.7	18.4	5.2	4.7	0.0	48.9	0.3	0.1	78.7	23.1	1.8	5.2	45.5	1.5	124.9
2020	287.6	15.2	112.9	82.6	9.9	0.0	7.0	0.8	18.7	5.9	4.3	0.0	49.3	0.2	0.1	80.9	21.1	2.0	4.3	47.9	1.6	145.2
2021	304.3	15.7	113.8	86.0	9.8	0.1	7.2	0.9	18.3	6.0	4.4	0.0	49.0	0.3	0.1	80.7	22.7	2.0	3.0	52.3	1.5	155.6

7.5.3. Uncertainties and time-series consistency

See chapter 7.2.3.

7.5.4. Source-specific QA/QC and verification

See chapter 7.2.4.

7.5.5. Source-specific recalculations

Recalculations details:

- update of data on protein consumption in FAOSTAT database in 2019,
- new source of data on landfilled sludge and extrapolation of data on sum of sludge applied in agriculture, in land reclamation, and in cultivation of plants intended for compost production.

Table 7.32. Change in emissions in result of recalculations in sector 5.D

Change	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
kt eq. CO ₂	- 4 768.29	- 4 542.85	- 4 567.75	- 3 751.46	- 3 109.41	- 2 437.91	- 2 627.57	- 2 357.55	- 2 247.61	- 2 244.16	- 2 169.86
%	-59%	-57%	-59%	-51%	-44%	-35%	-40%	-37%	-36%	-37%	-37%

Change	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
kt eq. CO ₂	- 2 273.14	- 2 448.16	- 2 152.44	- 2 062.31	- 1 745.00	- 1 709.57	- 1 470.78	- 1 365.97	- 1 101.77	- 768.41	- 643.65
%	-40%	-42%	-40%	-39%	-33%	-33%	-30%	-29%	-24%	-17%	-15%

Change	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
kt eq. CO ₂	- 439.70	- 446.76	- 397.58	- 233.55	- 255.66	- 251.54	- 218.97	- 151.67	-164.21	-155.62	-175.42
%	-10%	-11%	-11%	-7%	-8%	-8%	-7%	-5%	-5%	-5%	-6%

7.5.6. Source-specific planned improvements

Analysis on new AD and methodology in subsector 5D2.

8. OTHER (CRF SECTOR 6)

No other emissions were identified in the Polish GHG inventory apart from those given in CRF categories 1-5.

9. INDIRECT CO₂ AND NITROUS OXIDE EMISSIONS

Following recommendation G1 included in the review report FCCC/ARR/2022/POL the indirect CO₂ emissions from the atmospheric oxidation of NMVOC, as described in the Chapter 4.5.2.3.1, is reported separately to the IPPU sector, in the CRF Table 6.

As relates to indirect N₂O emissions, resulted from livestock manure management as well as from managed soils (atmospheric deposition and Nitrogen leaching and run-off) – these are reported within the Agricultural sector, see Chapter 5 of the NIR and CRF Tables 3.B(b) and 3.D.

10. RECALCULATIONS AND IMPROVEMENTS WITHIN THE GHG INVENTORY

10.1. Explanations and justifications for recalculations

Recalculations made in 2023 consists mostly of further improvements in calculation methods based on the IPCC 2006 Guidelines and country specific ones but also relate to AD update and ERT recommendations implementation. Detail sectoral information on recalculations made are given in Chapters 3-7 dedicated to source/sink categories and in CRF table 8.

The percentage change caused by recalculation with respect to the previous submission, has been calculated as follows:

$$\text{Change} = 100\% \times [(LS-PS)/PS]$$

where:

LS = Latest Submission (for 1988–2019 inventory submitted in NIR 2023)

PS = Previous Submission (for 1988–2019 inventory submitted in NIR 2022)

10.2. Implications for emission levels and trends

Recalculations of CO₂ emissions are insignificant and mostly are related to update of statistical energy data (Fig. 10.1) as well as methodological changes in Waste sector. In Waste sector estimates of emissions from incineration of municipal waste and sewage sludge were assigned to category 1A, but with no impact on total emissions, because of identified double counting.

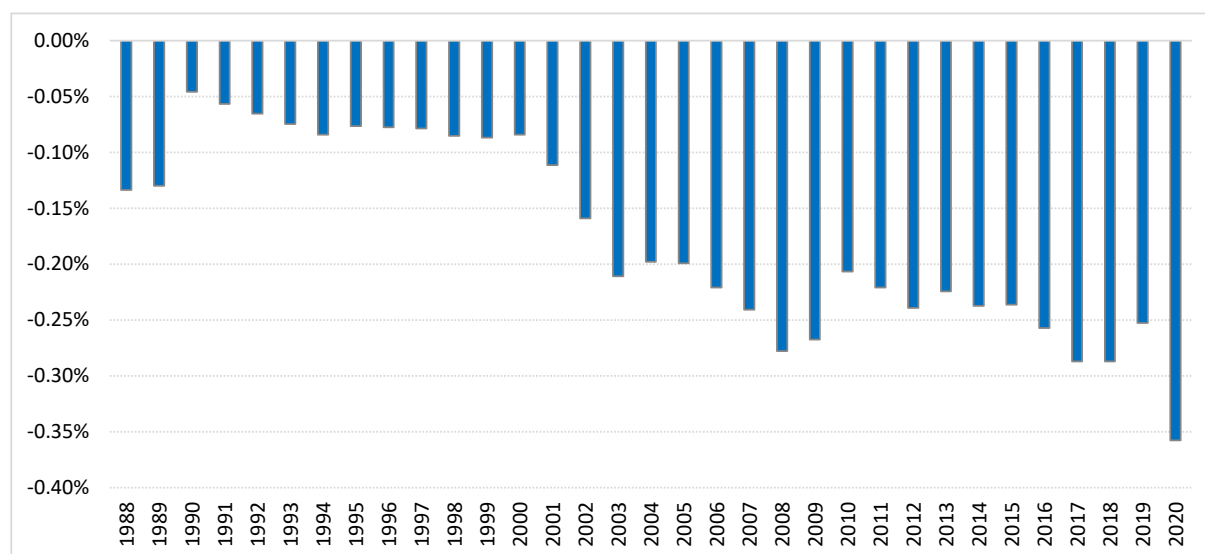


Figure 10.1. Recalculation of CO₂ for entire time series made in CRF 2023 comparing to CRF 2022

In the case of CH₄ the biggest recalculations occurred in Waste sector which exceeded 16% in 2012–2014. Those were related to new source of AD and morphology of MSW since 2006 (landfilled waste) and 2011 (landfilled sludge), and new data on AD and morphology of landfilled ISW (Fig. 10.2).

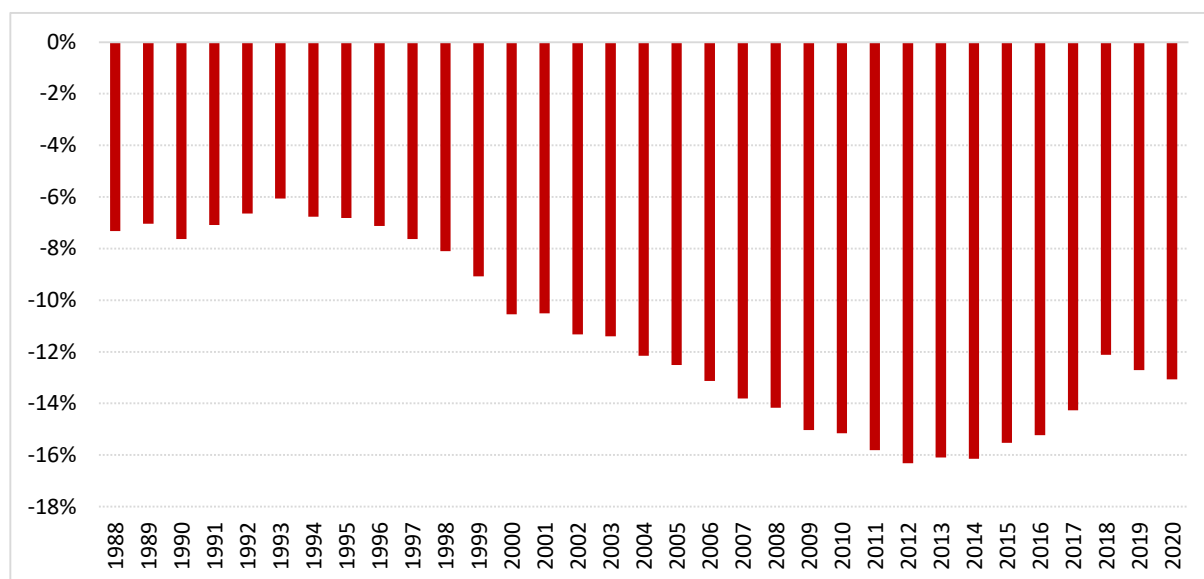


Figure 10.2. Recalculation of CH₄ for entire time series made in CRF 2023 comparing to CRF 2022

Changes in N₂O emissions between Submissions 2023 and 2022 vary from -0.3% up to +1.6%. The main influence on change in trend between submissions in late 1990. and early 2000. is related to recalculations made in road transport with the use of newest version of COPERT model (1.A.3.b). Additionally some methodological changes were made in the Waste sector related to a new source of AD on incinerated industrial waste as well as submission of incineration of municipal waste and sewage sludge in Energy sector.

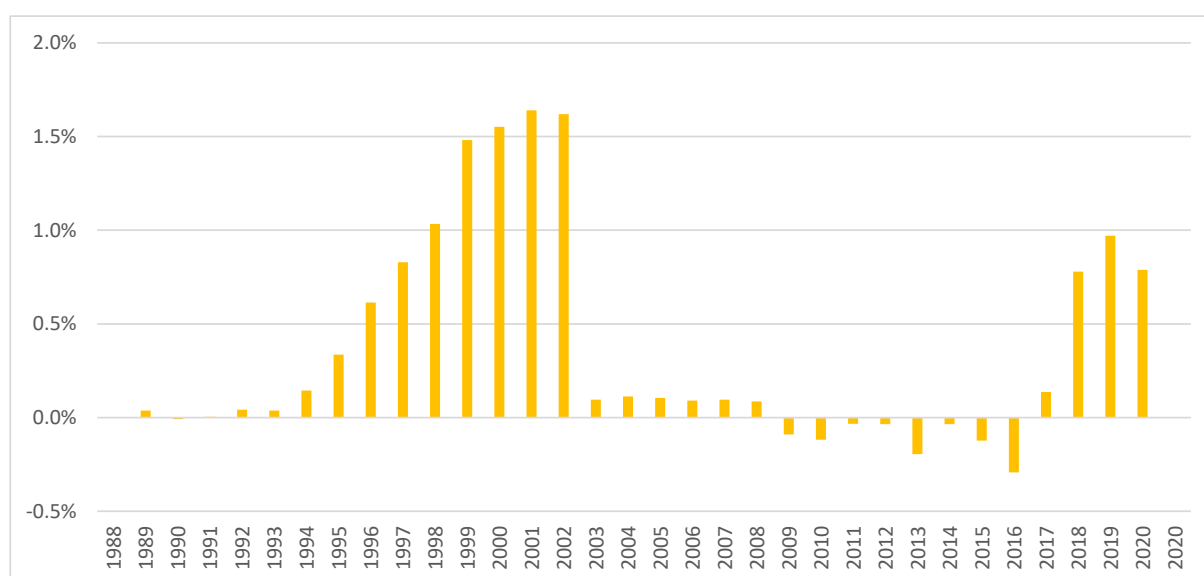


Figure 10.3. Recalculation of N₂O for entire time series made in CRF 2023 comparing to CRF 2022

10.3. Implications for emission trends

GHG emissions reported in 2023 in relation to previous Submission 2022 for period 1988-2020 are lower up to 2% in 2014 what was generally related to methodological changes in Waste sector elaborated above. GHG emissions presented here in CO₂ eq. are calculated based on GWP from AR4 in line with CRF files reported on 15 January 2023 (Fig. 10.7).

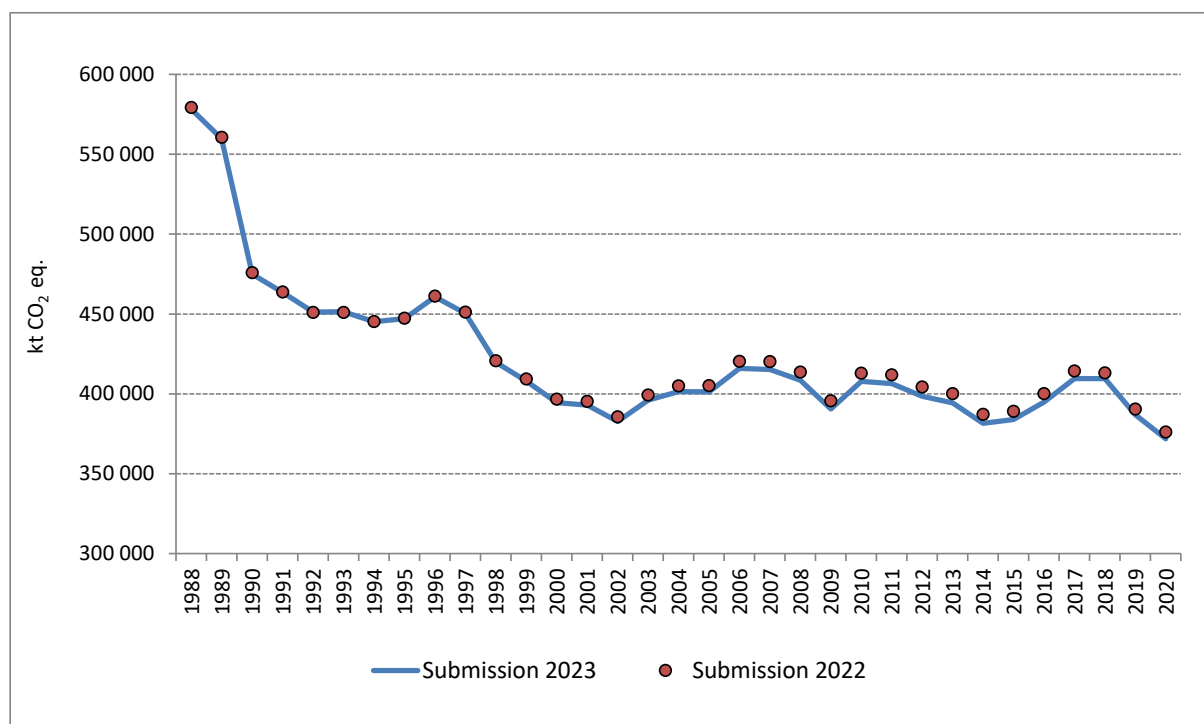


Figure 10.7. GHG emission trends according to Submissions made in 2023 and 2022

10.4. Changes in methodological description

The major methodological changes that have been made since the previous Polish submission in 2023 are presented below in aggregated form.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please mark the relevant cell where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year	Please mark the relevant cell where this is also reflected in recalculations compared to the previous years' CRF	If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed
1. Energy			
A. Fuel Combustion (sectoral approach)			
1. Energy industries	X	X	CS EFs for CH ₄ from combustion of coal, lignite and solid biomass
2. Manufacturing industries and construction			
3. Transport	X	X	AD data update; method of calculation shifted from COPERT 5.5 to COPERT 5.6.1
4. Other sector			
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 and product use			
A. Mineral industry			
B. Chemical industry			
C. Metal industry			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please mark the relevant cell where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year	Please mark the relevant cell where this is also reflected in recalculations compared to the previous years' CRF	If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed
D. Non-energy products from fuels and solvent use		X	Emission from 2.D.3 Solvents now is reported as indirect
E. Electronic industry			
F. Product uses as substitutes for ODS			
G. Other product manufacture and use			
H. Other			
3. Agriculture			
A. Enteric fermentation			
B. Manure management			
C. Rice cultivation			
D. Agricultural soils			
E. Prescribed burning of savannahs			
F. Field burning of agricultural residues			
G. Liming			
H. Urea application			
I. Other carbon containing fertilisers			
J. Other			
4. Land use, land-use change and forestry			
A. Forest land		X	Updated soil AD for the year 2020
B. Cropland		X	Updated LUC data Updated soil AD for the period 2000-2021
C. Grassland		X	Updated LUC data Updated soil AD for the period 2000-2021
D. Wetlands			
E. Settlements			Updated LUC data Updated soil AD for the period 2000-2021
F. Other land			
G. Harvested wood products			Updated production data on FAO items 1875, 1876, 1874, 1872
H. Other			
5. Waste			
A. Solid waste disposal		X	New source of AD and morphology of MSW since 2006 (landfilled waste) and 2011 (landfilled sludge), and new data on AD and morphology of landfilled ISW
B. Biological treatment of solid waste		X	New source of AD on composted waste since 2006. Change of IPCC 2006 EF from dry to wet basis.
C. Incineration and open burning of waste		X	New source of AD on incinerated industrial and medical waste (CSO and BDO). Submission of municipal waste and sewage sludge incineration in Energy sector.
D. Wastewater treatment and discharge			New source of AD on landfilled sewage sludge (CSO/BDO)
E. Other			

10.5. Recalculations, including in response to the review process, and planned improvements to the inventory

The following list of recommendations (and its implementation status) comes from the individual review of the annual submission of Poland submitted in 2020 (FCCC/ARR/2020/POL).

CRF category/issue	Review recommendation	Review report/ paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
TABLE 3					
General					
QA/QC	Improve its QA/QC procedures so that inconsistencies between the NIR and the CRF tables are minimized in future submissions (namely between data in NIR tables 2.2 and 2.8 and CRF table 10 for IPPU, LULUCF sectors and category 1.A.5 (other).	G.1	Addressing. Poland corrected the numerical discrepancies between the NIR and the CRF tables identified during the previous review, including for total N ₂ O emissions for LULUCF for 2018, which was reported both in NIR table 2.2 and in CRF table 10s4 as 2.31 kt. Further, notation keys were consistently used across the NIR and CRF tables for the LULUCF sector and category 1.A.5 (other). However, the ERT noted that there are still discrepancies for some LULUCF categories. For example, CH ₄ emissions were reported as "IE, NO" in NIR table 2.2 and "NO, NA" in CRF table 10s3 for cropland (4.B); 0.00 Gg in NIR table 2.2 and "NO, NA" in CRF table 10s3 for wetlands (4.D); and "NA, NO" in NIR table 2.2 and "NO" in CRF table 10s3 for settlements (4.E). The ERT also noted that the total CO ₂ eq emissions with LULUCF for the base year reported in NIR table 2.8 (558,708.88 kt) differs from the amount reported in CRF table 10s1 (558,843.08 kt). During the review, Poland explained that this difference arose because in the NIR, emissions for the base year took into of the account the actual base year, as defined by the Party, which is 1988 for CO ₂ , CH ₄ and N ₂ O and 1995 for F-gases (and 2000 for NF ₃ , though these emissions do not occur). In the CRF tables, the total emissions value is generated automatically as the sum of emissions for the calendar year 1988, which does not take into account the Party's choice of the base year for F-gases. The description of the base year for Poland is given in the NIR (section 1.1.1 and table 2.7; p.36).	-	Resolved. Information on differences between base years and 1988 is given together with emissions data
Energy					
General	Elaborate on the description of how the Party maintains time-series consistency while using different sources of AD, in particular how the Party ensures consistency of data from the IEA database for 1988–1989 and the Eurostat database for 1990 onward with some of the EU ETS data	E.1	Resolved. The Party explained in its NIR (section 1.4, p.25; section 3.1.1, p.46; section 3.2.6.4, p.58) that data from IEA for 1988–1989 and Eurostat for 1990–2018 are provided by Statistics Poland. Data submitted to the IEA and Eurostat databases are collected using the same questionnaire and are identical, as reported in the NIR (annex 10, table 1). Further, the estimates are cross-checked with EU ETS data. The share of national emissions related to installations covered by the EU ETS in 2005–2018 amounted to about 50 per cent, on average (NIR, p.29).	-	Resolved
General	Improve the reporting of the details of the annual QA/QC measures implemented in the energy sector and provide information on the cross-checks made among the national	E.2	Resolved. The Party reported in its NIR (section 1.2, p.22) that the National Centre that collaborates with Statistics Poland is responsible for the QA/QC of published energy data. Statistics Poland compares the data with those in the Eurostat database, the IEA database and the GHG	-	Resolved

CRF category/issue	Review recommendation	Review report/paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
	statistics data, the Eurostat data and the EU ETS data, as well as information on any validation of EFs by comparison with the EU ETS data.		inventory and makes corrections, as necessary. Data on energy use are also checked against those in previous submissions to the EU ETS. The verified data form the basis of the national energy balance. In addition, Statistics Poland checks data on major fuels by establishing balances between national and sectoral totals. During the review, the Party explained how emissions from EU ETS installations are checked against sectoral emissions for convergence.		
1.A.1 Energy industries – all fuels – CO ₂	Complete and report on the planned development of country-specific CO ₂ EFs for the significant fuels in the energy sector, and consider applying the country-specific CO ₂ EF for gasoline used in road transportation to stationary combustion.	E.3	Resolved. The Party reported in its NIR (section 3.1.1, p.45) that country-specific CO ₂ EFs are based on site-specific data from EU ETS installations. Details on how these EFs were derived are given in the NIR (section 3.1.1, p.45). Poland also reported that 94 per cent of CO ₂ emissions for category 1.A.1 are based on country-specific EFs, and that the share of CO ₂ emissions from liquid fuels of the total emissions from combustion in stationary sources is not significant because the share of individual liquid fuels under 1.A.1 amounted to only 0–1.4 per cent in 2018 (NIR table 3.1.1 shows the CO ₂ emission contribution by fuel for 1.A.1, p.45). During the review, the Party explained that applying the country-specific EF for gasoline in mobile combustion to gasoline in stationary combustion would not be appropriate as gasoline is not used in stationary combustion.	-	Resolved
1.A.1 Energy industries – solid fuels and biomass – CH ₄	Apply a tier 2 method to estimate CH ₄ emissions from stationary combustion (solid fuels and biomass).	E.4	Addressing. During the review, the Party clarified that CH ₄ emissions from stationary combustion were not identified as a key category, with such emissions from solid fuels and biomass accounting for 0.009 and 0.011 per cent, respectively, of national total GHG emissions. However, the Party acknowledged the need to develop a country-specific EF for CH ₄ emissions from biomass fuels for category 1.A.1 in the future, as the use of biomass fuels is increasing so it could become a key category.	-	Resolved. CS EFs have been developed for methane in category 1.A.1. Sub. 2023, Chapter 3.1.1 and Annex 2.2.
Feedstocks, reductants and other NEU of fuels – solid fuels – CO ₂	Report in CRF table 1.A(d) the CO ₂ emissions associated with the NEU of other bituminous coal (cell J30), and report under column J (cell J30) in which categories the CO ₂ emissions are reported in the IPPU sector in accordance with footnote 3 to the CRF table	E.5	Resolved. The Party reported in CRF table 1.A(d) emissions from NEU of other bituminous coal. The Party specified in cell J30 that the emissions are reported under iron and steel production.	-	Resolved
1.A.3.b Road transportation – liquid fuels – CO ₂ , CH ₄ and N ₂ O	Include in the NIR information on how combustion of lubricants is considered in the inventory and, if it is insignificant, provide a justification based on the likely level of emissions in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	E.6	Not resolved. The Party reported in the NIR (section 10.4.1, p.297) that information on the combustion of lubricants is included under the road transport sector (section 3.2.8), but this section does not contain information on how the combustion of lubricants is considered. During the review, the Party explained that emissions from the combustion of lubricants are included as a variable in COPERT V, which the Party uses. The ERT deems that the recommendation has not yet been addressed because the Party did not include information in the NIR on how emissions from the combustion of lubricants are considered in the inventory. During the review, the Party indicated that details on data inputs for the estimation of these emissions will be included in its next NIR.	-	Resolved. Detail information on combustion of lubricants is given in the Chapter 3.2.8

CRF category/issue	Review recommendation	Review report/paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
1.A.4 Other sectors – liquid fuels – CO ₂ , CH ₄ and N ₂ O	Explain in the NIR (e.g. in a footnote to tables 11 and 12 in annex 2) whether or not consumption of motor gasoline occurs under the subcategories offroad vehicles (1.A.4.a(ii)) and machinery (1.A.4.b(ii)), and use the documentation box in CRF table 1.A(a)s4 and CRF table 9 to explain the inclusion of emissions (related to all fuels) from offroad vehicles and machinery in the road transport emissions.	E.7	Not resolved. Poland reported “IE” in CRF table 1.A(s)s4 for liquid fuels under the subcategories off-road vehicles (1.A.4.a(ii)) and machinery (1.A.4.b(ii)) and did not include an explanation in the documentation box to the table or in CRF table 9 on the allocation of these emissions. During the review, Poland indicated that gasoline and related GHG emissions from off-road vehicles and machinery are reported under subcategory 1.A.3.b (road transportation) as this type of fuel consumption is aggregated in the national energy balance. The Party plans to include, in its next submission, explanatory footnotes to tables 11–12 in annex 2 to the NIR and comments in the documentation box in CRF table 1.A(a)s4 and CRF table 9. The ERT considers that the recommendation has not yet been fully addressed because the Party did not explain in the NIR whether emissions from gasoline consumption occur for subcategories 1.A.4.a(ii) and 1.A.4.b(ii) and where these emissions are included.	-	Resolved. Chapter 3.2.9.2.
IPPU					
2.B.2 Nitric acid production – CO ₂	Include in the NIR information on how the Party ensures that the AD cover all nitric acid production in the country, for example by including an explanation of the comparison performed between the statistical data and data from installations using nitric acid for larger production processes and the results obtained.	I.1	Resolved. The Party reported in its NIR (p.128) on the comparison performed between the statistical data and data from installations using nitric acid for larger production processes and the results obtained. The comparison revealed only slight variations for certain years (from –1.3 to +2.6 per cent), indicating that all production was covered by the statistical data.	-	Resolved
2.C.4 Magnesium production – SF ₆	Implement the new data from the Polish Geological Institute and ensure the consistent reporting of SF ₆ arising from magnesium production across the time series.	I.2	Not resolved. The Party did not report in its NIR on efforts to ensure a consistent times series of magnesium production AD. However, the Party did report in its NIR (p.162) that, under new legislation, magnesium production has not occurred in Poland since 2018, and will be reported from now on as “NO”. During the review, the Party indicated that it will continue its efforts to update the time series. The ERT considers that the recommendation has not yet been addressed because the Party did not implement the Polish Geological Institute data, or any other new data, with a view to ensuring the time-series consistency of the AD, and still reported the AD from 2007 for 2008–2018.	Lack of available data for primary magnesium production 2008-2017. Surrogate data is still used. Since 2018 magnesium production is not occurring.	Addressing
2.F Product uses as substitutes for ozone-depleting substances – HFCs	Include in the NIR (section 4.7.1) the correct reference to the European Union regulation on F-gases (regulation 517/2014/EU) and correct the data on the share and mix of gases for commercial refrigerators in NIR table 4.7.2 to ensure consistency with the 2006 IPCC Guidelines (vol. 3, chap. 7, table 7.8).	I.3	Not resolved. The Party included a reference in its NIR (p.153) to Commission Regulation (EU) 517/2014 on maximum residue levels for dimethomorph, indoxacarb and pyraclostrobin in or on certain products, rather than to regulation 517/2014/EU. In addition, the Party did not report the correct share and mix of gases for commercial refrigerators in NIR table 4.7.2.	-	Resolved. Information in table 4.7.2 corrected
2.F Product uses as substitutes for ozone-depleting	Change the notation key reported in CRF table Summary 3s1 to “NO” for SF ₆ and NF ₃ under “method applied” and “emission factor” for this category.	I.4	Not resolved. The Party did not report “NO” in CRF table Summary 3s1 for SF ₆ and NF ₃ under “method applied” and “emission factor”. The relevant cells were left blank for category 2.F.	-	Resolved. Information in the table Summary 3s1 was corrected

CRF category/issue	Review recommendation	Review report/ paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
substances – SF6 and NF3					
2.F.1 Refrigeration and air conditioning – HFCs	Explain in the NIR the rationale behind the assumptions on the percentage of refrigeration equipment in which HFC-32, HFC-125, HFC-134a and HFC-143a are used, and provide the sources of information for the estimation of emissions for this category as well as the rationale for their selection	I.5	Addressing. The Party reported in the NIR (p.153) that its assumptions and QA/QC procedures are based on working knowledge, direct contact with F-gas operators and analysis of (1) questionnaires returned from installations and operators, (2) the parameters applied by other countries with comparable national circumstances (eastern European Union member States) and (3) the phasing-out effect and conversion of equipment not containing F-gases. However, the ERT considers that the recommendation has not yet been fully addressed because the Party did not report specific information on how it arrived at the assumptions on the percentage of substances used in refrigeration and air-conditioning equipment in which HFC-32, HFC-125, HFC-134a and HFC-143a are used. In addition, it did not provide any information on data sources for the estimation of emissions for this category or the rationale for their selection. During the review, the Party indicated that such information will be included in its next submission and mentioned the two databases created as result of implementation of the European Union F-gas regulation: Installation's Reports Database and Central Registry of Operators.	-	Resolved. Methodological description in the NIR of f-gases inventory was updated
2.F.1 Refrigeration and air conditioning – HFCs	Include in the NIR sufficient information to explain the trends and significant inter-annual changes observed for HFCs remaining in products at decommissioning for categories 2.F.1.e and 2.F.1.f, including information on the assumed lifetime for different types of equipment in line with the information provided to the ERT during the review	I.6	Addressing. While the Party explained in its NIR (p.154) the trend observed for HFCs remaining in products at decommissioning for mobile air conditioning (2.F.1.e), it did not do so for stationary equipment (2.F.1.f) – although it did provide such information during the previous review.	-	Resolved. Information provided in the NIR
2.F.1 Refrigeration and air conditioning – HFCs	Include in the NIR a relevant analysis of the national F-gas market and an explanation for the lack of HFC-23 and HFC-152a emissions from refrigeration and air-conditioning equipment.	I.7	Resolved. The Party reported in its NIR (p.154) on the analysis of the national Fgas market, explaining the lack of HFC-23 and HFC-152a emissions from refrigeration and air-conditioning equipment under category 2.F as resulting from the legal restrictions on and high price of blends containing these gases.	-	Resolved
2.F.1 Refrigeration and air conditioning – HFCs	Justify in the NIR the 15-year lifetime used for transport refrigeration.	I.8	Addressing. The Party did not include in its NIR (section 4.7) a justification of the 15-year lifetime for transport refrigeration, although it did provide such justification in NIR table 10.1 (p.299) and confirmed the justification during the review and during the previous review.	-	Resolved. Information provided in the NIR
2.F.2 Foam blowing agents – HFCs	Obtain the correct value for the HFC-152a product manufacturing factor for closed cell foams and revise the emission estimates accordingly. Include a clear explanation in the NIR of the recalculation performed, in accordance with paragraph 44 of the UNFCCC Annex I inventory reporting guidelines.	I.9	Not resolved. The Party did not revise the value given in its NIR (p.159) for the HFC-152a product manufacturing factor for closed cell foams, which remained 95 per cent. During the review, the Party stated that it will revise this value during the compilation of the next F-gas inventory.	-	Resolved. Data revised
2.F.2 Foam blowing agents – HFCs	Either justify the use of the HFC-227ea product manufacturing factor for closed cell foams (1	I.10	Not resolved. The Party provided two values for the HFC-227ea product manufacturing factor for closed cell foams – 10 per cent in the NIR	-	Resolved. Data revised

CRF category/issue	Review recommendation	Review report/ paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
	per cent for all reported years) or apply the 2006 IPCC Guidelines default factor (vol. 3, table 7.5, p.7.35). Include a clear explanation in the NIR of the recalculation performed, in accordance with paragraphs 43–45 of the UNFCCC Annex I inventory reporting guidelines.		(p.159) and 1 per cent in CRF table 2(II)B-Hs2 – without explanation. During the review, the Party clarified that a factor of 1 per cent should be reported, noting that foams containing HFC-227ea are manufactured in a well-controlled environment, and indicated that it will report the correct value and the rationale in the next NIR.		
Agriculture					
3. General (agriculture)	Document the main findings of the sector-specific QA/QC activities, particularly the reasons for any discrepancies between EFs applied in Poland and those applied in other countries or reported in the international literature, in the category-specific subchapters of the NIR.	A.1	Resolved. The Party provided detailed information in its NIR (sections 5.2.4, 5.3.4, 5.4.4 and 5.5.4; pp.179–203) on the sector-specific QA/QC activities implemented, and documented the main findings, including reasons for any discrepancies among EFs used by Poland, EFs reported by other countries and default EFs from the 2006 IPCC Guidelines.	-	Resolved
3.A Enteric fermentation – CH4	Include additional information on the methods and assumptions used to derive the gross energy intake values by livestock subcategory.	A.2	Resolved. The Party provided additional information in its NIR (section 5.2.2 and tables 5.2.5, 5.2.6 and 5.2.7; pp.171–178) on the methods and assumptions used to derive the gross energy intake values for cattle (the only livestock subcategory for which a tier 2 method is used).	-	Resolved
3.B Manure management – CH4 and N2O	Provide additional information that justifies the distribution of animal waste management systems used (including, for example, information on general agricultural structures and policies).	A.3	Not resolved. Poland provided the same justification in its NIR for the distribution of animal waste management systems as it did in its previous NIR, and included only a brief note to corroborate the data on pigs provided by the National Research Institute of Animal Production (NIR, p.183). During the review, the Party clarified that the Agricultural Census 2020 organized by Statistics Poland has started (the previous one was conducted in 2010); detailed data on farms and their activities collected under this census should allow the update of AWMS data for inventory purposes, but first results are expected in 2021 at the earliest. The ERT notes that the census, due to be completed in 2021, will provide a sound basis for reporting the required information. It also notes that, whereas the Party indicated in its previous review that it might collect data on animal waste management systems as part of a pre-census satellite study on a representative sample of farms, no such study was carried out and no reference was made to it in the NIR.	-	Resolved. Wider description is given NIR 2022 Chapter 5.3.2.
3.B Manure management – CH4	Separately report CH4 emissions from anaerobic digesters.	A.4	Not resolved. Poland collected data on manure and other inputs used in agricultural biogas plants for 2011–2017 but was unable to separately report CH4 emissions from anaerobic digesters. During the review, the Party informed the ERT that it plans to disaggregate estimates of CH4 emissions from anaerobic digesters from national data in the next submission.	Work on finish, additional data from Nat. Statistics and KOWR on 2020–2021 need to be checked, estimated and applied	Addressing
3.B Manure management – CH4 and N2O	Improve the transparency of the characterization of fur-bearing animals by reporting the population trends for rabbits, foxes, minks and polecats in the NIR, and ensure consistency of reporting between the	A.5	Resolved. Poland provided data in its NIR on the population of rabbits and furbearing animals in 1988–2018 (NIR table 5.2.2, p.172). The data were based on agricultural censuses and other studies, and interpolation was used for intermediate years and for 2016 onward. The statistical data on rabbits cover female rabbits capable of reproducing and also other fur-bearing animals, namely female foxes,	-	Resolved

CRF category/issue	Review recommendation	Review report/paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
	NIR and the CRF tables for rabbits and other fur-bearing animals.		minks, polecats, nutrias, polecat–ferret hybrids, chinchillas and raccoons. No statistical data were available for deer. The ERT considers that the data reported in the NIR and CRF tables for rabbits and other fur-bearing animals are now consistent.		
3.B Manure management – N ₂ O	Explain in the NIR the recalculation performed, including the method and parameters used to calculate Nex rates and N ₂ O emissions for categories 3.B(b).1 and 3.B(b).4, in accordance with paragraph 44 of the UNFCCC Annex I inventory reporting guidelines.	A.6	Addressing. Poland submitted recalculated estimates in its 2019 submission that were based on the revision of the conservative approach introduced in response to the Saturday paper in relation to Nex rates for cattle and poultry for 1988– 2016 (2019 NIR, section 5.3.5). In response to a question raised by the ERT during the 2020 review, Poland stated that this recommendation is still under consideration, because the recalculations proposed in the list of potential problems and further questions raised by the ERT were based primarily on default parameters (and their ranges) from a publication (Bittman et al., 2014) that does not reflect the subcategories used for cattle in the Party's inventory. It added that information on the specific feeding and maintenance characteristics of cattle, including the percentage of crude protein in their diet, for the entire inventory period was collated by the National Research Institute of Animal Production in 2019–2020 and will be included in the next submission.	-	Resolved
3.B Manure management 3.D Direct and indirect N ₂ O emissions from agricultural soils – N ₂ O	Explain in the NIR the recalculation performed, including the method and parameters used for categories 3.B(b).5, 3.D.a.2.a, 3.D.a.3, 3.D.b.1 and 3.D.b.2.	A.7	Not resolved. Recalculations were for the 2019 submission but the NIR (section 5.4.5) did not include an explanation of the rationale behind the recalculations. In the 2020 submission, the methods and parameters used for categories 3.B(b).5 (NIR, section 5.3.2.2, p.184), 3.D.a.2.a (NIR, section 5.4.2.1, p.192), 3.D.a.3 (NIR, section 5.4.2.1, p.195), and 3.D.b.1 and 3.D.b.2 (NIR, section 5.4.2.2, p.198) include country-specific Nex rates based on categories of livestock raised in Poland, national conditions, and international literature and research (NIR, section 5.3.2.2, p.186). In response to a question raised by the ERT during the review, Poland indicated that information on the specific feeding and maintenance characteristics of cattle, including the percentage of crude protein in their diet, for the entire inventory period was collated by the National Research Institute of Animal Production in 2019–2020 and will be included in the next submission.	-	Resolved
3.D Direct and indirect N ₂ O emissions from agricultural soils – N ₂ O	Report the assumptions and methods used to estimate uncertainty, and apply methods provided in the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories to combine uncertainties.	A.8	Resolved. The Party provided additional information in its NIR (section 5.2.3, p.178–179) on the assumptions and methods used to estimate uncertainty for the entire agriculture sector, including on the application of approach 1 from the 2006 IPCC Guidelines (vol. 1, chap. 3) to combine the uncertainties. The Party also provided a table with the uncertainty of AD by source for the whole GHG inventory, including category 3.D, in the NIR (annex 8, table on pp.452–455).	-	Resolved
3.D.a Direct N ₂ O emissions from managed soils – N ₂ O	Improve QA/QC to ensure that the reference to the table containing AD for crop production is correct and that table 5.23 is included in the NIR.	A.9	Resolved. The reference to the table containing AD for crop production (NIR table 5.4.1, p.191) was corrected.	-	Resolved

CRF category/issue	Review recommendation	Review report/paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
3.D.a.6 Cultivation of organic soils (i.e. histosols) – N2O	Update the NIR to reflect the revised estimates of N2O emissions and provide an explanation of the recalculations performed, including methods applied, as well as a description of the planned improvements to the estimation of the area of cultivated organic soils.	A.10	Resolved. The Party noted in its NIR (section 5.4.2.1, p.197) that the area of cultivated organic soils had been updated (Walęzak et al., 2020) and reported the methods applied and improvements implemented in that regard. The cultivated area of histosols reported in the Party's submission was established primarily on the basis of the results from the Spatial Information System for Wetlands in Poland project carried out in 2004/2006 by the Institute of Technology and Life Sciences. Vector layers identified for organic soils were associated with CORINE land-cover maps for 1990, 2000, 2006, 2012 and 2018. Land cover was classified in accordance with the 2006 IPCC Guidelines, with cropland and grassland accounted for under the agriculture sector. Data for years between those covered by the CORINE land-cover maps were interpolated, while data for 1988–1989 were extrapolated on the basis of changes after 1990. Generally speaking, the area of organic soils subject to agricultural use decreased by 1 per cent for cropland and by 4 per cent for grassland from 1988 to 2018 (NIR, figure 5.4.4, p.197).	-	Resolved
LULUCF					
4. General (LULUCF)	Provide detailed information on the rationale for and impact of the recalculations for the LULUCF sector.	L.1	Resolved. Poland provided updated information on the rationale for the recalculations in LULUCF sector performed in the NIR 2023 Chapter 6.6.7.	-	NIR 2023 Chapter 6.6.7.
4. General (LULUCF)	Estimate and report the carbon stock changes for all mandatory categories.	L.2	Resolved. Poland reported in CRF tables 4.B, 4.C and 4(III) CO2 emissions for organic soils under cropland converted to grassland and grassland converted to cropland as well as N2O emissions from mineralization under land converted to cropland. During the relevant review, Poland confirmed that conversion of land to settlements did not occur for organic soils.	-	
4. General (LULUCF)	Apply different FLU or FMG values for different landuse or management categories in accordance with the 2006 IPCC Guidelines.	L.3	Resolved. Poland provided information in its NIR on the carbon stock values for different land-use categories, for example for cropland (p.228) and permanent meadows and pastures (pp.233–234), referencing the correct sections of the 2006 IPCC Guidelines, and distinguishing between time “T” and time “T-20” (from equation 2.25 in the 2006 IPCC Guidelines (vol. 4)).	-	
4. General (LULUCF)	Include in the NIR sufficient information on the rationale for and the impacts of changing from the gain–loss to the stock-change method to estimate CO2 emissions and removals from forest land remaining forest land for all years.	L.4	Adressing. Poland included information in NIR 2022 on the rationale for and the impacts of changing from the gain–loss to the stock-change method to estimate CO2 emissions and removals from forest land remaining forest land in NIR 2022 Chapter 6.2.4.3.	Limited data accessibility in this regard should be considered an issue in this regard. Domestic NFI data is providing increment data at the aggregated level. Moreover, associated data related to harvest amounts is not provided by age classes and species. Furthermore, this information is limited to the information on harvest amounts resulting from the final felling only. Associated characteristic do not consider this information to be disaggregated by the age classes.	Issue under consideration. NIR 2023 Chapter 6.2.4.3.

CRF category/issue	Review recommendation	Review report/paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
4.A Forest land – CO2	Correct the forest land area reported in NIR table 6.4 for 2016.	L.5	Resolved. Poland reported the correct forest area for 2016 in its NIR (p.211) and in CRF table 4.A. However, the ERT noted that in NIR table 6.4, the data for 2016, 2017 and 2018 are labelled as 2017, 2018 and 2019, respectively.	-	
4.A.1 Forest land remaining forest land – CO2	Change the heading of the second column of NIR table 6.7 to “Basic wood density”.	L.6	Resolved. Heading of the second column of NIR table providing information related to “Basic wood density” has been changed according to ERT recommendation.	-	NIR 2022 Chapter 6.2.4.4.
4.A.1 Forest land remaining forest land – CO2	Verify the BEF2 values used for pines and broadleaves and clarify in the NIR (perhaps in a footnote to table 6.8) that the BEF2 values applied in the inventory are at the lower end of the range of default values in table 3A1.10 of the IPCC good practice guidance for LULUCF. Explain in the NIR the assumptions made in applying those values and the results of that choice.	L.7	Resolved. Explanatory footnotes describing assumptions for application BEF2 values are provided in the NIR 2022 Chapter 6.2.4.5.	-	NIR 2022 Chapter 6.2.4.5.
4.A.1 Forest land remaining forest land – CO2	Clarify in the NIR (perhaps in a footnote to table 6.9) that the default values applied in the inventory for “Oak AGB < 50 tonnes/ha” and “Oak AGB 50–70 tonnes/ha” are the same as the IPCC default for “Quercus spp. AGB >70 tonnes/ha” in accordance with table 4.4 of the 2006 IPCC Guidelines, and explain the assumptions made in applying those values and the results of that choice.	L.8	Resolved. Explanatory footnotes describing assumptions for application BEF2 values are provided in the NIR 2022 Chapter 6.2.4.5.	-	NIR 2022 Chapter 6.2.4.5.
4.A.1 Forest land remaining forest land – CO2	Provide information (e.g. a table) in the NIR showing the average growing stock volume (m3/ha) and the stock difference (m3/ha/year) and provide a detailed explanation of why the implied carbon stock change factors for forest land remaining forest land are not in line with the annual stock differences.	L.9	Addressing. Information related to the differences between the estimations on average growing stock volume (m3/ha) and the stock difference (m3/ha/year) has been provided in the NIR 2022 Chapter 6.2.4.3.	-	Resolved NIR 2022 Chapter 6.2.4.3
4.A.1 Forest land remaining forest land – CO2	Provide more detailed information on how the NFI data were factored into the calculation to estimate the growing stock volume since 2009.	L.10	Resolved. Information, provided to the ERT explaining how growing stock volume had been factored in for the 2009–2018 period is amended in the NIR 2022 Chapter 6.2.4.3.	-	Resolved NIR 2022 Chapter 6.2.4.3.
4.A.1 Forest land remaining forest land – CO2	Seek to resolve the issue regarding time-series consistency between 2008 and 2009 for the gross timber resources using IPCC approaches.	L.11	Resolved. Poland reported information on calibration methods applied for pre 2009 AD on gross timber resources in the NIR 2022 Chapter 6.2.4.3.	-	NIR 2022 Chapter 6.2.4.3.
4.A.1 Forest land remaining forest land – CO2	Explore the possibility of using country-specific values for the BEF and the root-to-shoot ratio, and indicate the results of such an attempt and its limitations in the NIR.	L.12	Addressing. Information summarizing recent progress in addressing ERT recommendation will be amended in the NIR 2023 Section 6.2.9.	-	Resolved. NIR 2022 Section 6.2.9.
4.A.1 Forest land remaining forest land – CO2, CH4 and N2O	Use a tier 2 or higher IPCC approach to estimate emissions from both the litter and the deadwood carbon pools.	L.13	Resolved. CSC in deadwood reservoir for category 4.A.1 (4(KP)B.1) has been estimated by application Tier 2 (stock-difference method) as described in the Section 2.3.2.1 of the Volume 4 of the IPCC 2006.	-	NIR 2022 Section 6.2

CRF category/issue	Review recommendation	Review report/ paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
			Additional information will be provided in the relevant section in the Chapter 6.2 of the NIR 2023.		
4.A.2 Land converted to forest land – CO2	Further analyse the NFI data and use data exclusively from age class I (1–20 years) for estimating the carbon stock changes in living biomass and deadwood for land converted to forest land.	L.14	Adressing. Information summarizing recent progress in adressng ERT recommendation will be ammended in the NIR 2023 Section 6.2.9.	-	Resolved. NIR 2023 Section 6.2.9.
4.A.2 Land converted to forest land – CO2	Apply the gain–loss method (tier 2), which follows a more disaggregated approach and allows for more precise estimates of the carbon stock changes in biomass.	L.15	Adressing. Information summarizing recent progress in adressng ERT recommendation will be ammended in the NIR 2023 Section 6.2.9.	-	Resolved. NIR 2023 Section 6.2.9.
4.A.2 Land converted to forest land – CO2	Disaggregate the area converted by species and clarify in the NIR why the conversion occurs only for extensively managed forests and not intensively managed forests, as would be the case for plantations.	L.16	Adressing. Information on the disaggregation of the area by species and explanation on assumptions applied in terms of land to forest land conversions has been provided in the NIR 2022 Section 6.2.5.3.	-	Resolved. NIR 2022 Section 6.2.5.3.
4.A.2 Land converted to forest land – CO2	Provide in the NIR more detailed information on the estimation methods used for the carbon stock changes in the dead organic matter and soil pools.	L.17	Resolved. Information on the estimation methods used for the carbon stock changes in the dead organic matter and soil pools has been provided in the NIR 2022 Sections 6.2.5.4 and 6.2.5.5.	-	NIR 2022 Sections 6.2.5.4 and 6.2.5.5.
4.A.2 Land converted to forest land – CO2	Use a higher-tier method (e.g. using NFI data exclusively from age class I (1–20 years)) to estimate a country-specific biomass increment value to increase the accuracy of the estimate for the land converted to forest land category, and provide the results and the limitations encountered in the next NIR.	L.18	Adressing. Information on the limitations encountered in estimating a country-specific biomass increment value has been provided in the NIR 2022 Section 6.2.5.3.	According to the indication given in the NIR 2022 (section 6.6.8 and) and previous NIR's the national forest inventory does not provide annual aggregated increment data exclusively for age class I (1-20 years) not allowing its application and substitution of the default values. Recent approach based on default method is resulting in a consistent and comparable time series of both area and GHG estimates. It is worth to note that historically assumed i nventory improvements are taking into account utilisation of carbon modelling framework (mainly by introducing CBM CFS) and incorporation of subsequent results into GHG inventory. Recent focus was given to the issue of carbon emission and removal balances by defining gross standing volume by age class for each species in land converted to forest area.	Issue under consideration. NIR 2022 Section 6.2.5.3.
4.A.2 Land converted to forest land – CO2	Account for emissions and removals from deadwood and litter following the 2006 IPCC	L.19	Adressing. Poland is considering of tier 1 approach application to estimate emissions from both the litter and the deadwood carbon pools	According to the indication given in the chapter 11.3.1.2. of the NIR 2022 Justification when omitting any carbon	Resolved. NIR 2022 Section 6.2.5.4.

CRF category/issue	Review recommendation	Review report/paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
	Guidelines (vol. 4, chap. 2.3.2) with the highest possible tier approach.		at the recent stage. Relevant information has been provided in the NIR 2022 Section 6.2.5.4.	pool or GHG emissions/removals from activities under Article 3.3 and elected and mandatory activities under Article 3.4 For FM and AR, Poland informed that does not explicitly quantify emissions and removals for two forest carbon pools, i.e., deadwood and litter for the activity AR and subcategory 4.A.2 Land converted to forest land, but decided to demonstrate that these pools are not a source of GHG emissions. To demonstrate that soils are not a source, a conservative approach is taken based on the IPCC 2006GL methodology using country-specific and other data. The demonstration for DW and LT is based on expert judgment which is a practicable method in our situation (see below). Although, we have focus on emissions and removals estimations from deadwood under subcategory 4.A.1 (and in parallel in activity FM). It should be noted that recent inventory in terms of method applied assumes estimating carbon dynamics of dead organic matter with the estimation procedure described for Tier 2 method, described in the section 2.3.2.1 of the Chapter 2 of the Volume 4 of the IPCC 2006. Unfortunately, estimates are considering the difference in DW pool at two points in time at the level of the aggregated category 4.A and are reported under subcategory 4.A.1.	
4.B.1 Cropland remaining cropland – CO2	Report in the NIR the correct annual EF for cultivated organic soils applied in the inventory and verify the values reported in the inventory for net carbon stock change in organic soils in CRF table 4.B for the entire time series.	L.20	Resolved. Poland reported in its NIR (p.229) the actual EF used (5 t C/ha). It also corrected the data reported in CRF table 4.B such that the IEF is constant for all years.	-	
4.B.2 Land converted to cropland 4.C.2 Land	Update the relevant parts of the NIR to reflect the correct climate zones used for the default biomass carbon stock present in grassland after conversion from other land uses (13.6 t dry matter/ha) and for carbon stock present on	L.21	Resolved. Poland updated relevant parts of the NIR (sections 6.3.4.3, p.226, and 6.4.4.2, p.232) to reflect the correct climate zones.	-	

CRF category/issue	Review recommendation	Review report/ paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
converted to grassland – CO2	annual crops for land converted to cropland one year following conversion (5.0 t C/ha).				
4.C.2 Land converted to grassland – CO2	Use the correct values for change in carbon stocks in biomass on land converted to other land-use category (–4.7 t C/ha) and biomass before conversion (4.7 t C/ha) for annual crops converted to grassland.	L.22	Resolved. Poland has corrected values for change in carbon stocks in biomass on land converted to other land-use category (–4.7 t C/ha) and biomass before conversion (4.7 t C/ha) for annual crops converted to grassland. Updated information has been provided in the NIR 2022 Chapter 6.4.4.2.	-	NIR 2022 Chapter 6.4.4.2
4.D.2 Land converted to wetlands – CO2	Update the NIR to reflect the correct methodology applied for estimating the change in carbon stock for land converted to wetlands, including information on the correct climate zones used.	L.23	Resolved. Poland included an up-to-date description in its NIR (p.240) of the methodology and EFs used for land converted to wetlands, including the correct value for the amount of living biomass before conversion, and removed the incorrect reference to page 6.8 (vol. 4) of the 2006 IPCC Guidelines.	-	
4.D.1 Wetlands remaining wetlands – CO2	Verify the methodology applied for category 4.D.1.1 to estimate net carbon stock change in soils (both mineral and organic soils) and report the values correctly in CRF table 4.D under the appropriate category; report “NE” for net carbon stock change in soils under flooded land (category 4.D.1.2); and update the NIR to reflect the correct methodologies applied for categories 4.D.1.1 and 4.D.1.2 for net carbon stock change in soils.	L.24	Resolved. Updated application of notations keys has been performed in the CRF 2022.	-	CRF 2022 4.D.1.2
4.D.1 Wetlands remaining wetlands 4.D.2 Land converted to wetlands – CO2, CH4 and N2O	Make efforts to estimate CO2-C off-site emissions, CO2-C on-site emissions and N2O emissions managed for peatland extraction (category 4.D.1.1). Improve the description in the NIR by explaining: (a) What type of land is reported under organic soils and how losses in living biomass are calculated under category 4.D.1.1; (b) Why land converted for peat extraction is reported under category 4.D.2.2 (land converted to flooded land); (c) How land converted for peat extraction and land under peat extraction are reported in the inventory; (d) What methods and assumptions are used to estimate the emissions under categories 4.D.1 and 4.D.2.	L.25	Addressing. Poland is developing methodology for differentiating between nutrient-rich and nutrient-poor soils, any available result obtained will be included in the forthcoming submissions. Nevertheless, additional information on methods and assumptions used to estimate the emissions under categories 4.D.1 and 4.D.2 are provided in the NIR 2022 Section 6.5.4.	Issue is still under consideration. In relation to the methodology to differentiate between nutrient rich and nutrient poor soils under WL land use information contained in the database (Spatial Information System on Wetlands/ GIS Mokradła) accessible for the inventory experts since 2020 is expected to be applied. An assessment of the usefulness of GIS Mokradła has been conducted (notably as a part of InCoNaDa project - more: https://inconada.eu/index.php/about-the-project/) Preliminary results (subject to accessibility) are expected to be included in the 2023 inventory.	Issue under consideration NIR 2022 Section 6.5.4.
4.E.2 Land converted to settlements – CO2	Explain in the NIR the decision to apply instant oxidation instead of transition time for estimating carbon stock change in soil organic matter.	L.26	Resolved. Poland has been applied transition time for estimating carbon stock change in soil organic matter. Relevant information has been provided in the NIR 2022 Chapter 6.4.4.2.	-	NIR 2022 Chapter 6.4.4.2.
4.E.2 Land converted to settlements – CO2	Clearly explain in the NIR the reasons for the large increase in deforested area in 2016 under	L.27	Resolved, however still under consideration. The updated information on investigation exercise results (related to the large increase in	Since inventory compilation utilises annual statistics on reported area of forest land designated for non-forest	Resolved, however still under

CRF category/issue	Review recommendation	Review report/ paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
	forest land converted to settlements when compared with other years.		deforested area in 2016) has been provided in the NIR 2022 Section 6.6.1.	purposes as well as on changes in total forest area, the annual information on annual forest land area conversion for non-forest and non-agriculture purposes (independent statistical survey) has been found not in line with the annual changes of total annual forest land (statistical survey on land utilisation). With this explanation, cadastral land statistics (describing forest land area changes) has been considered more accurate and more important for the overall accuracy. With this interpretation information on annual forest land changes in terms of cadastral changes as a matter of the scope while interpreting annual forest land conversions has been applied in the inventory. Although it might lead to potential overestimation of emissions, we assume this is a matter of conservativeness, considering that any emissions should be covered with the inventory, even though they can be potentially lower.	consideration. NIR 2022 Section 6.6.1.
4.E.2.2 Cropland converted to settlements – CO2	Clearly explain the allocation of the emissions and removals from all carbon pools in the category cropland converted to settlements.	L.28	Resolved. Recent application of notation key “IE” in terms of biomass losses in the category cropland converted to settlement is triggered by estimation method of living biomass losses, considering the changes in carbon stocks between biomass in the land prior to conversion and that in the settlements after conversion. Default approach considers cropland biomass stock peaks to be utilised in the above mentioned equation reflecting any potential net changes of carbon stocks over the inventory year to be considered relevant as of the end of the year (eg. as of 31 Dec.).	-	NIR 2022 Chapter 6.4.4.2.
4(V) Biomass burning – CO2	Provide more information on the values used for mass of available fuel, fraction of biomass combusted and EFs to estimate non-CO2 emissions from wildfires.	L.29	Resolved. Information on the mass of forest biomass fuel and the fraction of biomass combusted has been provided in the NIR 2022 Chapter 6.2.4.11. Furthermore, applied combustion factor for forest fires of 0.3 has been updated in line with the 2006 IPCC Guidelines.	-	NIR 2022 Chapter 6.2.4.11
Waste					
5.A Solid waste disposal on land – CH4	Improve the accuracy of estimated emissions from landfills by using the new waste database.	W.1	Not resolved. In the NIR (p.320) and during the review, the Party explained that the new waste database containing facility data is due to be established in 2021. However, it gave no indication of progress in collating new country-specific AD and whether this will enhance the accuracy of Poland's estimates in future inventory submissions.	-	Will be resolved in Submission 2023. NIR Chapter 7.2.2

CRF category/issue	Review recommendation	Review report/ paragraph	MS response/status of implementation	Reason for non- implementation	Chapter/section in the NIR
5.C.1 Waste incineration – CO ₂	Appropriately describe the recalculation in the NIR when reporting the corrected estimates for municipal solid waste incineration.	W.2	Resolved. Poland reported corrected estimates for municipal solid waste incineration, specifically estimates related to the share of biogenic and non- biogenic waste, in CRF table 5.C. Recalculations made in its 2019 submission are described appropriately in its 2020 NIR (section 7.4.5).	-	Resolved
5.D Wastewater treatment and discharge – CH ₄	Improve the transparency of the reporting on sludge removed in domestic and industrial wastewater by including in the NIR the amount of domestic sludge removed under category 5.D.1, disaggregated by final use, and an explanation that the amount of sludge removed under industrial wastewater (category 5.D.2) is zero, in accordance with the IPCC default tier 1 value, given the lack of any data on sludge split by industry. Verify the values reported in NIR table 7.10 with the amount of sludge removed and landfilled (20.67 kt in 2016) in the table provided during the review (and used for the calculation of emissions), and justify and explain the reasons for any significant differences in values.	W.3	Not resolved. During the review, Poland provided a table showing the amount of domestic sludge removed, disaggregated by final use (incinerated, landfilled, applied in agriculture, applied in cultivation for compost production and applied in land reclamation), which allowed the ERT to verify whether sludge removal from wastewater is consistent with the estimates for sludge applied to other uses, as reported in footnote 1 to CRF table 5.D. However, the Party did not include in the NIR the amount of domestic sludge removed under category 5.D.1, disaggregated by final use, or the explanation that the amount of sludge removed from industrial wastewater (category 5.D.2) is zero in accordance with the default value from the 2006 IPCC Guidelines (vol. 5, chap. 6, p.6.9) given the lack of any data on sludge split by industry. During the review, Poland explained that NIR table 7.10 presents the mass of landfilled municipal sludge determined on a dry basis (20.67 kt in 2016), and that this was the reason for the difference in values presented in the NIR with those provided to the ERT during the previous review.	-	Resolved. Information provided in the NIR 2022 chapter 7.5.2.1 and chapter 7.2.2.2
5.D.2 Industrial wastewater – CH ₄	Include a description in the NIR of how wastewater management has evolved over time with regard to the management of industrial liquid effluents.	W.4	Not resolved. During the review, Poland confirmed that the evolution of industrial wastewater management is based on a country-specific study (Przewłocki, 2007) and is presented in NIR table 7.31. However, there was no change in Poland's reporting since the previous NIR, and no analysis was presented in the current NIR of the AD trend with regard to the management of industrial liquid effluents.	-	Will be resolved in Submission 2023. NIR Chapter 7.5.2.2

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non- implementation	Chapter/section in the NIR
TABLE 5					
General					
Uncertainty analysis	The uncertainty analysis included in annex 8 to the NIR (p.447) includes only the final uncertainty values per category and per gas and does not demonstrate the propagation process, including methods used and underlying assumptions. Table 3.3 from the 2006 IPCC Guidelines (vol. 1) should be used to report uncertainty analysis information as well as which categories have been identified as key in the Party's inventory. During the review, the Party clarified that it had included a methodological description in the NIR (pp.447–451) and had decided not to use table 3.3 as it was not mandatory under the UNFCCC Annex I inventory reporting guidelines. While acknowledging the Party's response, the ERT notes that the description of the uncertainties as it is currently given in the NIR does not provide the interim results and is lacking some important parameters used for calculating uncertainties in trend (e.g. type A and type B sensitivity). Using table 3.3 from the 2006 IPCC Guidelines (vol. 1) would enable a more detailed analysis of uncertainty contribution by category and by gas, especially for trend uncertainties, which would enhance the transparency of the	G.2	Not an issue	-	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	inventory. It would also make it easier to compare Poland's GHG inventory uncertainty with that of other Parties included in Annex I to the Convention. The ERT encourages the Party to present the uncertainty analysis using the more detailed tabular approach as given in the 2006 IPCC Guidelines (vol. 1, table 3.3) to make the uncertainty analysis of its GHG inventory more transparent and comparable.				
Uncertainty analysis	Poland reported in its NIR (p.450) that assumptions for forest land (category 4.A) under LULUCF were based on a study of European Union countries (Laitat et al., 2000) in which AD uncertainty was reported as 1–15 per cent, and on the IPCC good practice guidance for LULUCF, which gives an uncertainty range of 10–50 per cent for the CO ₂ EF (chaps. 3.2.1.1.1.4, p.3.50, and 3.2.2.1.1.4, p.3.56). However, Poland applied uncertainty values of 5 per cent for AD and 30 per cent for the CO ₂ EF (NIR, p.450) without providing any rationale for its decision. During the review, the Party clarified that, having analysed the collection and verification system for forest data, it considered the data reliable and accurate. On the basis of that analysis, Poland had decided to apply a lower-range uncertainty value for AD to better reflect its national circumstances. It had based its EFs on default values from the IPCC good practice guidance for LULUCF (p.3.32) and other country-specific EFs available in the literature. Poland considered that the available country-specific EFs incorporated some uncertainty as they reflected sophisticated and uncertain processes. The ERT recommends that the Party (1) include in its NIR a more detailed justification of its choice of uncertainty values for AD and EFs for LULUCF category 4.A (forest land) in order to reflect country-specific circumstances and improve the transparency of its inventory and (2) update the reference to the 2006 IPCC Guidelines default uncertainty values.	G.3	Resolved. (1) Text in the NIR was revised to include more information on choice of assumptions for uncertainty analysis. (2) Reference was corrected	-	
Uncertainty analysis	The overall level and trend uncertainties including and excluding LULUCF reported in the NIR (pp.26 and 447) differ from those reported in the 2019 submission, and no explanation for the differences was provided in the NIR. The ERT notes that providing such an explanation and identifying the key drivers of the differences would enhance the transparency of reporting and make it easier to monitor the impact of changes in different categories on the overall inventory uncertainty values. During the review, the Party clarified that the results of the most recent uncertainty assessment were comparable with those used for the 2019 submission, and that minor variations were attributable to changes in the share of high- and low-uncertainty sources between reported years. It added that F-gas data were constantly improving (HFC uncertainty fell from 14.2 per cent in the 2019 submission to 10.9 per cent in the 2020 submission) as a result of European Union regulations and the availability of data from national F-gas registers for operators and importers. The ERT welcomes this explanation. The ERT encourages the Party to include a transparent explanation of the changes in overall level and trend uncertainties, including and excluding LULUCF, and to identify key drivers of those changes in the next submission.	G.4	Not an issue	-	
Key category analysis	The key category analysis provided in annex I to the NIR (p.362) uses high-level summary tables rather than tables 4.2–4.3 from the 2006 IPCC Guidelines (vol. 1). During the review, the Party clarified that since the introduction of the key category analysis functionality in CRF Reporter, Poland had decided to include in the NIR the results from this software, and noted that using tables 4.2–4.3 from the 2006 IPCC Guidelines was not mandatory under the UNFCCC Annex I inventory reporting guidelines. The ERT encourages the Party to provide a more detailed key category analysis in its NIR, for example by using tables 4.2–4.3 from the 2006 IPCC Guidelines (vol. 1), to improve its inventory reporting and comparability.	G.5	Not an issue	-	
Recalculations	The net effects of recalculations of CO ₂ and CH ₄ emissions and removals reported in the NIR (tables 6.36 (pp.249–250) and 6.37 (pp.251–252), respectively) differed significantly from those reported in CRF table 8s. For example, for 2017, after recalculation, CH ₄ emissions for the LULUCF sector were reported to have fallen by 1.28 kt (85.46 per cent) in CRF table 8s and to have risen by 0.34 kt (24.98 per cent) in NIR table 6.37. The ERT observed similar discrepancies for other years and gases, and no explanations	G.6	Resolved. Information on recalculations reported in the NIR 2022 (tables 6.46, 6.47, 6.48) are based on latest available data, similarly to those reported in CRF table 8s, in	-	NIR 2022, Chapter 6.6.7

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	were given for them in the NIR or CRF documentation boxes. In addition, it noted that explanations included in the NIR for recalculations across all inventory sectors lacked transparency (see ID#s E.9, I.17 and KL.9 below). During the review, the Party clarified that the differences were due to the use of different data. The values reported in the NIR (tables 6.36, 6.37 and 6.38, pp.249–254) were based on data from 14 January 2020, while those reported in CRF table 8s were based on the data provided to the ERT during the review week. The Party added that it had experienced technical difficulties while updating data in the report compilation software. The ERT, noting that in accordance with decision 24/CP.19, annex I, paragraph 44, recalculations should be reported in the NIR with explanatory information and justification, recommends that the Party improve the transparency of its inventory reporting by (1) checking for inconsistencies between the recalculation data included in the NIR and the CRF tables (once the final calculations are complete) and including detailed explanations for any discrepancies that cannot be corrected prior to submission and (2) ensuring that detailed explanations for inventory recalculations are included in the NIR for all sectors, categories and gases.		accordance with decision 24/CP.19, annex I, paragraph 44. Furthermore, recalculations for all categories and gases are reported in the NIR 2022 with explanatory information and justification in Chapter 6.6.7.		
Notation keys	Without providing any explanation for doing so, Poland reported as “NE” CO ₂ emissions from coal mining and handling (category 1.B.1.a) and AD for solvent use (category 2.D.3); N ₂ O emissions from land converted to forest land (category 4.A.2); and carbon stock changes and N ₂ O emissions for AR (mineral soils) (category 4(KP-II)3.A.1) and FM (category 4(KP-II)3.B.1). This is not in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. During the review, the Party clarified that it reported “NE” for CO ₂ emissions for category 1.B.1.a because no data were available for estimating CO ₂ emissions from flaring of CH ₄ released from coal mines. For category 2.D.3, the Party reported “NE” to reflect its decision not to report AD in CRF table 2(I)A-Hs2 for CO ₂ emissions calculated on the basis of non-methane volatile organic compound emissions from solvent use, which would have resulted in a false IEF. Lastly, it did not estimate N ₂ O emissions for categories 4.A.2 (land converted to forest land), 4(KP-II)3.A.1 (AR (mineral soils)) and 4(KP-II)3.B.1 (FM) because they were below the significance threshold (each amounting to less than 0.05 per cent of national total emissions and not exceeding 500 kt CO ₂ eq). The ERT noted that N ₂ O emissions for category 4(KP-II)3.B.1 amounted to 0.09 per cent of national total emissions excluding LULUCF, which is above the 0.05 per cent threshold set out in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. It also noted that the total national aggregate value of estimated emissions for all gases and categories, which the Party considered insignificant and reported as “NE”, was above 0.1 per cent of national total GHG emissions. For the 2018 reporting year these were CO ₂ emissions from coal mining and handling (1.B.1.a) and AD for solvent use (2.D.3); N ₂ O emissions from land converted to forest land (4.A.2); and carbon stock changes and N ₂ O emissions for AR (mineral soils) (4(KP-II)3.A.1) and FM (4(KP-II)3.B.1). The ERT recommends that the Party estimate and report N ₂ O emissions from FM (category 4(KP-II)3.B.1) and CO ₂ emissions from coal mining and handling (category 1.B.1.a) or provide in its NIR an explanation for reporting them as “NE” along with estimates to justify that the corresponding emissions are insignificant in line with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. The ERT also recommends that the Party provide a detailed explanation as to the use of “NE”, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, for all categories for which the notation key “NE” is used and emissions are insignificant.	G.7	Partially resolved / addressing. Resolved in the area of N ₂ O emissions from land converted to forest land (category 4.A.2); and carbon stock changes and N ₂ O emissions for AR (mineral soils) (category 4(KP-II)3.A.1) were estimated. N ₂ O emissions from forest land remaining forest land (category 4.A.1), and N ₂ O emissions for 4(KP-II)3.B.1 (mineral soils) will continue to be reported by application of notation key “NE” taking into account the annual change in organic carbon stocks in mineral soils ($\Delta C_{\text{mineral}}$) is estimated with the positive values for the whole reporting period. Therefore, annual loss of soil organic carbon ($\Delta C_{\text{mineral}}$) to applied in the Equation 11.8 (Chapter 11 of the Volume 4 of IPCC 2006) for this particular land-use type is not observed.	-	Resolved. CRF Table 4(III)4.A.2, Table 4(KP-II)
Notation keys	Poland reported indirect CO ₂ emissions from the atmospheric oxidation of non-methane volatile organic compounds under solvent use (category 2.D.3 of the IPPU sectoral tables) but reported “NA” for indirect CO ₂ emissions for the IPPU sector in CRF table 6. The ERT noted that the indirect CO ₂ emissions reported in the CRF sectoral tables are accounted for as direct CO ₂ emissions in the CRF summary tables and in national totals, whereas the UNFCCC Annex I inventory reporting guidelines (para, 29) state that Parties that decide to report indirect CO ₂ emissions shall present their national total emissions including	G.8	Implemented in submission 2023. Emission of CO ₂ from solvents reported as indirect CO ₂ .	-	Resolved

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	and excluding indirect CO ₂ emissions. During the review, the Party stated that it is analysing its reported indirect CO ₂ emissions as part of its efforts to harmonize its approach with that of other European Union member States and that it will make any changes necessary in next submission. The ERT recommends that Poland, as a Party that has elected to report indirect CO ₂ emissions in its inventory, present in its next submission its national total emissions including and excluding indirect CO ₂ emissions.				
Notation keys	Poland reported "IE" in the CRF tables without including an explanation for the allocation in the documentation boxes of the CRF tables or in the NIR for the following categories: 2.C.1.a (steel) (CO ₂ , CH ₄), 2.F.1.c (industrial refrigeration), 4(IV) (indirect N ₂ O emissions from managed soils/atmospheric deposition), 4.A.1 (forest land remaining forest land)/4(I) (direct N ₂ O emissions from N inputs to managed soils/inorganic N fertilizers), 4.A.1 (forest land remaining forest land)/4(I) (direct N ₂ O emissions from N inputs to managed soils/organic N), 4.A.2 (land converted to forest land)/4(I) (direct N ₂ O emissions from N inputs to managed soils/inorganic N fertilizers), fertilizers, 4.A.2 (land converted to forest land)/4(I) (direct N ₂ O emissions from N inputs to managed soils/organic N fertilizers) and 2.F.1.c (industrial refrigeration) (HFC-125, HFC-134a and HFC-143a). According to decision 24/CP.19 (annex I, para. 37(d)), where "IE" is used in an inventory, the Party should indicate in the CRF completeness table where in the inventory the emissions or removals for the displaced source or sink category are included and explain why the data are not included under the expected category. During the review, the Party clarified that emissions from industrial refrigeration and commercial refrigeration were reported together owing to a lack of detailed data, and that the missing explanations will be provided in the next submission. The ERT encourages the Party to provide an explanation in its next submission for all categories for which data are not included under the expected category when "IE" is reported.	G.9	Not an issue	-	
QA/QC and verification	While acknowledging the considerable efforts made by the Party to address the QA/QC issues raised in previous review reports, the ERT observed a number of further QA/QC issues in all sectors in the 2020 submission, including inconsistencies between the NIR and the CRF tables (see ID#s E.11, L.30, L.33, L.34 and W.5 below) and a few references that were missing or incorrect in the NIR. The ERT recommends that the Party enhance general QC procedures, as described in the 2006 IPCC Guidelines (vol. 1, table 6.1) for each inventory sector. It encourages Poland to apply category-specific QC procedures for key categories and for individual categories for which significant methodological changes and/or data revisions have occurred, in accordance with the 2006 IPCC Guidelines.	G.10	Resolved. Poland improved QA/QC procedures to eliminate number of QA/QC issues. Internal procedures were changed to ensure consistency between NIR and CRF. Revision of text in the NIR corrected missing or incorrect references.	-	
Energy					
1.A Fuel combustion – sectoral approach – solid fuels – CO ₂	The Party reported in the NIR (p.44) its derivation of a country-specific EF for CO ₂ emissions from hard coal combustion, but did not provide references for the methodology applied in deriving this EF. During the review, the Party provided clarification on its assumptions and references for the technical documents used in deriving the country-specific EF. The ERT recommends that the Party include in its NIR the references used in developing country-specific EFs for CO ₂ emissions from hard coal combustion.	E.8	Resolved. Wider information is given in addressed chapter of NIR	-	Chapter 3.1.1
1.A.1 Energy industries	The Party reported in its NIR (section 3.2.6.5, p.61) significant recalculations for category 1.A.1 but did not provide any explanation for these in the NIR or CRF tables. The ERT noted that this is not in accordance with the UNFCCC Annex I inventory reporting guidelines. During the review, the Party clarified that the recalculations reflected the reallocation of fuels between categories 1.A.1.a and 1.A.1.b in line with energy balance corrections by Eurostat. The Party provided extracts from the energy balance for illustrative purposes. The ERT recommends that the Party include in its next submission a detailed explanation (justification and impact) of the recalculations performed.	E.9	Resolved. The main reasons for recalculation are explained in the relevant recalculation subchapters (e.g. 3.2.6.5). If there are very significant recalculations, the information about the reasons will be extended.	-	Recalculation subchapters

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
1.A.3.b Road transportation – liquid fuels – N2O	The N2O IEFs for gasoline for road transport for 2015, 2016, 2017 and 2018 under CRF table 1.A(a), category 1.A.3.b (1.68 kg/TJ in 2018), were below the IPCC default range of 3.2–8.0 kg/TJ for N2O (2006 IPCC Guidelines, vol. 2, table 3.2.2). During the review and in the NIR (section 3.2.8.2.2, p.77), the Party clarified that emissions from road transport were derived using COPERT V. The ERT recommends that the Party include in the next NIR justification for, and more detailed information on, its use of a COPERT V EF, including a comparison and explanation of the differences between the emissions obtained using COPERT V and the lower-tier methods provided in the 2006 IPCC Guidelines.	E.10	Resolved. In NIR justification, Poland provides more detailed information on the use of COPERT V EF, including a comparison and explanation of the differences between the emissions obtained using COPERT V and the provided lower-order methods in the 2006 IPCC Guidelines.	-	NIR chapter 3.2.8
1.A.3.b.iii Heavyduty trucks and buses – biomass and other fossil fuels	The Party reported in NIR table 3.2.8.4 and CRF table 1.A(a)s3 for the source category 1.A.3.b.iii (heavy-duty trucks and buses) different AD values for fuel totals but the same value for biomass and other fossil fuels. During the review, the Party clarified that the data reported in the CRF table are incorrect, and that the value for biomass and other fossil fuels should be 2,381.95 TJ rather than 19,444.24 TJ. It indicated that the error does not affect emissions and these data will be corrected in the next submission. The ERT recommends that the Party include in its next submission corrected data on biomass and other fossil fuels consumed in the source category 1.A.3.b.iii.	E.11	Resolved. Revised data for biomass and other fossil fuels consumed in source category 1.A.3.b.iii have been included in this submission.	-	CRF table 1.A(a)3
IPPU					
2.A.3 Glass production – CO2	The Party reported in its NIR (p.120) that a cullet ratio of 20 per cent was used for glass production, which is at the lower end of the range given in the 2006 IPCC Guidelines (vol. 3, table 2.6, p.2.30). During the review, the Party clarified that data on the turnover of waste suitable for recycling in production and commercial units were taken from statistical yearbooks published by Statistics Poland. On the basis of its analysis of those data, the Party indicated that the amount of cullet used in glass production in Poland is lower than the default value provided in the 2006 IPCC Guidelines. Noting that, in any event, cullet consumption in glass production is reported with relatively high uncertainty, the Party applied a cullet ratio of 20 per cent for the entire time series. The ERT recommends that the Party include in the NIR a justification for the use of a 20 per cent cullet ratio for estimating CO2 emissions from glass production.	I.11	Resolved. The description in NIR was extended in line with the recommendation.	-	Chapter 4.2.2.3
2.A.4 Other process uses of carbonates – CO2	The Party reported in its NIR (p.121) that for ceramic production (category 2.A.4.a) the AD were taken from Statistics Poland and the CO2 EF was taken from the EU ETS. However, it is not clear from the information reported in the NIR whether those two data sources cover artisanal production. During the review, the Party clarified that as the EU ETS sets threshold production values for ceramic producers, production volume data for this category were taken from Statistics Poland on the assumption that they would be more appropriate for determining AD. These data were the result of an annual survey on the production of all goods manufacturers and service providers in the national economy employing 10 or more people. The Party explained that since the 2006 IPCC Guidelines do not provide default EFs for CO2 emissions based on ceramic production, country-specific EFs were determined for each year on the basis of data reported by installations covered by the EU ETS. The ERT recommends that the Party include in its next submission the information provided during the review that clarifies the inclusion of artisanal production of ceramics in the AD from Statistics Poland and the development of CO2 EFs on the basis of data reported by installations covered by the EU ETS.	I.12	Resolved. The description in NIR was extended in line with the recommendation.	-	Chapter 4.2.2.4.
2.B.1 Ammonia production – CO2	The Party reported in the NIR (section 4.3.2.1 and annex 3.2, table 2) that CO2 recovery from ammonia production occurs. However, the ERT noted that in CRF table 2(l)As-Hs1, O2 recovery was reported as "NA". It also noted that the CO2 emissions reported in CRF table 2(l)As-Hs1 are net (i.e. emissions from ammonia production minus CO2 recovery for urea production), while the CRF table allows for separate reporting of gross emissions and recovery for urea production. During the review, the Party clarified that it reported "NA" because it encountered technical difficulties when entering numerical data. It confirmed that CO2 recovery from ammonia production occurs and was subtracted from the emissions	I.13	Resolved. Data in the CRF is provided according to recommendation	-	CRF table 2(l)As-Hs1

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	for category 2.B.1. It indicated that it will try to provide numerical values for such recovery in the next submission. The ERT recommends that the Party separately report CO ₂ emissions from ammonia production and recovery for urea production in CRF table 2(l)As-Hs1 to improve the comparability of the corresponding IEF and the transparency of the reporting.				
2.B.1 Ammonia production – CO ₂	Poland reported in its NIR (annex 3.2, table 2) urea production (1,267.14 kt) and 929.23 kt CO ₂ recovered in ammonia production. Urea production is reported as 563.04 kt (with 412.90 kt CO ₂ released) in CRF table 3.G-I and 434.73 kt (with 47.17 kt CO ₂ released) under category 2.D.3 (use of urea in vehicle catalysts). The ERT noted that a net amount of urea of 269.37 kt and corresponding CO ₂ emissions remained unaccounted for in the inventory. During the review, the Party clarified that in addition to the domestic production and other uses of urea accounted in the inventory, there were urea imports and exports. It provided estimates for these imports and exports based on Eurostat data converted from kg N. The ERT recommends that the Party include in its NIR a description of the urea balance, as explained to the ERT during the review, to ensure that all uses of urea, including imports and exports, are taken into account in the inventory.	I.14	Resolved. The description in NIR has been extended.	-	Chapter 4.3.2.1.
2.B.4 Caprolactam, glyoxal and glyoxylic acid production – N ₂ O	The Party reported in its NIR (p.129) an EF of 4.74 kg N ₂ O/t caprolactam for the entire time series. This EF, taken from a 2001 Polish study (Kozłowski, 2001), amounts to 53 per cent of the IPCC default value, which falls outside the 60–100 per cent default range of the tier 1 method (see 2006 IPCC Guidelines, vol. 3, p.3.37). During the review, the Party clarified that it was conducting analyses with a view to updating the country-specific N ₂ O EF for caprolactam production on the basis of data from installations producing that compound. On the basis of the data already obtained, the Party indicated that the N ₂ O EF for recent years appeared to be even lower than the EF currently used in the inventory. The ERT recommends that the Party include in its next submission the outcome of its analysis of the EF for caprolactam production and, if the EF is revised, provide a consistent time series of emissions and an explanation of the recalculations performed.	I.15	Resolved. New country specific EFs for emission of N ₂ O from caprolactam production were applied for the years 2015-2020.	-	Chapter 4.3.2.4
2.B.7 Soda ash production – CO ₂	The Party reported emissions from soda ash production under the energy rather than the IPPU sector (NIR, para. 4.3.2.7), which is not in accordance with the 2006 IPCC Guidelines (vol. 3, chap. 3.8). During the review, the Party clarified that national statistics provide only an aggregate value for coke used in the production of all chemicals, which it reported under category chemical industry (1.A.2.c). This made it difficult to distinguish emissions from the consumption of coke for soda ash production alone. In addition, the Party could not transfer CH ₄ and N ₂ O emissions from coke consumption from category 1.A.2.c to category 2.B.7 because the cells related to those gases in the IPPU sectoral CRF table for 2.B.7 were greyed out. Moreover, according to the Party, if the coke consumption was reallocated to 2.B.7, then the IEFs for CH ₄ and N ₂ O would be inconsistent. The Party considered that it should continue to report emissions from coke used in the production of soda ash under category 1.A.2.c and change the notation key reported for category 2.B.7 from “NO” to “IE” (with a cross-reference to category 1.A.2.c). The ERT recommends that the Party include in its next submission the explanation provided during the review as the rationale for reporting CO ₂ emissions from coke used in soda ash production under the energy rather than the IPPU sector, and to change the notation key reported for category 2.B.7 from “NO” to “IE”.	I.16	Resolved. Notation Key was corrected in the CRF. Explanation was included in appropriate chapter of NIR.	-	Chapter 4.3.2.7
2.D.1 Lubricant use – CO ₂	CRF table 2(l).A-Hs2 shows an inter-annual reduction of 2 per cent in the IEF for CO ₂ emissions from lubricant use in 2018 (from 0.62 to 0.60 t/t). During the review, the Party clarified that CO ₂ emissions from lubricant use were estimated using AD from Eurostat on non-energy consumption of lubricants. However, since the Eurostat data were expressed in energy units (TJ) and the CRF table was to be completed in mass units (kt), older data expressed in kt were reported in the CRF table for the entire time series, resulting in the inter-annual change in the CO ₂ IEF. The Party indicated that the	I.17	Resolved. CO ₂ emissions related to lubricant consumption is now calculated based on TJ values using constant calorific value therefore IEFs remain constant.	-	

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	consumption data in the CRF table will be updated in the next submission on the basis of available data from Eurostat expressed in TJ and the corresponding net calorific values. The ERT recommends that the Party clearly report on differences in the CO ₂ IEF for the latest reporting year where Eurostat data for lubricant consumption are not available in the unit of reporting, and ensure the accurate conversion of values from TJ to kt as an AD unit.				
2.D.3 Other (nonenergy products from fuels and solvent use) – CO ₂	The CO ₂ IEF for urea use in transport (2.D.3.c) was reported as 0.11 t/t in the CRF tables. The ERT noted that Parties with similar conditions to Poland (such as Czechia, Estonia, Hungary and Lithuania) reported an IEF of 0.24 t/t for the same category. During the review, the Party clarified that it used COPERT V for estimating CO ₂ emissions from urea-based catalyst additives in catalytic converters, and that the AD value of 434.73 kt given in CRF table 2(I)A-Hs2 for 2018 represented the amount of urea solution at a concentration of 32.5 per cent rather than the amount of pure urea. The ERT recommends that the Party report more transparently on the AD and unit of measurement used (kt urea or kt urea solution) to enable a more accurate comparison of CO ₂ IEFs among Parties.	I.18	Resolved. CO ₂ emissions and activities for urea use in transport (2.D.3.c) have been calculated according to the latest COPERT methodology. The corrected values have been added to the CFR Table2 (I).A-Hs2 (for which the CO ₂ IEF is 0.26 t/t).	-	
2.F.1 Refrigeration and air conditioning – HFCs	In response to a previous recommendation (see ID# I.7 in table 3), the Party reported in the NIR (p.154) that the market for air-conditioned passenger cars, including imports, opened in 2000. However, in the same explanation, the Party stated that these imports consisted of used cars from Western Europe. The ERT noted that the Party appeared to apply the same lifetime to these used cars as to new air-conditioned cars (i.e. 15 years), which may be too long. During the review, the Party clarified that the 15-year lifetime was applied to all cars in the F-gas inventory on the basis of their production date, and not their import date. The ERT recommends that the Party include in its next submission the explanation regarding the lifetime of imported vehicles provided during the review to improve the transparency of the reporting of the applied methodology and assumptions for F-gas emissions from mobile air conditioning.	I.19	Resolved. Explanation included in the NIR as separate paragraph	-	p.155
2.F.1 Refrigeration and air conditioning – HFCs	The Party reported HFC emissions from industrial refrigeration (2.F.1.c) as “IE” under stationary air conditioning (2.F.1.f) in the CRF tables and not under commercial refrigeration (2.F.1.a) as stated in the NIR (p.165). It is the opinion of the ERT that refrigeration applications are quite different from air-conditioning applications in terms of manufacturing and operational losses. During the review, the Party reported that emissions from industrial refrigeration were included in stationary air conditioning as a result of an editorial error and will be adjusted in the CRF tables in the next submission. It stated that all HFC emissions from industrial refrigeration are reported under commercial refrigeration (2.F.1.a) and indicated that it will improve the description of the allocation of HFCs from 2.F.1.c to 2.F.1.a in the NIR. The ERT recommends that the Party provide transparent information in both the CRF tables and the NIR on the inclusion of HFC emissions from industrial refrigeration (2.F.1.c) under commercial refrigeration (2.F.1.a) (see also ID# G.9 above).	I.20	Resolved. Description was corrected and misleading information was removed.	-	CRF and NIR p.167
2.F.1 Refrigeration and air conditioning – HFCs	The ERT noted that the shares of different substances used in blends in air conditioning and refrigeration equipment listed in NIR tables 4.7.2–4.7.7 do not add up to 100 per cent for each application. During the review, the Party clarified that this is because some substances are not covered by the UNFCCC Annex I inventory reporting guidelines, but stated that it will present the shares such that they add up to 100 per cent to allay any confusion in the next submission. It confirmed that all required F-gases were estimated under category 2.F.1. The Party also clarified that all items (passenger cars, public transportation and trucks) listed in NIR table 4.7.7 for HFC-134a used in different types of mobile air conditioning are reported under category 2.F.1.e, and that 0 per cent is reported for passenger cars for 2018 because no passenger cars containing HFC-134a were produced in Poland that year. It added that emissions from trucks cover only cabin air conditioning, since refrigeration of cargo is reported under category 2.F.1.d (transport refrigeration). The ERT recommends that the Party transparently report on the shares of substances and blends used in air conditioning and refrigeration	I.21	Resolved.	-	Way of presenting information in NIR tables 4.7.2–4.7.7 was changed and now percents are summing up to 100%

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	and include a description of the definition of the reported shares of different substances used in blends in air conditioning and refrigeration equipment in line with the information provided during the review in its next NIR.				
2.F.2 Foam blowing agents – HFC-134a	The ERT noted that the inter-annual relationship between new manufactured products, manufacturing emissions, stocks and emissions from stocks for HFC-134a for 1999–2004 does not reflect the formula applied by the Party from the 2006 IPCC Guidelines (vol. 3, equation 7.7) for calculating operating stock and corresponding emissions for those years. The Party acknowledged that the estimated volume of HFC-134a contained in operating stock is incorrect for 1999–2004, leading to an overestimation of emissions. It indicated that it will align the formula with that used for 2005 onward. The ERT recommends that the Party revise the formula for calculating operating stock and corresponding emissions for 1999–2004, review the entire time series for HFC-134a contained in foam blowing agents in the light of this revision and report on any resulting recalculations in its next submission.	I.22	Resolved. Formula corrected	-	
Agriculture					
3.B Manure management – N2O	Poland reported in NIR table 5.3.9 country-specific Nex rates for manure disaggregated by livestock category (see ID# A.6 in table 3) but did not include any information on the origin of those values. The values for broilers and turkeys – 0.2 and 1.6, respectively – are below the 2006 IPCC Guidelines default values of 0.36 and 1.84, respectively. According to the NIR (section 5.3.6, p.190), the update of Nex rates is still among the source planned improvements. During the review, the Party noted that a more comprehensive analysis of the parameters used to calculate Nex rates for poultry was performed using data received from the national Institute of Soil Science and Plant Cultivation, and that the results of a comparison outlined in the NIR (table 5.3.12, p.189) demonstrate that the Nex rates for poultry in Poland are very similar both to those of other countries and to default values from the 2006 IPCC Guidelines. The ERT recommends that the Party implement the planned improvement to update the Nex rates for manure and include in the NIR more information on the sources, methods, parameters and references used in calculating country-specific Nex rates and N2O emissions for cattle.	A.11	Wider information is given on Nex values applied in emission calculations	-	Resolved. NIR Chapter 5.3.2.2
LULUCF					
Land representation	The total area of Poland is reported in CRF table 4.1 as 31,270.53 kha for most years, but not for 1993, 1995, 1996, 1997, 2006, 2009 and 2015. Poland stated in the NIR (section 6.1.3, p.209) that fluctuations in total area are caused by differences in statistical survey results and a changing coastline and that they are reflected under other land (category 4.F). However, the ERT noted that this did not explain why the same total area was reported for all but seven years. The ERT also noted that the final area of grassland for 2015 is reported as 4,150.131 kha in CRF table 4.1, while the initial area for 2016 is reported as 4,172.971 kha, and that the difference is equal to the difference in the total reported area of Poland between the two years. During the review, Poland clarified that the total reported area for all land-use categories is equal to the total land area of Poland according to official annual land-use statistics published by Statistics Poland. It added that while it had noticed an error in CRF table 4.1 related to an area of settlements converted to grassland for the years in question, the correct data were used in the calculation of emissions reported in CRF table 4.C. The ERT recommends that the Party correct CRF table 4.1 for 2015, review this value for other years where the total area is not equal to 31,270.53 ha, and include explanations for any such deviations in its next NIR.	L.30	Resolved. CRF table 4.1 (LTM) for 2015 has been corrected. Corrected information is provided in CRF 2021 (Submission 2023) Table 4.1	-	CRF 2021 (Submission 2023) Table 4.1
Land representation	Poland provided detailed information in its NIR (pp.438–443) on the land-use matrices reported under both the Convention and the Kyoto Protocol. However, the ERT noted that there was very little detail on how the matrices were determined and how annual land-use changes were estimated. During the review, Poland provided additional information to the ERT on the Program of Statistical Research of Public Statistics outlining the data sources for each land category of the 2006 IPCC Guidelines and the	L.31	Resolved. Information on the data sources and the hierarchy of data sets used for the estimation of annual land-use changes has been presented in the chapter chapter 6.1.3	-	NIR 2022 Chapter 6.1.4

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	hierarchy of available data sets used. The ERT recommends that the Party include in its next submission information on the data sources and the hierarchy of data sets used for the estimation of annual land-use changes.				
4.B.1 Cropland remaining cropland – CO ₂	Poland reported in its NIR (pp.227–228) the percentage of different soil types under cropland remaining cropland. The ERT noted that the soil type distribution has been constant since 2000 and that this results in a linear trend in emissions towards equilibrium, due to be reached in 2020. During the review, Poland acknowledged that there had been no recent assessments of soil type distribution under cropland remaining cropland. The ERT recommends that the Party include justification in its NIR for the absence of soil type changes under cropland remaining cropland since 2000.	L.32	Resolved. Assessments of soil type distribution under cropland remaining cropland has been considered. Additional information is to be found in the chapter 6.2.5.5	-	NIR 2022 chapter 6.2.5.5
4.B.1 Cropland remaining cropland – CO ₂	Poland reported in its NIR (p.228) the default stock change factors used in the calculation of CO ₂ emissions for this category. The ERT noted that the Party had used the default values for temperate/boreal dry climates (in tables 6.19 and 6.24 of the NIR), while in the previous review report, Poland indicated that it had used values for wet/moist climates. During the review, Poland clarified that CO ₂ emissions had in fact been calculated using the default values for temperate/boreal moist climates. The ERT recommends that the Party correct the information in its NIR on the default stock change factors used in the calculation of CO ₂ emissions, which are those for temperate/boreal moist climates.	L.33	Resolved. Information in its NIR on the default stock change factors used in the calculation of CO ₂ emissions has been corrected. Additional information is to be found in the chapter 6.3.4.2	-	NIR 2022 chapter 6.3.4.2
4.C.1 Grassland remaining grassland – CH ₄ and N ₂ O	The IEFs reported in CRF table 4(V) for CH ₄ and N ₂ O emissions from wildfires under grassland remaining grassland for 2018 – 0.041078 t/ha for CH ₄ and 0.0022724 t/ha for N ₂ O – were both 170 per cent higher than the IEFs reported for 2017, after having been constant since 1990. During the review, Poland clarified that an incorrect burning efficiency factor had been applied in the calculation of those IEFs. The ERT recommends that the Party correct the error in the burning efficiency factor used to estimate the emissions from wildfires under grassland remaining grassland for 2018.	L.34	Resolved. Burning efficiency factor used to estimate the emissions from wildfires under grassland remaining grassland has been corrected.	-	NIR 2022 chapter 6.4.4.5
4.C.1 Grassland remaining grassland – CO ₂	Poland reported in its NIR (p.233) the percentage of different soil types under grassland remaining grassland. The ERT noted that the soil type distribution has been constant since 2000 and that this results in a linear trend in emissions towards equilibrium, due to be reached in 2020. During the review, Poland acknowledged that there had been no recent assessments of soil type distribution under grassland remaining grassland. The ERT recommends that the Party include justification in its NIR for the absence of soil type changes under grassland remaining grassland since 2000.	L.35	Resolved. Assessments of soil type distribution under grassland remaining grassland has been considered. Additional information is to be found in the chapter 6.4.4.3	-	NIR 2022 chapter 6.4.4.3
4.C.1 Grassland remaining grassland – CO ₂	The default factors reported by the Party (NIR, p.234) for calculating emissions from the input of organic matter showed a stock change factor of 1.11, which corresponds to the high level indicated in the 2006 IPCC Guidelines (vol. 4, chap. 6, table 6.2). No information was provided in the NIR on why the high level was chosen over the medium level. During the review, Poland clarified that grassland underwent multiple improvements (e.g. fertilization and irrigation) and thus qualified for the high-level input in accordance with the 2006 IPCC Guidelines. The ERT recommends that the Party clarify the management practices for grassland, including whether the entire grassland area is subject to multiple improvements, to explain the high stock change factor for input of organic matter.	L.36	Resolved. Clarification for the management practices for grassland, including whether the entire grassland area is subject to multiple improvements, as well as explanation for the high stock change factor for input of organic matter has been provided in the section 6.4.4.3	-	NIR 2022 chapter 6.4.4.4
4.E.2 Land converted to settlements – CO ₂	The Party reported “IE” for gains under carbon stock change in living biomass in CRF table 4.E for cropland converted to settlements (4.E.2.2) (see also ID# L.28 above) and grassland converted to settlements (4.E.2.3) for 1988–2018. However, it did not include any comments in the relevant cells of the table or any information in the documentation box to indicate the allocation of those gains. During the review, the Party clarified that any gains were included under losses since the default cropland and grassland biomass stock peaks were used in equation 2.16 of the 2006 IPCC Guidelines (vol. 4). The ERT recommends that the Party explain in both the CRF tables and the NIR the use of the notation key “IE” for gains under carbon stock change in living biomass.	L.37	Resolved. Clarification for notation key “IE” application “IE” for gains under carbon stock change in living biomass in CRF table 4.E for cropland converted to settlements (4.E.2.2) and grassland converted to settlements (4.E.2.3) for 1988–2018 to be found in the section 6.6.4.2	-	NIR 2022 chapter 6.6.4.2

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
4(II) Emissions/removals from drainage and rewetting and other management of organic/mineral soils – N ₂ O	Poland did not report N ₂ O emissions from drained forest soils despite default EFs being available in the 2006 IPCC Guidelines (vol. 4, table 11.1). During the review, Poland stated that the Forest Act of 28 September 1991 and the Protection of Agricultural and Forest Land Act of 3 February 1995 limited drainage activities on forest soils. The ERT recommends that the Party provide evidence in the NIR that the cited laws prevent the draining of forest soils.	L.38	Resolved. Evidences proving prevention of the draining of forest soils (such as legal constrains) are provided in the NIR 2022 Chapter 11.6.1	-	NIR 2022 Chapter 11.6.1
Waste					
5.A Solid waste disposal on land – CH ₄	The Party reported values in the range of 0.12–0.20 for DOCf in CRF table 5.A for all disposal site classifications and inventory years despite indicating in the NIR (p.263) that it had applied the 2006 IPCC Guidelines default value (0.5). During the review, the Party clarified that it had applied the default DOCf value of 0.5 in its calculations. The ERT recommends that the Party correct its reporting error in CRF table 5.A for the DOCf parameter.	W.5	Resolved. Recommendation will be implemented in upcoming submission.	-	NIR 2022 Table 7.2
5.B.1 Composting – CH ₄ and N ₂ O	The ERT noted significant inter-annual changes in the amount of waste treated for composting for 1990/1991 (260.1 per cent), 1993/1994 (68.4 per cent), 1994/1995 (–84.8 per cent) and 2017/2018 (95.5 per cent). It also noted that the Party did not provide any explanation in its NIR for the resulting emission trend for category 5.B.1. During the review, the Party indicated that waste data are currently taken from the national statistics, and it is investigating alternative data sets (e.g. those based on local authorities' fee collection systems) to improve the accuracy of its reporting for this category. The ERT recommends that the Party report on the results of its investigation of available alternative data sets that would improve the reporting for category 5.B.1 in its NIR and recalculate emissions, if appropriate, while also better describing the emissions trend.	W.6	Results of investigation will be available this year, installation data are currently under analysis.	-	NIR 2022 Chapter 7.3
5.B.2 Anaerobic digestion at biogas facilities – CH ₄ and N ₂ O	The Party reported in its NIR (p.275) that it planned to examine the possibility of estimating GHG emissions from anaerobic digestion of organic waste, which implies that the activity occurs in Poland, yet the Party also reported "NO" and "NA" in CRF table 5.B for emissions of CH ₄ and N ₂ O, respectively, from anaerobic digestion at biogas facilities (category 5.B.2). During the review, the Party provided additional information and noted that it should report (1) "NO" for 1988–2004, as the first anaerobic digestion plant was established in 2005; (2) "NE" for 2005–2012, as the CH ₄ emissions of 0.73 kt from the digestion of 917.1 kt of waste for 2012, according to the National Support Centre for Agriculture, was below the threshold of significance set out in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, excluding recovery; and (3) "IE" for 2013–2018, since cumulative data on composting and anaerobic digestion for 2013, as provided by Statistics Poland, are reported under category 5.B.1 (composting). The ERT, while welcoming the clarification, recommends that the Party report emissions separately for anaerobic digestion of organic waste (5.B.2) in its future submissions. If this is not possible, Poland should explain the allocation of emissions between categories 5.B.2 and 5.B.1 (composting) in its NIR and revise its use of notation keys. For the period 2005–2012, Poland should include its emissions under category 5.B.2 – even if deemed insignificant – in order to provide a consistent time series	W.7	Resolved. Recommendation will be implemented in upcoming submission.	-	NIR 2022 Chapter 7.3
5.D.1 Domestic wastewater – CH ₄	The Party reported in its NIR (p.281) a country-specific methane correction factor value of 0.05 for well-managed wastewater treatment plants. The ERT noted that this value was taken from a study (Bernacka, 2005) published at a time when less than a third of urban wastewater and less than 10 per cent of rural wastewater was being treated by well-managed wastewater treatment plants in Poland, compared with over 90 per cent and over 40 per cent, respectively, according to the latest data presented by the Party for 2018 (NIR table 7.23). During the review, the Party clarified that the only available domestic data source on the methane correction factor for well-managed wastewater treatment plants is the 2005 study. The ERT recommends that the Party evaluate the appropriateness of the country-specific	W.8	Resolved. Recommendation will be implemented in upcoming submission.	-	NIR 2022 Chapter 7.5

CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Reason for non-implementation	Chapter/section in the NIR
	methane correction factor value (0.05) applied for well-managed wastewater treatment plants given the changing nature of wastewater handling in Poland since the publication of the referenced study (Bernacka, 2005), and justify the continued application of that value in its NIR.				

ABBREVIATIONS

AR	Afforestation/ Reforestation
AR 5	IPCC Fifth Assessment report on climate change
AWMS	Animal waste management system
BEF	Biomass expansion factor (LULUCF)
BOD	Biochemical Oxygen Demand
CBDK	Central Database of Equine
CEP	Climate and Energy Package
COD	Chemical Oxygen Demand
CRF	Common reporting format
D	Deforestation
DOC	Degradable organic component
DW	Dead wood
ERT	Expert Review Team
FM	Forest management
GHG	Greenhouse Gases
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HWP	Harvested wood products
IE	Included elsewhere
KOBIZE	National Centre for Emissions Management
LT	Litter
LULUCF	Land use, land-use change and forestry
MCF	Methane correction factor (Waste)
MCF	Methane Conversion Factor (Agriculture)
MSW	Municipal solid waste
NA	Not applicable
NE	Not estimated
NO	Not occurring
NMVOC	Non-methane volatile organic compounds
PFCs	Perfluorocarbons
SOC	Soil organic carbon
SWDS	Solid waste disposal site
TC	Technical correction

REFERENCES

- ARR (2020). Report of the individual review of the annual submission of Poland submitted in 2020. FCCC/ARR/2020/POL. 5 July 2021. UNFCCC.
- Background Papers, IPCC Expert Meetings on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories;
<http://www.ipcc-nggip.iges.or.jp/public/gp/gpg-bgp.htm>
- BDO. KOBIZE Waste Database, 2023.
- Bernacka (2005). Bernacka J., Pawłowska L. Elaboration and analysis of data regarding GHG emissions from municipal wastewater management (in Polish). Institute of Environmental Protection, Warsaw 2007.
- Bureau for Forest Management and Geodesy Reports (1968-2020). Annual update of forest area and woody biomass in State Forests at 1 January. Forest Management and Geodesy Bureau. Warsaw. 1969-2021 (in Polish).
- Bureau for Forest Management and Geodesy (2016- 2021) Reports of forest management data and for forecasts <https://www.bdl.lasy.gov.pl/portal/zestawienia-en>.
- Bureau for Forest Management and Geodesy (2016-2020) Reports of National Forest Inventory (<https://www.bdl.lasy.gov.pl/portal/zestawienia-en>).
- CEPiK, Polish Central Vehicle and Driver Register system.
- CSO. Database of Central Waste Management System. Ministry of the Environment, 2019.
- Czuraj (1991). Tables of log's timber volume and standing trees (in Polish). PWRiL. Warsaw 1991.
- EMEP (2023). National inventory of SO₂, NO_x, CO, NH₃, NMVOCs, PMs, heavy metals and POPs for 1990–2021 according to SNAP and NFR classifications (in Polish). Report elaborated in the National Emission management Centre accepted by the Ministry of the Environment.
- EMEP/EEA GB (2016). EMEP/EEA air pollutant emission inventory Guidebook 2016.
- EMEP/EEA GB (2019). EMEP/EEA air pollutant emission inventory Guidebook 2019.
- ENERGOPOMIAR (2022). Development of country specific emission factors of methane emission from the combustion of hard coal, lignite and biomass, Warsaw 2022. (in Polish)
- EUROCONTROL, Annual Fuel Burnt and Emissions Calculation for the EEA (for data from 2005).
- EUROSTAT, EUROSTAT database, available at: <https://ec.europa.eu/eurostat/data/database>
- FAOSTAT, FAOSTAT database available at: <https://www.fao.org/faostat/en/>
- Fott (1999). Fott P.: Carbon emission factors of coal and lignite: analysis of Czech coal data and comparison to European values, Environmental Science & Policy, 2 (1999), 347-354.
- Galos (2013). Galos K. Elaboration of database and data analysis on dolomite and limestone use in specific sectors of economy in 1988-2012 for the purpose of GHG inventory in Poland, Cracow 2013. (in Polish).
- Gellynck (2011). Identifying the key factors in increasing recycling and reducing residual household waste: a case study of the Felmich region of Belgium. Journal of Environmental Management 92. 2011.
- Górka (1991). Górka W., Zajączkowski K., Zajączkowska B. Estimation of timber stock on wooded and shrubbery lands in Poland (in Polish). Forest Research Institute. 1991.
- GUS (1987). Statistical Yearbook of The Republic of Poland 1987. GUS. Warsaw 1987
- GUS (1989-2022). Statistical Yearbook of The Republic of Poland 1989-2022. GUS, 1989-2022.
- GUS (1989a-2022a). Energy statistics in 1988–1989 up to 2019–2021. GUS, Warsaw 1989–2022.
- GUS (1989b-2022b). Production of industrial products. GUS, Warsaw 1989–2022.
- GUS (1991c-2022c). Forestry. GUS, Warsaw 1991–2022.
- GUS (1974d-1979d). Environmental Protection 1974 up to 1979. GUS, Warsaw 1974–1979.
- GUS (1981d-2022d). Environmental Protection from 1981 up to 2022. GUS, Warsaw 1981–2022.
- GUS (1989e-2022e). Questionnaire/Report G-03. Selected data from energy statistic system. GUS 1989–2022.
- GUS (1994f-2022f). Materials Management. GUS, Warsaw 1994-2022.
- GUS OZE (2000-2022). Energy from renewable sources in 2021 (publication). GUS, Warsaw 2000-2022.
- GUS T (2022). Transport – activity results in 2021. GUS, Warsaw 2022

- GUS R (2022). 2021 Statistical yearbook of agriculture. GUS, Warsaw 2022.
- GUS R1 (2022). Livestock in 2021. GUS, Warsaw 2022.
- GUS R2 (2021). Means of production in agriculture in the 2019/2020 farming year. GUS, Warsaw, 2021.
- GUS R3 (2022). Agricultural Census 2020. Characteristics of agricultural holdings in 2020. GUS, Warsaw 2022.
- GUS R4 (2022). Agriculture in 2021. GUS. Department of Agriculture. Warsaw 2022.
- GUS R5 (1987). Statistical yearbook of agriculture and food economy 1986. GUS, Warsaw 1987.
- GUS R6 (1996). Agricultural Census 1996. Livestock population. GUS, Warsaw 1997.
- GUS R7 (2002). Report from Agricultural Census 2002. GUS, Warsaw 2002.
- GUS R8 (2010). Agricultural Census 2010 – Livestock and selected elements of animal production. GUS, Warsaw 2010.
- GUS R9 (2014). Characteristics of agricultural holdings in 2013. GUS, Warsaw 2014.
- GUS R10 (2022). Production of agricultural and horticultural crops in 2022. Department of Agriculture. GUS, Warsaw 2022.
- GUS R11 (2022). Local Bank Data. GUS, Warsaw 2022.
- GUS R12 (2017). Characteristics of agricultural holdings in 2016. GUS, Warsaw 2017.
- GUS M (2022). Concise Statistical Yearbook of Poland 2022. GUS, Warsaw 2022.
- GUS W (2016). Average monthly salary in national economy in years 1950-2016. GUS, Warszawa 2016
- Gworek (2003). Gworek B., Barański A., Czarnomski K., Bojanowicz A. GHG emission from waste disposal sites (in Polish). Institute of Environmental Protection, Warsaw 2003.
- HIPH (2007). CO₂ emissions from iron and steel./ making operations. HIPH 2007.
- IEA – database of International Energy Agency.
- IFA database. Available at: <https://www.ifastat.org/databases/plant-nutrition>
- IMMB (2006). Cement sector in Poland. Allocation plan of CO₂ allowances in frames of NAP for 2008-2012. Institute of Mineral Construction Materials, Opole 2006.
- IOŚ (2001). Strategy of reduction of GHG emission until 2020 in the division into separate gases (N₂O, HFCs, PFCs and SF₆) and sectors (in Polish). Institute of Environmental Protection, Warsaw 2001.
- IOŚ (2009). National programme for Quality Assurance and Quality Control of the Polish Greenhouse gas inventory. ver. 2. National Emission Centre. Institute of Environmental Protection. Warsaw, 2009.
- IUNG (2012). *Factors describing residue to crop ratio for crops*. Information from the Ministry of Agriculture and Rural Development, document nr RR.te.st-75/21/2012 (1345) on 16.04.2012.
- IUNG (2012a). *Temporal and spatial differences in emission of nitrogen and phosphorus from Polish territory to the Baltic Sea*. Issued by the Institute of Soil Science and Plant Cultivation, IUNG-PIB, Puławy, MIR Gdynia, 2012: 421-432. Chapter 12: Auxiliary tables by M. Fotyma, J. Kopiński.
- IUNG 2014, 2018. *Coefficients N, P, K 2014 new method OECD_Eurostat*. Institute of Soil Science and Plant Cultivation, IUNG-PIB, Puławy, J. Kopiński, with update in 2018.
- IPCC (2014). AR5 Climate Change. Fifth Assessment Report. IPCC 2014.
- IPCC (1997). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. IPCC 1997.
- IPCC (2000). Good Practice Guidance and Uncertainty Management in National GHG Inventories. IPCC 2000.
- IPCC (2003). Good Practice Guidance for Land Use, Land use Change and Forestry. IPCC 2003.
- IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
- IPCC (2013). 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement).
- IRR (2020). Report of the review of the initial report of Poland. 5 July 2021. UNFCCC.
- Jadczyzyn T., Maćkowiak Cz., Kopiński J. (2000). Model SFOM – a tool for simulating quantity and quality of organic fertilizers produced at the farm (in Polish, English description of tables and figures). Pam. Puł. Z. 120/I s. 168-175.

- Jadczyzyn T. (2009). Fertilization planning on farm using NawSald programme (in Polish). *Studia i raporty IUNG-PIB*. Z. 16, 2009.
- KCIE (2004). Olendrzyński K., Cieślińska J., Estimation of national GHG emissions from sector 3: *Solvent and Other Product Use* (in Polish). Warsaw. 2004
- KOBIZE (2016) "The methodology for estimating N₂O emissions in food industry (primarily as a propellant in aerosol products) for reporting to the national inventory of emissions and removals of greenhouse gases" (National Centre for Emission Management 2017, in Polish)
- KOBIZE (2022). Database of National Administration of Emission Trading Scheme containing information on emissions of GHG and other pollutants. National Research Institute of Environmental Protection, KOBIZE, Warsaw 2022.
- KOBIZE (2016b). Report on the DIRECTIVE 2001/81/EC of the EUROPEAN PARLIAMENT and of the council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants.
- KOBIZE (2016). The national methodology for estimating methane emissions from coal mining for reporting to the national inventory of emissions and removals of greenhouse gases (in Polish). National Centre for Emission Management. Warsaw 2016.
- KOBIZE (2021). CO₂ emission from refineries based on the annual report for the purpose of EU Emissions Trade System.
- Kozłowski (2001). Kozłowski K. Strategy of reduction of N₂O emission in industry processes. (Part of the report: Radwański E. et al. – Strategy of reduction of GHG emission until 2020 in the division into separate gases (N₂O, HFCs, PFCs and SF₆) and sectors up to 2020 (in Polish). 2001.
- Krzysik (1975). Krzysik S. Wood science (in Polish). PWN Warsaw 1975.
- Kwarciński (2005). Kwarciński et al. Estimation of actual methane emissions caused by coal production. Polish Geological Institute, Sosnowiec 2005.
- Łoboda (1994). Łoboda T., Pietkiewicz S. Estimation of amount of CH₄, CO, N₂O and NO_x released to atmosphere from agricultural residues burning in 1992 (in Polish). Warsaw Agricultural University, Warsaw 1994.
- Mąkosa J. (2011). Elaboration and data analysis for national emission inventory of HFCs, PFCs and SF₆ in 1995–2005 and in 2009 in category 2. *Industrial processes* (in Polish). Warsaw, January 2011.
- Mercik (2001). Mercik S., Moskal S., Study on GHG emission and sinks from arable land soils (in Polish). 2001.
- Myczko (2001). Myczko A., Karłowski J., Szulc R. Study on GHG emissions from enteric fermentation and animal manure in 1999 (in Polish). 2001.
- NC8/BR5 2022. Republic of Poland. Eight national communication and Fifth Biennial Report to the Conference of the parties of the United nations Framework Convention on climate change. Warsaw, Ministry of Climate and Environment, 2022. Available at: <https://cop23.unfccc.int/documents/624748>
- Pastuszek M., Igras J. (2012): Temporal and special differences in emission of nitrogen and phosphorus from Polish territory to the Baltic Sea. National Marine Fisheries Research Institute, Institute of Soil Science and Plant Cultivation - State Research Institute, Fertilizer Research Institute. Gdynia-Puławy, 2012. ISBN 978-83-61650-08-9, ISBN 978-83-7562-107-5, ISBN 978-83-935354-0-8.
- Pietrzak S. (2006). Methodology of ammonia emissions inventory from agricultural sources in Poland and its practical application (in Polish). *Water-Environment_Rural areas*. T. 6 z.1 (16) s. 319-334. Instytut Melioracji i Użytków Zielonych w Falentach, 2006.
- Popławska-Jach J. (2022). Elaboration and data analysis for national emission inventory of HFCs, PFCs, SF₆ and NF₃ in 2021 and revision of available data since 1988 (in Polish). Warsaw, December 2022.
- Przewłocki (2007). Methodology of estimation of methane emission in industrial wastewater treatment processes in Poland in 1988-2004, Wrocław 2007.
- PIG (2003-2021). Balance of mineral fossil amounts in Poland (in Polish). Polish Geological Institute, Warsaw.

- PLNC5 (2010). Fifth National Communication under the United Nations Framework Convention on Climate Change. Republic of Poland. Ed. Institute of Environmental Protection. Warsaw 2010. ISBN 978-83-60312-56-8.
- QA-QC 2012. National programme for Quality Assurance and Quality Control of the Polish Greenhouse Gas inventory. ver. 3. Institute of Environmental Protection National Research Institute, National Centre for Emission Management. Warsaw, September 2012.
- Radwański (1995). Radwański E. National Study on sources and sinks of GHG (in Polish). National Foundation of Environmental Protection, 1995.
- Radwański E. (2006a). Estimation of emissions of C–CO₂ according to Reference Approach (in Polish). Warsaw 2006.
- Radwański E. (2006b). Estimation of carbon content in liming of agricultural and forest soils (in Polish). Warsaw 2006.
- Rosik-Dulewska Cz. (2000). The basics of waste management, PWN, Warsaw 2000.
- Rueffer (1998). Rueffer H., Rosewinkel K.H. Industrial wastewater treatment. Guidebook. Projprzem-EKO, 1998.
- Rzeczyński B. (1996). Solid municipal wastes trademarks, Eko-problemy, No 1, 1996.
- Siebielec G., Stuczyński T. (2008). Trace metals in municipal biosolids produced in Poland. Proceedings Of ECOpole, vol. 2., No 2.
- Sobczak (2011). Sobczak J. J. et al. Situation in the world foundry, current state and forecasting. Foundry Journal of the Polish Foundrymen's Association, 61, 1-2, 2011, p. 16-21.
- Steczko (1994). Steczko K. et al., Establishment of emission sources of GHG associated with the operation of the (high-methane and nitrified) natural gas system and the system involving other network gases, together with the determination of emission factors for emission sources in the system, the calculation of emission for the last year using the OECD/IPCC methodology for the continuous updating of information. Cracow 1994.
- Steczko K. (2003) Analysis of unaccounted quantities of natural gas and reasons for losses occurring in the gas distribution system of PGNIG. Stage II: Inventory of methane emission from Polish gas transmission system based on available reported data and emission factors"). Instytut Górnictwa Naftowego i Gazownictwa (Oil and Gas Institute). Cracow 2003.
- Szargut J. (1983). Heat engineering in metallurgy (in Polish). Wydawnictwo Śląsk, Katowice 1983.
- Ubysz, Szczygiał, Piwnicki (2006) Report on the national situation regarding the impact of fires on the forest. www.fire.uni-freiburg.de/GlobalNetworks/BalticRegion/Poland-Fire-Impacts-Forests-2005-2006.pdf
- Walczak J. (2003). Correction of N₂O emissions in agriculture, in: Realization of tasks of National Emission Centre in the emission inventory (in Polish). Institute of Environmental Protection. Warsaw 2003.
- Walczak J. (2006). Elaboration of activity data and GHG emission factors in Polish agriculture (unpublished). Instytut Zootechniki, Cracow 2006.
- Walczak J. (2009). Estimation of factors for animal waste management system, used in the inventory of greenhouse gases emission from agriculture sector in 2007, (unpublished). Instytut Zootechniki, Cracow 2009.
- Walczak J. (2011). Assessment of livestock population and its animal waste management systems in Poland in 2004–2009 based on database of the National research Institute of Animal Production for the purpose of GHG and other pollutants inventories. Instytut Zootechniki, Cracow 2011.
- Walczak J. (2012). Assessment of livestock population and its animal waste management systems in Poland in 2010–2011 based on database of the National research Institute of Animal Production for the purpose of GHG and other pollutants inventories. Instytut Zootechniki, Cracow 2012.
- Walczak J. (2013). Assessment of livestock population and its animal waste management systems in Poland in 2012 based on database of the National research Institute of Animal Production for the purpose of GHG and other pollutants inventories. Instytut Zootechniki, Cracow 2013.

- Walczak J. (2016): Proposals of identified NH₃ abatement techniques in livestock manure management. Working material prepared for the Ministry of Agriculture and Rural Areas. Instytut Zootechniki, Kraków. (in Polish), 2016.
- Walczak J. 2020. Elaboration of parameters for GHG emission estimation for agricultural sector. Cracow, 2020. (in Polish)
- Walczak (2022): Update of identified NH₃ abatement techniques in livestock manure management. Working material prepared for the Ministry of Agriculture and Rural Areas. Instytut Zootechniki, Kraków. (in Polish), 2022.
- Walęzak et al.(2020). Elaboration of methodology for GHG emissions estimation from organic soils w Poland (unpublished). National Centre for Emission Management. Institute of Environmental Protection – National Research Institute. Warsaw 2020. (in Polish)
- Waśniewska et al. (2016). Country specific CO₂ EFs from naural gas and refinery gas combustion, (unpublished). National Centre for Emission Management. Institute of Environmental Protection – National Research Institute. Warsaw 2016. (in Polish)
- Wielgosiński G. (2003). Estimation of data and update of methodology for pollutants emissions inventory from waste combustion. Łódź 2003.
- Wielgosiński G. (2011). Information on waste incinerated in Poland in 2009 (in Polish). Łódź 2011.
- Winnicki S. et al (2009). Expertise – Technics and technology of pigs production. (in Polish) Rozwój potencjału innowacyjnego Sieci Naukowej "Agroinżynieria dla rozwoju zrównoważonego rolnictwa, przemysłu rolno-spożywczego I obszarów wiejskich". Poznań 2009. <http://www.agengpol.pl/LinkClick.aspx?fileticket=U%2B6Wa3h%2B3eo%3D&tabid=144>
- WUG (1988-2021) "Evaluation of work safety, mine rescue and public safety in connection with the activities of mining and geology in 2021". Katowice 2022. (https://www.wug.gov.pl/bhp/stan_bhp_w_gornictwie).
- WUG (2022) The letter informing of the number of closed mines in the period of 01.01.2021-30.06.2022.

ANNEX 1. KEY CATEGORIES IN 2021

1. [UNFCC inventory](#)

The source/sink categories in all sectors, are identified to be key sources on the basis of their contribution to the total level and/or trend assessment. The methodology of reporting key categories is based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Approach 1. Additionally, qualitative method is used to identify key categories.

Poland's key category analysis guides the inventory preparation and is used to set priorities for the development of more advanced methodologies. In 2021, 30 sources were identified as Poland's key categories excluding LULUCF and 38 including LULUCF, while in 1988 - 22 and 27 respectively with the application of quantitative and qualitative approach.

The biggest contributors of the GHG emissions (without sector LULUCF) identified as key sources in level assessment analysis in 2021 are:

1.A.1 <i>Fuel combustion - Energy Industries - Solid Fuels</i>	CO ₂
1.A.3.b <i>Road Transportation</i>	CO ₂
1.A.4 <i>Other Sectors - Solid Fuels</i>	CO ₂

Emission from abovementioned sources made up to 58.71% of the total GHG emissions in Poland expressed in units of CO₂ equivalents.

The biggest contributors of the GHG emissions in trend assessment (without sector LULUCF) in 2021 are categories:

1.A.3.b <i>Road Transportation</i>	CO ₂
1.A.4 <i>Other Sectors - Solid Fuels</i>	CO ₂
1.A.1 <i>Fuel combustion - Energy Industries - Solid Fuels</i>	CO ₂

Share of these sources made up to 58.71% of the total GHG emissions in Poland (CO₂ equivalent).

As a result of analysis with use of qualitative criteria no additional categories were identified as key sources.

2. [Results of Key Source Analysis](#)

Following tables present results of Key Source Analysis under UNFCC inventory for year 1988 and current year of inventory.

Summary of key category analysis with sector LULUCF in 2021

No.	IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)			Comments
1	1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	L	T		
2	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	L	T		
3	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	L	T		
4	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	L	T		
5	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	L	T		
6	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	L	T		
7	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	L	T		
8	1.A.3.b Road Transportation	CO2	L	T		
9	1.A.3.c Railways	CO2		T		
10	1.A.4 Other Sectors - Biomass	CH4	L	T		
11	1.A.4 Other Sectors - Gaseous Fuels	CO2	L	T		
12	1.A.4 Other Sectors - Liquid Fuels	CO2	L	T		
13	1.A.4 Other Sectors - Solid Fuels	CO2	L	T		
14	1.A.4 Other Sectors - Solid Fuels	CH4	L	T		
15	1.B.1 Fugitive emissions from Solid Fuels	CH4	L	T		
16	1.B.1 Fugitive emissions from Solid Fuels	CO2	L			
17	1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH4		T		
18	1.B.2.d Fugitive Emissions from Fuels - Other	CO2	L	T		
19	2.A.1 Cement Production	CO2	L	T		
20	2.A.2 Lime Production	CO2		T		
21	2.A.4 Other Process Uses of Carbonates	CO2	L	T		
22	2.B.1 Ammonia Production	CO2	L	T		
23	2.B.2 Nitric Acid Production	N2O		T		
24	2.C.1 Iron and Steel Production	CO2	L	T		
25	2.F.1 Refrigeration and Air conditioning	F-gases	L	T		
26	3.A Enteric Fermentation	CH4	L	T		
27	3.B Manure Management	N2O	L			
28	3.D.1 Direct N2O Emissions From Managed Soils	N2O	L			
29	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	L			
30	4(III).Direct N2O emissions from N mineralization/immobilization	N2O	L			
31	4.A.1 Forest Land Remaining Forest Land	CO2	L	T		
32	4.A.2 Land Converted to Forest Land	CO2	L			
33	4.B.1 Cropland Remaining Cropland	CO2	L			
34	4.D.2 Land Converted to Wetlands	CO2	L	T		
35	4.E.2 Land Converted to Settlements	CO2	L	T		
36	4.G Harvested Wood Products	CO2	L	T		
37	5.A Solid Waste Disposal	CH4		T		
38	5.D Wastewater Treatment and Discharge	CH4	L			

Summary of key category analysis without sector LULUCF in 2021

No.	IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)			Comments
1	1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	L	T		
2	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	L	T		
3	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	L	T		
4	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	L	T		
5	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	L			
6	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	L	T		
7	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	L	T		
8	1.A.3.b Road Transportation	CO2	L	T		
9	1.A.3.c Railways	CO2		T		
10	1.A.4 Other Sectors - Biomass	CH4	L	T		
11	1.A.4 Other Sectors - Gaseous Fuels	CO2	L	T		
12	1.A.4 Other Sectors - Liquid Fuels	CO2	L	T		
13	1.A.4 Other Sectors - Solid Fuels	CO2	L	T		
14	1.A.4 Other Sectors - Solid Fuels	CH4	L	T		
15	1.B.1 Fugitive emissions from Solid Fuels	CH4	L	T		
16	1.B.1 Fugitive emissions from Solid Fuels	CO2	L			
17	1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH4		T		
18	1.B.2.d Fugitive Emissions from Fuels - Other	CO2	L	T		
19	2.A.1 Cement Production	CO2	L	T		
20	2.A.4 Other Process Uses of Carbonates	CO2	L	T		
21	2.B.1 Ammonia Production	CO2	L	T		
22	2.B.2 Nitric Acid Production	N2O		T		
23	2.C.1 Iron and Steel Production	CO2	L	T		
24	2.F.1 Refrigeration and Air conditioning	F-gases	L	T		
25	3.A Enteric Fermentation	CH4	L	T		
26	3.B Manure Management	N2O	L			
27	3.D.1 Direct N2O Emissions From Managed Soils	N2O	L	T		
28	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	L			
29	5.A Solid Waste Disposal	CH4		T		
30	5.D Wastewater Treatment and Discharge	CH4	L			

Summary of key category analysis with sector LULUCF in 1988

No.	IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)			Comments
1	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	L			
2	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	L			
3	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	L			
4	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	L			
5	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	L			
6	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	L			
7	1.A.3.b Road Transportation	CO2	L			
8	1.A.3.c Railways	CO2	L			
9	1.A.4 Other Sectors - Gaseous Fuels	CO2	L			
10	1.A.4 Other Sectors - Liquid Fuels	CO2	L			
11	1.A.4 Other Sectors - Solid Fuels	CO2	L			
12	1.A.4 Other Sectors - Solid Fuels	CH4	L			
13	1.B.1 Fugitive emissions from Solid Fuels	CH4	L			
14	1.B.1 Fugitive emissions from Solid Fuels	CO2	L			
15	2.A.1 Cement Production	CO2	L			
16	2.A.2 Lime Production	CO2	L			
17	2.B.1 Ammonia Production	CO2	L			
18	2.B.2 Nitric Acid Production	N2O	L			
19	2.C.1 Iron and Steel Production	CO2	L			
20	3.A Enteric Fermentation	CH4	L			
21	3.B Manure Management	N2O	L			
22	3.B Manure Management	CH4	L			
23	3.D.1 Direct N2O Emissions From Managed Soils	N2O	L			
24	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	L			
25	4.A.1 Forest Land Remaining Forest Land	CO2	L			
26	5.A Solid Waste Disposal	CH4	L			
27	5.D Wastewater Treatment and Discharge	CH4	L			

Summary of key category analysis without sector LULUCF in 1988

No.	IPCC Source Categories	GHG	Identification criteria (Level, Trend, Qualitative)			Comments
1	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	L			
2	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	L			
3	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	L			
4	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	L			
5	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	L			
6	1.A.3.b Road Transportation	CO2	L			
7	1.A.4 Other Sectors - Gaseous Fuels	CO2	L			
8	1.A.4 Other Sectors - Liquid Fuels	CO2	L			
9	1.A.4 Other Sectors - Solid Fuels	CO2	L			
10	1.A.4 Other Sectors - Solid Fuels	CH4	L			
11	1.B.1 Fugitive emissions from Solid Fuels	CH4	L			
12	1.B.1 Fugitive emissions from Solid Fuels	CO2	L			
13	2.A.1 Cement Production	CO2	L			
14	2.A.2 Lime Production	CO2	L			
15	2.B.1 Ammonia Production	CO2	L			
16	2.B.2 Nitric Acid Production	N2O	L			
17	2.C.1 Iron and Steel Production	CO2	L			
18	3.A Enteric Fermentation	CH4	L			
19	3.B Manure Management	N2O	L			
20	3.D.1 Direct N2O Emissions From Managed Soils	N2O	L			
21	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	L			
22	5.A Solid Waste Disposal	CH4	L			

Level assessment without sector LULUCF in 2021

KEY CATEGORIES OF EMISSIONS AND REMOVALS		GHG	Level Assessment	Cumulative Total
1	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	0.361	0.361
2	1.A.3.b Road Transportation	CO2	0.166	0.527
3	1.A.4 Other Sectors - Solid Fuels	CO2	0.060	0.587
4	1.B.1 Fugitive emissions from Solid Fuels	CH4	0.040	0.627
5	3.A Enteric Fermentation	CH4	0.036	0.663
6	1.A.4 Other Sectors - Gaseous Fuels	CO2	0.036	0.699
7	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	0.034	0.733
8	3.D.1 Direct N2O Emissions From Managed Soils	N2O	0.028	0.761
9	1.A.4 Other Sectors - Liquid Fuels	CO2	0.027	0.788
10	1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	0.026	0.814
11	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	0.025	0.838
12	2.A.1 Cement Production	CO2	0.018	0.857
13	2.F.1 Refrigeration and Air conditioning	F-gases	0.012	0.869
14	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	0.010	0.879
15	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	0.010	0.889
16	2.B.1 Ammonia Production	CO2	0.009	0.898
17	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	0.007	0.905
18	3.B Manure Management	N2O	0.006	0.911
19	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	0.006	0.917
20	2.A.4 Other Process Uses of Carbonates	CO2	0.006	0.924
21	1.B.1 Fugitive emissions from Solid Fuels	CO2	0.006	0.930
22	5.D Wastewater Treatment and Discharge	CH4	0.005	0.935
23	1.A.4 Other Sectors - Biomass	CH4	0.005	0.940
24	1.A.4 Other Sectors - Solid Fuels	CH4	0.005	0.945
25	1.B.2.d Fugitive Emissions from Fuels - Other	CO2	0.004	0.949
26	2.C.1 Iron and Steel Production	CO2	0.004	0.953

Level assessment without sector LULUCF in 1988

KEY CATEGORIES OF EMISSIONS AND REMOVALS		GHG	Level Assessment	Cumulative Total
1	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	0.425	0.425
2	1.A.4 Other Sectors - Solid Fuels	CO2	0.158	0.582
3	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	0.069	0.651
4	1.B.1 Fugitive emissions from Solid Fuels	CH4	0.046	0.697
5	3.A Enteric Fermentation	CH4	0.039	0.736
6	1.A.3.b Road Transportation	CO2	0.036	0.772
7	3.D.1 Direct N2O Emissions From Managed Soils	N2O	0.026	0.798
8	5.A Solid Waste Disposal	CH4	0.025	0.823
9	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	0.013	0.837
10	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	0.013	0.850
11	2.A.1 Cement Production	CO2	0.012	0.862
12	2.C.1 Iron and Steel Production	CO2	0.012	0.874
13	1.A.4 Other Sectors - Gaseous Fuels	CO2	0.011	0.885
14	1.A.4 Other Sectors - Solid Fuels	CH4	0.009	0.894
15	1.A.4 Other Sectors - Liquid Fuels	CO2	0.009	0.903
16	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	0.009	0.912
17	1.B.1 Fugitive emissions from Solid Fuels	CO2	0.007	0.919
18	2.B.1 Ammonia Production	CO2	0.007	0.926
19	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	0.007	0.932
20	2.B.2 Nitric Acid Production	N2O	0.006	0.939
21	3.B Manure Management	N2O	0.006	0.945
22	2.A.2 Lime Production	CO2	0.006	0.951

Level assessment with sector LULUCF in 2021

KEY CATEGORIES OF EMISSIONS AND REMOVALS		GHG	Level Assessment	Cumulative Total
1	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	0.330	0.330
2	1.A.3.b Road Transportation	CO2	0.152	0.483
3	1.A.4 Other Sectors - Solid Fuels	CO2	0.055	0.538
4	4.A.1 Forest Land Remaining Forest Land	CO2	0.047	0.585
5	1.B.1 Fugitive emissions from Solid Fuels	CH4	0.036	0.621
6	3.A Enteric Fermentation	CH4	0.033	0.655
7	1.A.4 Other Sectors - Gaseous Fuels	CO2	0.033	0.688
8	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	0.031	0.718
9	3.D.1 Direct N2O Emissions From Managed Soils	N2O	0.026	0.744
10	1.A.4 Other Sectors - Liquid Fuels	CO2	0.024	0.769
11	1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	0.024	0.793
12	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	0.023	0.815
13	2.A.1 Cement Production	CO2	0.017	0.832
14	4.G Harvested Wood Products	CO2	0.011	0.843
15	2.F.1 Refrigeration and Air conditioning	F-gases	0.011	0.854
16	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	0.009	0.863
17	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	0.009	0.873
18	2.B.1 Ammonia Production	CO2	0.008	0.881
19	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	0.006	0.887
20	3.B Manure Management	N2O	0.006	0.893
21	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	0.006	0.899
22	4.E.2 Land Converted to Settlements	CO2	0.006	0.904
23	2.A.4 Other Process Uses of Carbonates	CO2	0.006	0.910
24	1.B.1 Fugitive emissions from Solid Fuels	CO2	0.006	0.916
25	5.D Wastewater Treatment and Discharge	CH4	0.005	0.920
26	1.A.4 Other Sectors - Biomass	CH4	0.005	0.925
27	1.A.4 Other Sectors - Solid Fuels	CH4	0.004	0.929
28	4.A.2 Land Converted to Forest Land	CO2	0.004	0.934
29	4(III). Direct N2O emissions from N mineralization/immobilization	N2O	0.004	0.938
30	1.B.2.d Fugitive Emissions from Fuels - Other	CO2	0.004	0.942
31	4.B.1 Cropland Remaining Cropland	CO2	0.004	0.945
32	4.D.2 Land Converted to Wetlands	CO2	0.004	0.949
33	2.C.1 Iron and Steel Production	CO2	0.004	0.952

Level assessment with sector LULUCF in 1988

KEY CATEGORIES OF EMISSIONS AND REMOVALS		GHG	Level Assessment	Cumulative Total
1	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	0.403	0.403
2	1.A.4 Other Sectors - Solid Fuels	CO2	0.149	0.552
3	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	0.065	0.617
4	1.B.1 Fugitive emissions from Solid Fuels	CH4	0.044	0.661
5	3.A Enteric Fermentation	CH4	0.037	0.698
6	1.A.3.b Road Transportation	CO2	0.034	0.732
7	4.A.1 Forest Land Remaining Forest Land	CO2	0.034	0.766
8	3.D.1 Direct N2O Emissions From Managed Soils	N2O	0.025	0.791
9	5.A Solid Waste Disposal	CH4	0.024	0.814
10	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	0.013	0.827
11	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	0.012	0.840
12	2.A.1 Cement Production	CO2	0.012	0.851
13	2.C.1 Iron and Steel Production	CO2	0.011	0.862
14	1.A.4 Other Sectors - Gaseous Fuels	CO2	0.011	0.873
15	1.A.4 Other Sectors - Solid Fuels	CH4	0.009	0.882
16	1.A.4 Other Sectors - Liquid Fuels	CO2	0.009	0.890
17	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	0.008	0.898
18	1.B.1 Fugitive emissions from Solid Fuels	CO2	0.007	0.905
19	2.B.1 Ammonia Production	CO2	0.006	0.912
20	3.D.2 Indirect N2O Emissions From Managed Soils	N2O	0.006	0.918
21	2.B.2 Nitric Acid Production	N2O	0.006	0.924
22	3.B Manure Management	N2O	0.006	0.930
23	2.A.2 Lime Production	CO2	0.006	0.936
24	1.A.3.c Railways	CO2	0.005	0.940
25	5.D Wastewater Treatment and Discharge	CH4	0.004	0.944
26	3.B Manure Management	CH4	0.004	0.948
27	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	0.004	0.952

Trend assessment without sector LULUCF in 2021

KEY CATEGORIES OF EMISSIONS AND REMOVALS		GHG	Trend Assessment	Cumulative Total
1	1.A.3.b Road Transportation	CO2	0.188	0.246
2	1.A.4 Other Sectors - Solid Fuels	CO2	0.140	0.430
3	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	0.093	0.552
4	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	0.051	0.619
5	1.A.4 Other Sectors - Gaseous Fuels	CO2	0.036	0.666
6	1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	0.032	0.709
7	5.A Solid Waste Disposal	CH4	0.032	0.750
8	1.A.4 Other Sectors - Liquid Fuels	CO2	0.025	0.784
9	2.F.1 Refrigeration and Air conditioning	F-gases	0.017	0.806
10	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	0.016	0.827
11	2.C.1 Iron and Steel Production	CO2	0.011	0.842
12	1.B.1 Fugitive emissions from Solid Fuels	CH4	0.009	0.855
13	2.A.1 Cement Production	CO2	0.009	0.866
14	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	0.009	0.878
15	2.B.2 Nitric Acid Production	N2O	0.008	0.888
16	2.A.4 Other Process Uses of Carbonates	CO2	0.007	0.897
17	1.A.4 Other Sectors - Solid Fuels	CH4	0.007	0.906
18	1.A.4 Other Sectors - Biomass	CH4	0.007	0.914
19	1.B.2.d Fugitive Emissions from Fuels - Other	CO2	0.006	0.923
20	1.A.3.c Railways	CO2	0.006	0.931
21	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	0.005	0.936
22	1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH4	0.004	0.942
23	3.D.1 Direct N2O Emissions From Managed Soils	N2O	0.004	0.946
24	2.B.1 Ammonia Production	CO2	0.003	0.951
25	3.A Enteric Fermentation	CH4	0.003	0.955

Trend assessment with sector LULUCF in 2021

KEY CATEGORIES OF EMISSIONS AND REMOVALS		GHG	Trend Assessment	Cumulative Total
1	1.A.3.b Road Transportation	CO2	0.165	0.218
2	1.A.4 Other Sectors - Solid Fuels	CO2	0.131	0.392
3	1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	0.101	0.525
4	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	0.048	0.589
5	1.A.4 Other Sectors - Gaseous Fuels	CO2	0.032	0.631
6	5.A Solid Waste Disposal	CH4	0.029	0.670
7	1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	0.028	0.707
8	1.A.4 Other Sectors - Liquid Fuels	CO2	0.022	0.737
9	4.A.1 Forest Land Remaining Forest Land	CO2	0.018	0.761
10	2.F.1 Refrigeration and Air conditioning	F-gases	0.015	0.781
11	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	0.014	0.799
12	4.G Harvested Wood Products	CO2	0.013	0.816
13	2.C.1 Iron and Steel Production	CO2	0.011	0.830
14	1.B.1 Fugitive emissions from Solid Fuels	CH4	0.010	0.844
15	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	0.008	0.854
16	2.A.1 Cement Production	CO2	0.007	0.864
17	2.B.2 Nitric Acid Production	N2O	0.007	0.873
18	1.A.4 Other Sectors - Solid Fuels	CH4	0.006	0.882
19	2.A.4 Other Process Uses of Carbonates	CO2	0.006	0.889
20	1.A.4 Other Sectors - Biomass	CH4	0.006	0.897
21	1.B.2.d Fugitive Emissions from Fuels - Other	CO2	0.006	0.905
22	1.A.3.c Railways	CO2	0.006	0.912
23	4.D.2 Land Converted to Wetlands	CO2	0.005	0.918
24	3.A Enteric Fermentation	CH4	0.005	0.925
25	1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	0.005	0.931
26	4.E.2 Land Converted to Settlements	CO2	0.004	0.936
27	1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH4	0.003	0.941
28	1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	0.003	0.945
29	2.A.2 Lime Production	CO2	0.003	0.949
30	2.B.1 Ammonia Production	CO2	0.003	0.953

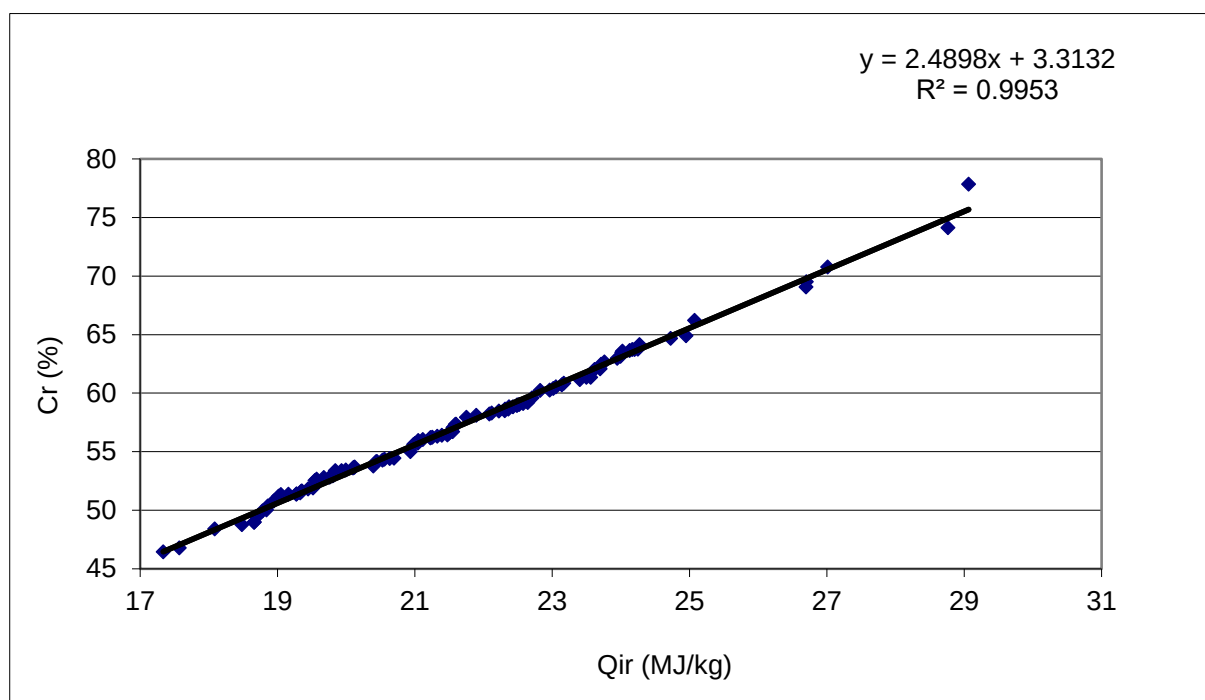
ANNEX 2.1. COUNTRY SPECIFIC CO₂ EFs FOR COAL AND LIGNITE

Correlation Cr vs Qi for coal

C - carbon content (%)

Qi - net calorific value (MJ/kg)

r - related to raw material

Parameters of the empirical function for coal: $a=2.4898$ $b=3.3132$

Aggregated measurement source data for the derivation of the function formula for lignite

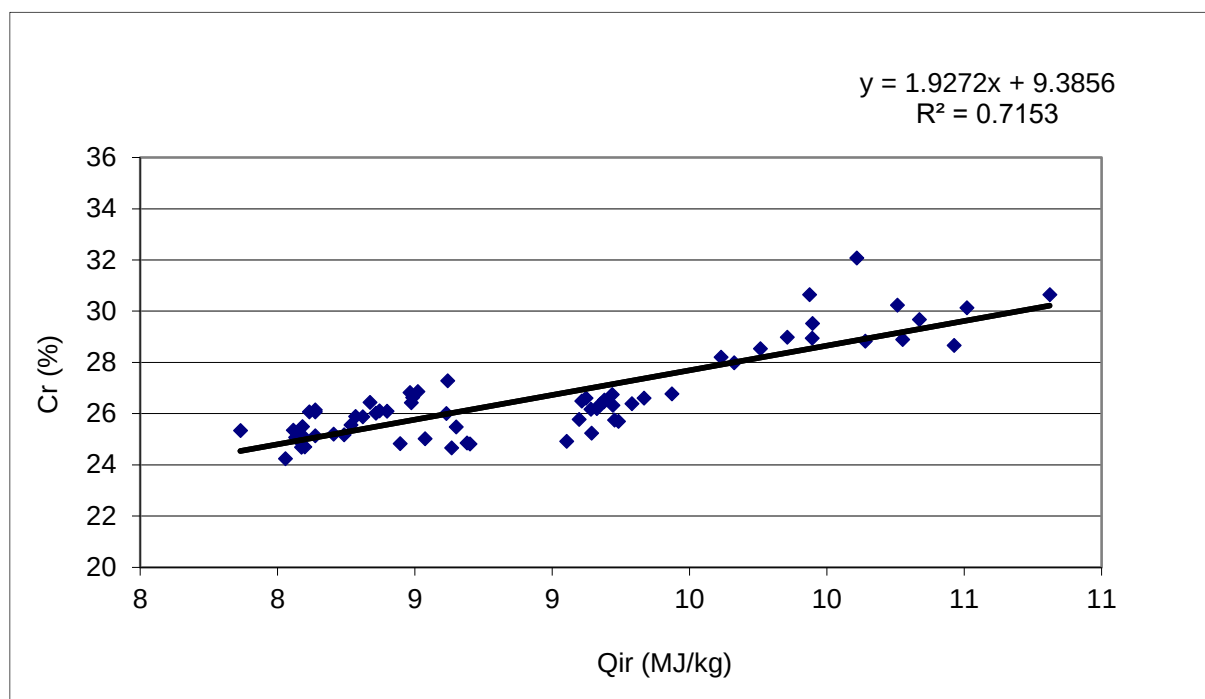
Qir	17.33	17.57	18.08	18.48	18.66	18.66	18.70	18.78	18.84	18.86
Cr	46.45	46.77	48.40	48.75	48.95	48.99	49.45	49.94	50.03	50.37
Qir	18.94	19.01	19.05	19.16	19.27	19.28	19.33	19.34	19.35	19.45
Cr	50.77	51.19	51.35	51.36	51.36	51.40	51.47	51.62	51.64	51.81
Qir	19.52	19.53	19.54	19.57	19.67	19.76	19.80	19.82	19.84	19.93
Cr	51.91	52.08	52.54	52.65	52.80	52.82	52.93	52.99	53.39	53.39
Qir	19.99	20.10	20.11	20.12	20.39	20.43	20.44	20.53	20.56	20.63
Cr	53.44	53.61	53.65	53.68	53.78	54.14	54.16	54.26	54.35	54.42
Qir	20.69	20.93	20.98	21.00	21.04	21.05	21.11	21.22	21.23	21.25
Cr	54.43	55.01	55.61	55.71	55.73	55.95	56.05	56.18	56.20	56.22
Qir	21.32	21.39	21.47	21.50	21.55	21.56	21.56	21.58	21.60	21.75
Cr	56.31	56.41	56.43	56.59	56.70	57.03	57.11	57.32	57.35	57.95
Qir	21.89	22.09	22.12	22.22	22.31	22.31	22.36	22.37	22.42	22.49
Cr	58.10	58.21	58.29	58.48	58.51	58.64	58.64	58.84	58.84	58.94
Qir	22.49	22.52	22.57	22.64	22.70	22.82	22.96	23.01	23.05	23.14
Cr	59.01	59.04	59.11	59.19	59.60	60.22	60.26	60.41	60.53	60.70
Qir	23.17	23.40	23.50	23.56	23.62	23.70	23.71	23.76	23.94	23.99
Cr	60.84	61.16	61.34	61.36	62.03	62.09	62.46	62.67	62.96	63.13
Qir	24.01	24.02	24.13	24.17	24.20	24.24	24.27	24.72	24.95	25.07
Cr	63.49	63.60	63.65	63.72	63.74	63.75	64.14	64.68	64.89	66.22
Qir	26.70	26.70	27.01	28.76	29.06					
Cr	69.06	69.51	70.79	74.14	77.85					

Correlation Cr vs Qi for lignite

C - carbon content (%)

Qi - net calorific value (MJ/kg)

r - related to raw material

Parameters of the empirical function for lignite: $a=1.9272$ $b=9.3856$

Aggregated measurement source data for the derivation of the function formula for lignite

Qir	7.865	8.028	8.057	8.066	8.070	8.087	8.087	8.091	8.099	8.116
Cr	25.34	24.24	25.35	25.07	25.06	25.17	24.68	25.49	24.70	26.07
Qir	8.137	8.137	8.137	8.204	8.242	8.267	8.284	8.336	8.398	8.358
Cr	26.07	26.14	25.14	25.20	25.17	25.55	25.89	26.44	26.09	26.02
Qir	8.482	8.487	8.510	8.619	8.650	8.700	8.689	8.633	8.537	8.446
Cr	26.82	26.43	26.86	27.28	25.48	24.82	24.85	24.66	25.02	24.83
Qir	8.310	8.371	8.491	8.614	9.188	9.162	9.221	9.143	9.052	9.241
Cr	25.87	26.11	26.63	26.00	26.47	26.20	26.32	25.24	24.92	25.70
Qir	9.290	9.123	9.107	9.226	9.098	9.218	9.141	9.189	9.175	9.334
Cr	26.39	26.60	26.49	25.75	25.77	26.74	26.17	26.53	26.38	26.60
Qir	9.435	9.614	9.662	9.758	9.856	9.937	9.946	9.947	10.109	10.139
Cr	26.77	28.20	27.98	28.53	28.98	30.65	28.95	29.52	32.08	28.83
Qir	10.257	10.275	10.337	10.463	10.509	10.811				
Cr	30.24	28.90	29.67	28.66	30.14	30.65				

ANNEX 2.2. FUEL CONSUMPTION AND GHG EMISSION FACTORS FROM SELECTED CATEGORIES OF CRF SECTOR 1.A

Table 1. Fuel consumption [PJ] in 1.A.1.a category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	1752.496	1719.899	1590.796	1571.596	1511.372	1368.183	1311.991	1204.471	1271.818	1218.620	1154.492
Lignite	568.786	575.819	554.955	561.134	548.470	550.602	539.102	529.015	532.981	530.634	535.210
Hard coal briquettes (patent fuels)	5.001	3.888	1.958	0.252	0.091	0.046	0.045	0.000	0.000	0.045	0.000
Brown coal briquettes	0.354	0.247	0.125	0.053	0.181	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	21.274	21.900	21.641	16.329	9.562	3.106	4.095	4.738	7.157	7.950	10.769
Fuel wood and wood waste	16.695	15.123	14.571	14.384	17.265	13.783	14.051	1.322	2.656	3.293	3.673
Biogas	0.004	0.006	0.014	0.003	0.024	0.000	0.006	0.125	0.137	0.088	0.204
Industrial wastes	3.741	3.873	5.265	8.914	7.354	6.658	6.876	3.878	3.393	3.267	0.550
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	13.591	12.561	11.512	11.967	10.187	8.161	6.897	6.730	6.535	5.009	3.878
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.189
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.767	0.724	0.602	0.602	0.559	0.430	0.387	0.344	1.161	1.677	1.548
Fuel oil	73.080	70.760	66.014	61.893	56.964	55.631	56.156	26.098	27.997	27.553	25.694
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	1.287	1.188	0.990	0.743	0.644	0.842	1.238	0.050	0.000	0.000	0.000
Coke oven gas	5.568	6.565	7.125	7.555	8.863	8.144	13.147	12.828	13.975	16.450	13.697
Blast furnace gas	28.221	26.733	22.377	12.797	13.378	10.239	13.190	5.905	3.218	3.306	3.060
Gas works gas	0.659	0.579	0.167	0.129	0.335	0.085	0.037	0.021	0.005	0.002	3.259
Fuels											
Liquid fuels	75.134	72.672	67.606	63.237	58.167	56.902	57.781	26.492	29.158	29.277	27.432
Gaseous fuels	21.274	21.900	21.641	16.329	9.562	3.106	4.095	4.738	7.157	7.950	10.769
Solid fuels	2374.674	2346.290	2189.015	2165.482	2092.877	1945.459	1884.409	1758.969	1828.531	1774.067	1713.596
Other fuels	3.741	3.873	5.265	8.914	7.354	6.658	6.876	3.878	3.393	3.267	0.550
Biomass	16.699	15.129	14.585	14.387	17.289	13.783	14.057	1.447	2.793	3.381	3.877
Total	2491.522	2459.864	2298.112	2268.349	2185.248	2025.908	1967.218	1795.524	1871.032	1817.942	1756.223

Table 1. (cont.) Fuel consumption [PJ] in 1.A.1.a category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	1122.253	1115.244	1122.612	1087.727	1142.443	1128.755	1112.673	1171.766	1151.920	1065.169	1038.763
Lignite	521.062	504.993	512.217	494.036	518.249	514.274	533.979	525.817	501.140	521.178	494.048
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	16.210	21.626	28.242	38.700	45.495	53.627	57.099	52.877	49.691	51.163	51.653
Fuel wood and wood waste	3.398	3.461	4.886	4.809	5.799	8.913	17.228	20.583	25.111	37.976	54.823
Biogas	0.349	0.443	0.563	0.615	0.843	0.526	0.561	0.944	1.158	2.025	2.199
Industrial wastes	0.575	0.883	1.031	1.520	0.372	0.459	0.541	0.477	0.440	0.209	0.314
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.384	0.368
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	2.742	1.912	1.620	1.199	0.852	0.571	0.320	0.162	0.135	0.081	0.055
Liquid petroleum gas (LPG)	0.237	0.189	0.189	0.189	0.047	0.000	0.000	0.000	0.000	0.000	0.000
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	1.634	2.451	2.150	2.537	2.322	1.548	1.247	1.247	0.774	0.860	0.996
Fuel oil	26.422	21.978	27.310	25.856	26.826	25.735	24.078	25.290	22.382	22.018	20.480
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.149	0.495	0.545	1.980	1.733	2.129
Coke oven gas	16.077	17.094	17.080	16.421	18.032	12.491	11.523	14.540	16.024	16.765	13.112
Blast furnace gas	3.286	4.317	4.976	4.783	5.715	7.053	4.489	8.677	6.395	10.204	7.730
Gas works gas	2.507	2.390	2.338	3.109	2.592	3.694	4.806	4.876	4.463	4.502	4.828
Fuels											
Liquid fuels	28.292	24.618	29.650	28.582	29.195	27.431	25.820	27.082	25.136	24.611	23.604
Gaseous fuels	16.210	21.626	28.242	38.700	45.495	53.627	57.099	52.877	49.691	51.163	51.653
Solid fuels	1667.926	1645.950	1660.843	1607.298	1687.883	1666.839	1667.789	1725.837	1680.076	1617.899	1558.535
Other fuels	0.575	0.883	1.031	1.520	0.372	0.459	0.541	0.477	0.440	0.593	0.682
Biomass	3.747	3.904	5.449	5.424	6.642	9.439	17.789	21.527	26.269	40.001	57.022
Total	1716.750	1696.981	1725.215	1681.524	1769.587	1757.795	1769.038	1827.800	1781.611	1734.266	1691.497

Table 1. (cont.) Fuel consumption [PJ] in 1.A.1.a category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	1102.203	1059.693	995.936	999.211	925.468	932.228	954.064	950.167	951.263	890.874	813.041
Lignite	477.464	517.019	527.310	539.682	513.422	507.964	484.888	496.919	466.064	395.024	364.454
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.014	0.010	0.008
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	52.287	57.962	61.963	53.395	52.017	60.426	70.592	83.467	101.008	114.019	131.248
Fuel wood and wood waste	65.114	78.589	105.585	87.694	96.989	95.657	74.057	56.414	58.484	71.201	78.849
Biogas	2.778	3.328	4.219	4.887	5.732	6.314	7.247	8.232	8.600	8.642	9.649
Industrial wastes	0.442	0.458	0.420	0.381	0.470	0.693	0.545	0.671	0.985	1.139	1.265
Municipal waste - non-biogenic fraction	0.367	0.403	0.371	0.337	0.343	0.859	3.833	5.488	7.516	9.104	8.691
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.016	0.009	0.331	1.420	1.544	2.055	3.576
Other petroleum products	0.060	0.000	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.055	0.026	0.026	0.027	0.027	0.000	0.000	0.012	0.039	0.030	0.027
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.010	0.012	0.011
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.909	1.083	0.866	0.953	0.909	1.247	1.204	1.822	1.899	2.202	2.167
Fuel oil	21.680	16.880	15.440	12.920	11.560	15.960	16.640	15.158	13.169	12.837	13.856
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	2.475	1.634	1.733	1.832	1.287	0.396	1.139	0.630	1.592	0.487	0.657
Coke oven gas	18.610	16.640	15.993	17.867	17.789	20.883	22.820	21.112	21.556	20.766	17.349
Blast furnace gas	9.954	11.001	11.328	11.729	13.937	16.242	14.630	15.884	16.215	13.933	11.428
Gas works gas	5.072	5.357	5.202	5.307	5.069	4.723	3.510	1.693	1.446	1.589	1.696
Fuels											
Liquid fuels	25.124	19.596	18.070	15.704	13.756	17.603	18.983	17.617	16.670	15.538	16.691
Gaseous fuels	52.287	57.962	61.963	53.395	52.017	60.426	70.592	83.467	101.008	114.019	131.248
Solid fuels	1613.359	1609.737	1555.795	1573.823	1475.713	1482.039	1479.913	1485.793	1456.596	1322.226	1208.003
Other fuels	0.809	0.861	0.791	0.718	0.813	1.552	4.378	6.159	8.501	10.243	9.956
Biomass	67.892	81.917	109.804	92.581	102.737	101.980	81.635	66.065	68.628	81.898	92.074
Total	1759.471	1770.072	1746.423	1736.221	1645.037	1663.600	1655.500	1659.101	1651.403	1543.925	1457.972

Table 1. (cont.) Fuel consumption [PJ] in 1.A.1.a category

Fuels	2021
Hard coal	951.403
Lignite	433.503
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.007
Crude oil	0.000
Natural gas	128.891
Fuel wood and wood waste	75.106
Biogas	9.702
Industrial wastes	1.689
Municipal waste - non-biogenic fraction	7.767
Municipal waste – biogenic fraction	4.411
Other petroleum products	0.000
Petroleum coke	0.000
Coke	0.042
Liquid petroleum gas (LPG)	0.018
Motor gasoline	0.000
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	3.619
Fuel oil	14.880
Feedstocks	0.000
Refinery gas	0.526
Coke oven gas	20.590
Blast furnace gas	11.838
Gas works gas	1.139
Fuels	
Liquid fuels	19.043
Gaseous fuels	128.891
Solid fuels	1418.522
Other fuels	9.456
Biomass	89.219
Total	1665.130

Table 2. Fuel consumption [PJ] in 1.A.1.b category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	0.114	0.113	0.045	0.090	0.070	0.248	0.067	1.296	1.509	1.315	0.620
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	2.395	2.396	1.671	1.539	1.508	1.608	1.591	1.562	1.749	2.529	8.244
Fuel wood and wood waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	7.724	7.487	5.222	0.272	0.682	0.002	0.259	1.919	0.350	0.163	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.523	1.085	0.884
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.028	0.028	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.095
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.000	0.000	0.043	0.043	0.000	0.086	0.086	0.172	0.172	0.215	0.344
Fuel oil	14.800	13.800	11.554	10.666	15.918	12.928	12.080	32.724	40.925	32.522	32.320
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	8.860	9.306	7.475	7.623	8.514	9.257	10.445	12.029	8.960	10.197	6.287
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.081
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	23.660	23.106	19.072	18.332	24.432	22.271	22.610	44.925	50.579	44.067	39.930
Gaseous fuels	2.395	2.396	1.671	1.539	1.508	1.608	1.591	1.562	1.749	2.529	8.244
Solid fuels	0.142	0.140	0.045	0.118	0.070	0.248	0.067	1.296	1.509	1.315	0.701
Other fuels	7.724	7.487	5.222	0.272	0.682	0.002	0.259	1.919	0.350	0.163	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	33.921	33.129	26.010	20.261	26.691	24.129	24.527	49.701	54.187	48.073	48.875

Table 2. (cont.) Fuel consumption [PJ] in 1.A.1.b category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	0.558	0.199	0.065	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.130
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	10.832	12.110	11.354	10.124	12.770	15.535	14.482	14.900	20.816	18.816	17.511
Fuel wood and wood waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.310	0.219	0.095	0.253	0.176	0.221	0.285	0.224	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	1.729	0.000	0.040	0.040	0.040	0.362	0.322	0.442	0.362	0.672	0.986
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Liquid petroleum gas (LPG)	0.189	0.284	0.000	0.047	0.095	0.000	0.000	0.000	0.000	0.000	0.000
Motor gasoline	0.089	0.133	0.000	0.000	0.133	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.044	0.000	0.000	0.000	0.000
Diesel oil	0.043	0.903	0.301	0.645	0.215	0.989	0.258	0.645	0.129	0.387	0.173
Fuel oil	25.896	28.361	30.219	30.462	29.169	27.755	27.108	24.967	29.532	29.452	30.360
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	6.386	9.059	10.445	10.049	10.049	11.484	10.197	12.425	14.603	15.692	13.118
Coke oven gas	0.051	0.069	0.070	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	34.331	38.739	41.005	41.243	39.700	40.590	37.929	38.479	44.626	46.202	44.637
Gaseous fuels	10.832	12.110	11.354	10.124	12.770	15.535	14.482	14.900	20.816	18.816	17.511
Solid fuels	0.610	0.269	0.135	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.130
Other fuels	0.310	0.219	0.095	0.253	0.176	0.221	0.285	0.224	0.000	0.000	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	46.082	51.337	52.589	51.642	52.646	56.346	52.696	53.603	65.442	65.018	62.278

Table 2. (cont.) Fuel consumption [PJ] in 1.A.1.b category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	0.134	0.130	0.106	0.130	0.182	1.037	0.935	0.890	0.778	0.695	0.539
Lignite	0.000	0.042	0.016	0.048	0.016	0.008	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	19.363	27.468	30.638	34.779	35.103	25.957	25.802	43.842	36.056	42.920	41.086
Fuel wood and wood waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.450	0.660	1.271	0.992	0.960	0.752	1.014	0.868	1.121	1.315	1.297
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Liquid petroleum gas (LPG)	0.000	0.092	0.092	0.092	0.138	0.644	0.828	0.285	0.326	0.205	0.372
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.087	0.130	0.087	0.000	0.043	0.000	0.000	0.007	0.003	0.019	0.017
Fuel oil	32.240	29.400	22.280	14.840	14.680	22.520	21.480	17.947	16.732	16.227	16.214
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	20.394	19.899	26.483	19.157	14.157	18.513	20.691	11.630	15.309	13.886	15.180
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	53.171	50.181	50.212	35.081	29.978	42.429	44.013	30.737	33.491	31.653	33.079
Gaseous fuels	19.363	27.468	30.638	34.779	35.103	25.957	25.802	43.842	36.056	42.920	41.086
Solid fuels	0.134	0.171	0.122	0.178	0.198	1.045	0.935	0.890	0.778	0.695	0.539
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	72.668	77.820	80.972	70.038	65.279	69.431	70.750	75.468	70.325	75.268	74.704

Table 2. (cont.) Fuel consumption [PJ] in 1.A.1.b category

Fuels	2021
Hard coal	0.602
Lignite	0.000
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.000
Crude oil	0.000
Natural gas	33.795
Fuel wood and wood waste	0.000
Biogas	0.000
Industrial wastes	0.000
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.000
Other petroleum products	0.858
Petroleum coke	0.000
Coke	0.000
Liquid petroleum gas (LPG)	0.655
Motor gasoline	0.000
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	0.007
Fuel oil	17.543
Feedstocks	0.000
Refinery gas	17.461
Coke oven gas	0.000
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	36.523
Gaseous fuels	33.795
Solid fuels	0.602
Other fuels	0.000
Biomass	0.000
Total	70.920

Table 3. Fuel consumption [PJ] in 1.A.1.c category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	12.314	10.347	10.294	7.866	6.296	23.762	56.968	58.730	62.410	54.793	52.552
Lignite	0.416	0.057	0.067	0.119	0.069	0.291	0.257	0.280	0.320	0.310	0.249
Hard coal briquettes (patent fuels)	0.023	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.035	0.018	0.018	0.017	0.000	0.036	0.018	0.018	0.036	0.034	0.016
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.085	0.085	0.085
Natural gas	13.736	15.364	12.371	12.432	14.666	12.353	17.401	14.851	23.270	21.155	17.779
Fuel wood and wood waste	0.018	0.001	0.006	0.000	0.004	0.008	0.011	0.003	0.003	0.003	0.003
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.011	0.028	0.023
Industrial wastes	0.046	0.001	0.000	0.000	0.000	0.311	0.235	0.184	0.158	0.138	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.080	0.080	0.040
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	1.173	0.522	0.546	0.500	0.278	0.505	1.225	0.866	0.596	0.141	0.080
Liquid petroleum gas (LPG)	0.092	0.092	0.095	0.095	0.095	0.047	0.047	0.047	0.047	0.000	0.047
Motor gasoline	0.088	0.088	0.089	0.089	0.089	0.177	0.310	0.266	0.089	0.089	0.044
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	2.130	1.960	1.849	2.150	2.279	4.429	3.569	3.784	3.268	2.838	2.236
Fuel oil	0.240	0.040	0.040	0.040	0.081	0.364	0.283	0.162	0.162	0.081	0.525
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	50.866	50.938	43.557	38.488	39.121	34.604	40.489	37.038	35.105	37.000	33.710
Blast furnace gas	5.632	4.440	3.961	1.995	1.430	2.123	2.488	1.954	1.582	1.893	1.695
Gas works gas	0.005	0.008	0.005	0.180	0.010	0.120	0.000	0.006	0.061	0.019	0.168
Fuels											
Liquid fuels	2.550	2.180	2.073	2.374	2.543	5.017	4.209	4.259	3.731	3.173	2.978
Gaseous fuels	13.736	15.364	12.371	12.432	14.666	12.353	17.401	14.851	23.270	21.155	17.779
Solid fuels	70.465	66.330	58.471	49.165	47.205	61.441	101.445	98.892	100.110	94.190	88.470
Other fuels	0.046	0.001	0.000	0.000	0.000	0.311	0.235	0.184	0.158	0.138	0.000
Biomass	0.018	0.001	0.006	0.000	0.004	0.008	0.011	0.004	0.014	0.031	0.026
Total	86.815	83.875	72.921	63.970	64.417	79.130	123.301	118.190	127.283	118.686	109.252

Table 3. (cont.) Fuel consumption [PJ] in 1.A.1.c category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	42.960	33.267	30.513	15.890	19.087	19.270	15.693	13.093	21.001	16.060	10.636
Lignite	0.249	0.375	0.283	0.907	0.577	0.492	0.165	0.191	1.284	2.021	0.888
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.018	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.085	0.043	0.000	0.043	0.128	0.127	0.000	0.000	0.000	0.000	0.000
Natural gas	19.458	19.490	12.987	12.515	9.741	11.190	10.106	10.363	9.680	9.239	8.858
Fuel wood and wood waste	0.005	0.006	0.039	0.029	0.008	0.004	0.002	0.011	0.057	0.020	0.134
Biogas	0.022	0.027	0.012	0.018	0.018	0.016	0.012	0.015	0.028	0.017	0.003
Industrial wastes	0.000	0.010	0.008	0.005	0.013	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.080	0.080	0.000	0.040	0.040	0.040	0.080	0.040	0.040	0.032	0.029
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.029	0.171	0.028	0.000	0.104	0.050	0.026	0.000	0.024	0.592	0.000
Liquid petroleum gas (LPG)	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.047	0.000	0.046
Motor gasoline	0.044	0.044	0.044	0.044	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	1.806	1.806	1.591	1.247	1.247	1.118	1.333	1.290	1.247	1.376	1.516
Fuel oil	0.162	0.242	0.081	0.364	0.242	0.162	0.283	0.040	0.162	0.040	0.040
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	29.871	32.634	33.111	32.027	36.095	40.940	35.719	40.127	43.722	44.789	32.527
Blast furnace gas	0.847	0.840	0.149	0.086	0.021	0.030	0.042	0.045	0.037	0.000	0.000
Gas works gas	0.168	0.005	0.004	0.004	0.004	0.004	0.003	0.004	0.005	0.006	0.012
Fuels											
Liquid fuels	2.225	2.216	1.716	1.738	1.657	1.447	1.696	1.418	1.496	1.448	1.631
Gaseous fuels	19.458	19.490	12.987	12.515	9.741	11.190	10.106	10.363	9.680	9.239	8.858
Solid fuels	74.141	67.310	64.088	48.914	55.888	60.786	51.647	53.458	66.074	63.469	44.062
Other fuels	0.000	0.014	0.008	0.005	0.013	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.027	0.037	0.052	0.047	0.026	0.020	0.014	0.026	0.085	0.037	0.137
Total	95.850	89.067	78.851	63.218	67.325	73.443	63.464	65.265	77.335	74.193	54.687

Table 3. (cont.) Fuel consumption [PJ] in 1.A.1.c category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	2.596	4.928	2.614	2.286	2.586	2.928	3.521	3.108	3.348	4.360	3.118
Lignite	1.075	1.379	0.523	0.169	0.201	0.074	0.065	0.067	0.490	0.153	0.042
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	10.321	9.805	11.205	12.013	12.788	24.089	17.804	15.999	15.014	18.586	22.482
Fuel wood and wood waste	0.349	0.162	0.160	0.122	0.039	0.000	0.026	0.015	0.033	0.020	0.026
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.009	0.004	0.009	0.009
Industrial wastes	0.002	0.010	0.001	0.002	0.002	0.002	0.005	0.006	0.012	0.001	0.001
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.030	0.060	0.062	0.032	0.000	0.000	0.000	0.020	0.015	0.014	0.010
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.000	0.049	0.000	0.000	0.000	0.000	0.000	0.004	0.001	0.001	0.001
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.013	0.002	0.002
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.034	0.025	0.015
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	1.645	2.078	1.472	1.819	1.429	1.892	1.376	1.335	1.274	1.685	1.126
Fuel oil	0.080	0.040	0.040	0.040	0.000	0.000	0.000	0.015	0.106	0.109	0.145
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	43.667	41.153	38.653	40.220	40.298	42.385	40.631	40.299	41.132	39.759	34.910
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.012	0.009	0.012	0.008	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	1.755	2.178	1.574	1.891	1.429	1.892	1.376	1.413	1.441	1.835	1.297
Gaseous fuels	10.321	9.805	11.205	12.013	12.788	24.089	17.804	15.999	15.014	18.586	22.482
Solid fuels	47.350	47.519	41.801	42.683	43.085	45.386	44.217	43.478	44.972	44.272	38.071
Other fuels	0.002	0.010	0.001	0.002	0.002	0.002	0.005	0.006	0.012	0.001	0.001
Biomass	0.349	0.162	0.160	0.122	0.039	0.000	0.032	0.023	0.036	0.029	0.035
Total	59.777	59.674	54.742	56.711	57.343	71.369	63.434	60.919	61.475	64.723	61.886

Table 3. (cont.) Fuel consumption [PJ] in 1.A.1.c category

Fuels	2021
Hard coal	3.114
Lignite	0.061
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.000
Crude oil	0.000
Natural gas	24.293
Fuel wood and wood waste	0.019
Biogas	0.000
Industrial wastes	0.001
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.000
Other petroleum products	0.010
Petroleum coke	0.000
Coke	0.000
Liquid petroleum gas (LPG)	0.002
Motor gasoline	0.007
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	1.150
Fuel oil	0.009
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	41.444
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	1.179
Gaseous fuels	24.293
Solid fuels	44.620
Other fuels	0.001
Biomass	0.019
Total	70.111

Table 4. Fuel consumption [PJ] in 1.A.2.a category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	2.367	1.278	1.138	1.243	1.494	9.159	8.513	25.320	28.922	23.636	21.085
Lignite	0.000	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.009	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	73.507	63.332	52.851	33.974	26.568	25.562	25.487	24.239	25.898	28.278	23.993
Fuel wood and wood waste	0.000	0.000	0.000	0.000	0.000	0.016	0.014	0.005	0.006	0.004	0.006
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	3.158	3.344	4.079	6.756	6.497	4.272	3.757	2.941	0.498	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	12.258	7.268	9.568	19.593	22.076	27.128	33.104	26.669	24.368	28.401	23.197
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.000
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.128	0.128	0.172	0.129	0.172	0.344	0.559	0.774	0.903	0.559	0.301
Fuel oil	18.120	15.400	11.110	7.878	5.333	4.323	2.990	2.060	0.970	4.767	1.616
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	32.570	30.997	26.038	22.091	22.568	21.605	25.480	27.686	24.404	24.257	24.742
Blast furnace gas	43.812	40.192	36.484	27.903	25.909	25.676	28.350	37.610	34.205	36.120	29.520
Gas works gas	4.316	3.219	2.174	1.462	0.718	0.613	0.067	0.068	0.080	0.059	0.007
Fuels											
Liquid fuels	18.248	15.528	11.282	8.007	5.505	4.667	3.549	2.834	1.873	5.374	1.917
Gaseous fuels	73.507	63.332	52.851	33.974	26.568	25.562	25.487	24.239	25.898	28.278	23.993
Solid fuels	95.323	82.955	75.403	72.311	72.764	84.180	95.514	117.353	111.979	112.482	98.551
Other fuels	3.158	3.344	4.079	6.756	6.497	4.272	3.757	2.941	0.498	0.000	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.016	0.014	0.005	0.006	0.004	0.006
Total	190.236	165.159	143.615	121.048	111.334	118.697	128.320	147.372	140.253	146.138	124.467

Table 4. (cont.) Fuel consumption [PJ] in 1.A.2.a category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	19.075	18.262	14.701	12.424	12.593	16.840	10.744	9.071	11.748	3.950	4.784
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.023	0.023	0.023	0.000	0.000	0.023	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	21.440	22.024	18.329	15.463	14.827	19.964	20.455	20.998	22.716	20.397	16.595
Fuel wood and wood waste	0.004	0.003	0.006	0.003	0.004	0.004	0.002	0.001	0.001	0.001	0.001
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	20.900	20.906	16.288	20.126	21.368	22.096	14.900	12.479	4.849	5.569	2.585
Liquid petroleum gas (LPG)	0.047	0.189	0.189	0.237	0.189	0.142	0.000	0.000	0.000	0.047	0.046
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.344	0.516	0.172	0.129	0.129	0.129	0.086	0.129	0.086	0.086	0.087
Fuel oil	1.818	1.050	0.646	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	15.875	17.574	16.994	15.122	16.132	15.302	12.570	12.835	13.885	9.850	5.296
Blast furnace gas	24.034	31.874	26.768	23.876	25.282	26.721	18.896	20.226	28.194	18.347	9.873
Gas works gas	0.008	0.000	0.277	0.706	1.195	1.654	0.965	1.015	1.313	0.993	0.474
Fuels											
Liquid fuels	2.209	1.756	1.008	0.366	0.318	0.271	0.086	0.129	0.086	0.133	0.133
Gaseous fuels	21.440	22.024	18.329	15.463	14.827	19.964	20.455	20.998	22.716	20.397	16.595
Solid fuels	79.891	88.616	75.051	72.276	76.592	82.612	58.075	55.649	59.989	38.709	23.012
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.004	0.003	0.006	0.003	0.004	0.004	0.002	0.001	0.001	0.001	0.001
Total	103.544	112.398	94.393	88.108	91.741	102.851	78.619	76.777	82.792	59.240	39.740

Table 4. (cont.) Fuel consumption [PJ] in 1.A.2.a category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	2.638	2.521	2.605	2.030	2.541	0.762	0.637	1.827	2.357	3.287	1.662
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	16.916	17.209	16.905	16.242	16.097	16.701	19.458	23.715	25.022	21.212	21.382
Fuel wood and wood waste	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.032	0.064	0.096	0.064	0.064	0.064	0.060	0.040	0.033	0.041
Coke	2.920	7.584	9.405	10.333	9.527	11.212	8.570	11.481	8.732	1.066	0.560
Liquid petroleum gas (LPG)	0.046	0.046	0.092	0.046	0.046	0.046	0.046	0.045	0.055	0.052	0.041
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.005	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.087	0.087	0.043	0.043	0.087	0.086	0.086	0.130	0.134	0.140	0.096
Fuel oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	8.378	8.420	8.231	8.518	9.014	5.555	4.361	4.981	5.282	4.436	4.058
Blast furnace gas	12.059	11.258	11.352	10.797	11.863	10.228	10.528	11.281	10.162	10.394	8.015
Gas works gas	0.187	0.203	0.047	0.028	0.099	0.770	0.607	0.554	0.351	0.477	0.517
Fuels											
Liquid fuels	0.133	0.165	0.199	0.185	0.197	0.196	0.196	0.238	0.232	0.230	0.179
Gaseous fuels	16.916	17.209	16.905	16.242	16.097	16.701	19.458	23.715	25.022	21.212	21.382
Solid fuels	26.182	29.987	31.663	31.706	33.044	28.527	24.703	30.124	26.884	19.660	14.812
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
Total	43.230	47.360	48.767	48.134	49.338	45.425	44.358	54.078	52.139	41.103	36.373

Table 4. (cont.) Fuel consumption [PJ] in 1.A.2.a category

Fuels	2021
Hard coal	2.734
Lignite	0.000
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.000
Crude oil	0.000
Natural gas	23.123
Fuel wood and wood waste	0.008
Biogas	0.000
Industrial wastes	0.000
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.000
Other petroleum products	0.000
Petroleum coke	0.050
Coke	0.738
Liquid petroleum gas (LPG)	0.046
Motor gasoline	0.001
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	0.098
Fuel oil	0.000
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	5.329
Blast furnace gas	8.499
Gas works gas	0.525
Fuels	
Liquid fuels	0.196
Gaseous fuels	23.123
Solid fuels	17.825
Other fuels	0.000
Biomass	0.008
Total	41.152

Table 5. Fuel consumption [PJ] in 1.A.2.b category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	1.411	1.323	0.455	0.565	0.850	1.916	1.771	4.172	4.285	3.907	3.331
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	5.638	5.470	4.599	4.633	1.213	1.745	5.321	5.447	5.108	5.424	5.639
Fuel wood and wood waste	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.149	0.042	0.026
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.870	0.719	0.439	0.483	0.514	0.729	0.823	2.150	2.411	2.361	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	9.754	8.730	5.706	4.953	2.149	2.659	6.061	5.927	6.324	6.248	5.983
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.000	0.000
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.043	0.043	0.043	0.043	0.129	0.086	0.129	0.172	0.215	0.215	0.258
Fuel oil	0.640	0.760	0.768	0.808	0.808	0.768	0.808	0.727	0.687	0.646	0.525
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.461	0.437	0.397	0.178	0.186	0.043	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.375	0.341	0.042	0.006	0.000	0.000	0.000	0.000	0.000	0.000	2.164
Fuels											
Liquid fuels	0.683	0.803	0.811	0.851	0.937	0.854	0.937	0.899	0.949	0.861	0.783
Gaseous fuels	5.638	5.470	4.599	4.633	1.213	1.745	5.321	5.447	5.108	5.424	5.639
Solid fuels	12.001	10.832	6.601	5.703	3.186	4.618	7.831	10.099	10.609	10.156	11.478
Other fuels	0.870	0.719	0.439	0.483	0.514	0.729	0.823	2.150	2.411	2.361	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.149	0.042	0.026
Total	19.191	17.823	12.449	11.670	5.850	7.947	14.913	18.595	19.226	18.844	17.925

Table 5. (cont.) Fuel consumption [PJ] in 1.A.2.b category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	3.117	3.108	3.790	2.560	2.115	1.092	0.024	0.024	0.570	0.000	0.000
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	5.660	5.814	5.700	5.589	5.868	6.402	6.464	6.880	6.740	6.537	5.846
Fuel wood and wood waste	0.010	0.011	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.040	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	5.919	6.050	6.111	6.132	5.937	5.821	5.693	5.929	6.297	6.481	6.078
Liquid petroleum gas (LPG)	0.000	0.047	0.095	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.046
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.172	0.258	0.172	0.172	0.129	0.172	0.172	0.172	0.172	0.172	0.173
Fuel oil	0.566	0.566	0.525	0.404	0.323	0.404	0.404	0.404	0.162	0.162	0.160
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	2.070	2.268	2.551	2.739	2.539	1.763	0.961	0.951	0.949	1.220	1.086
Fuels											
Liquid fuels	0.738	0.871	0.792	0.623	0.500	0.664	0.623	0.623	0.381	0.381	0.379
Gaseous fuels	5.660	5.814	5.700	5.589	5.868	6.402	6.464	6.880	6.740	6.537	5.846
Solid fuels	11.106	11.426	12.452	11.431	10.590	8.675	6.678	6.904	7.816	7.701	7.164
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.010	0.011	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	17.514	18.122	18.949	17.644	16.958	15.741	13.765	14.407	14.937	14.619	13.389

Table 5. (cont.) Fuel consumption [PJ] in 1.A.2.b category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	0.000	0.250	0.114	0.113	0.091	0.023	0.068	0.085	0.394	0.748	0.438
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	6.039	6.670	6.890	6.703	6.950	7.225	7.226	7.554	7.958	7.958	7.663
Fuel wood and wood waste	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	5.922	5.985	6.245	6.150	6.389	6.588	5.518	4.701	4.878	5.024	4.723
Liquid petroleum gas (LPG)	0.046	0.046	0.000	0.000	0.000	0.000	0.000	0.027	0.027	0.027	0.025
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.217	0.173	0.173	0.173	0.173	0.129	0.172	0.183	0.187	0.214	0.106
Fuel oil	0.120	0.120	0.120	0.120	0.080	0.120	0.240	0.463	0.258	0.292	0.337
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.039	0.043	0.039	0.051	0.047	0.053	0.086	0.072	0.069	0.075
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.960	0.967	0.928	1.066	1.275	1.316	1.202	1.337	1.394	1.255	1.303
Fuels											
Liquid fuels	0.383	0.339	0.293	0.293	0.253	0.249	0.412	0.673	0.472	0.533	0.468
Gaseous fuels	6.039	6.670	6.890	6.703	6.950	7.225	7.226	7.554	7.958	7.958	7.663
Solid fuels	6.882	7.241	7.329	7.367	7.806	7.974	6.841	6.209	6.738	7.096	6.539
Other fuels	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Biomass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	13.304	14.250	14.512	14.364	15.009	15.448	14.480	14.437	15.168	15.587	14.670

Table 5. (cont.) Fuel consumption [PJ] in 1.A.2.b category

Fuels	2021
Hard coal	0.462
Lignite	0.000
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.000
Crude oil	0.000
Natural gas	7.982
Fuel wood and wood waste	0.000
Biogas	0.000
Industrial wastes	0.000
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.000
Other petroleum products	0.000
Petroleum coke	0.000
Coke	4.930
Liquid petroleum gas (LPG)	0.030
Motor gasoline	0.000
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	0.057
Fuel oil	0.257
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	0.087
Blast furnace gas	0.000
Gas works gas	1.158
Fuels	
Liquid fuels	0.344
Gaseous fuels	7.982
Solid fuels	6.637
Other fuels	0.000
Biomass	0.000
Total	14.963

Table 6. Fuel consumption [PJ] in 1.A.2.c category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	9.197	9.059	7.216	6.623	4.550	13.125	7.945	70.221	71.191	63.913	54.992
Lignite	0.056	0.038	0.039	0.038	0.027	0.047	0.029	0.428	0.460	0.389	0.429
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	6.409	6.244	5.289	4.340	4.432	10.075	4.507	6.356	6.191	11.024	9.408
Fuel wood and wood waste	0.345	0.390	0.118	0.039	0.010	0.003	0.035	0.007	0.000	0.000	0.000
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Industrial wastes	12.255	14.915	16.712	18.586	17.039	18.003	22.591	21.546	17.374	14.356	0.672
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.613	2.894	3.457
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	1.763	4.530	2.542	1.868	1.746	1.790	1.832	3.257	2.835	1.379	1.455
Liquid petroleum gas (LPG)	3.726	4.554	0.000	0.000	0.000	0.047	0.000	0.000	0.000	0.000	0.000
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	1.406	1.363	0.989	0.860	0.774	0.731	0.731	0.946	1.075	1.075	1.419
Fuel oil	6.080	6.120	2.747	1.899	2.788	2.505	3.636	8.242	9.413	9.454	17.736
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	3.614	1.930	0.396	3.465	5.445	4.455	0.198	1.584	6.584	9.653	18.513
Coke oven gas	1.053	0.993	0.701	0.522	0.440	1.548	0.276	0.729	0.784	0.140	0.174
Blast furnace gas	0.148	0.136	0.047	0.010	0.006	0.011	0.014	0.023	0.004	0.013	0.004
Gas works gas	0.190	0.230	0.214	0.192	0.133	0.126	0.110	0.070	0.052	0.000	0.000
Fuels											
Liquid fuels	14.825	13.968	4.132	6.224	9.007	7.738	4.565	10.772	19.685	23.076	41.125
Gaseous fuels	6.409	6.244	5.289	4.340	4.432	10.075	4.507	6.356	6.191	11.024	9.408
Solid fuels	12.407	14.986	10.759	9.252	6.903	16.648	10.206	74.727	75.325	65.835	57.054
Other fuels	12.255	14.915	16.712	18.586	17.039	18.003	22.591	21.546	17.374	14.356	0.672
Biomass	0.345	0.390	0.118	0.039	0.010	0.003	0.035	0.007	0.000	0.000	0.001
Total	46.24061	50.503	37.011	38.440	37.390	52.467	41.905	113.408	118.575	114.290	108.260

Table 6. (cont.) Fuel consumption [PJ] in 1.A.2.c category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	50.522	50.115	48.485	45.458	27.959	26.665	27.446	25.398	26.780	43.781	42.011
Lignite	0.138	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	9.041	9.464	8.481	7.199	6.457	7.494	8.061	9.009	8.754	7.950	9.707
Fuel wood and wood waste	0.000	0.000	0.000	0.001	0.153	0.094	0.153	0.000	0.121	0.000	0.058
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.582	0.607	0.618	0.567	0.875	1.070	0.570	0.671	0.707	0.509	0.584
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	2.533	0.482	0.482	0.281	0.241	0.000	0.040	0.040	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	1.555	1.499	1.574	1.684	1.513	1.821	1.367	2.916	1.928	1.159	0.852
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.092
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.090
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	1.333	1.032	4.773	4.257	4.343	3.913	3.784	4.085	3.741	3.698	4.590
Fuel oil	15.837	13.655	7.434	7.716	7.151	7.353	3.919	3.878	3.596	0.646	1.080
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	19.602	23.315	20.543	20.741	21.830	22.424	18.266	21.335	22.473	19.157	20.889
Coke oven gas	0.131	0.050	0.150	0.285	0.635	0.606	0.608	0.547	0.658	0.654	0.483
Blast furnace gas	0.007	0.011	0.008	0.004	0.013	0.019	0.006	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	39.304	38.484	33.232	32.995	33.565	33.689	26.009	29.338	29.810	23.501	26.741
Gaseous fuels	9.041	9.464	8.481	7.199	6.457	7.494	8.061	9.009	8.754	7.950	9.707
Solid fuels	52.352	51.675	50.217	47.431	30.119	29.110	29.427	28.861	29.366	45.594	43.347
Other fuels	0.582	0.607	0.618	0.567	0.875	1.070	0.570	0.671	0.707	0.509	0.584
Biomass	0.000	0.000	0.000	0.001	0.153	0.094	0.153	0.000	0.121	0.000	0.058
Total	101.280	100.230	92.547	88.194	71.168	71.458	64.220	67.879	68.758	77.554	80.437

Table 6. (cont.) Fuel consumption [PJ] in 1.A.2.c category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	47.304	47.704	46.768	47.308	46.501	42.588	44.241	49.090	49.068	48.164	43.772
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	11.807	13.887	13.568	14.696	14.500	14.860	12.068	13.020	15.171	14.969	17.034
Fuel wood and wood waste	0.058	0.053	0.131	0.050	0.103	0.088	0.138	0.099	0.142	0.370	0.352
Biogas	0.000	0.000	0.000	0.000	0.008	0.006	0.006	0.005	0.004	0.001	0.001
Industrial wastes	0.770	0.732	0.581	1.092	1.082	0.936	0.652	1.494	0.744	0.393	0.330
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.002
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.791	1.260	3.089	2.944	2.942	3.151	3.456	1.496	1.819	2.258	2.796
Liquid petroleum gas (LPG)	0.138	0.138	0.138	0.184	0.138	0.230	0.276	0.300	0.307	0.337	0.272
Motor gasoline	0.000	0.045	0.045	0.045	0.000	0.000	0.000	0.008	0.010	0.009	0.001
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	4.200	3.637	3.334	4.027	2.468	1.806	1.505	1.744	1.714	1.976	1.857
Fuel oil	0.600	0.720	0.560	0.440	0.400	0.560	0.400	0.348	0.332	0.282	0.204
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	17.177	12.276	9.702	11.979	10.296	7.722	8.019	10.697	10.367	15.804	17.298
Coke oven gas	0.627	0.616	0.595	0.639	0.645	0.624	0.598	0.623	0.613	0.580	0.256
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	22.115	16.816	13.779	16.675	13.302	10.318	10.200	13.099	12.732	18.411	19.634
Gaseous fuels	11.807	13.887	13.568	14.696	14.500	14.860	12.068	13.020	15.171	14.969	17.034
Solid fuels	48.722	49.579	50.452	50.892	50.088	46.363	48.295	51.209	51.499	51.002	46.825
Other fuels	0.770	0.732	0.581	1.092	1.082	0.936	0.652	1.494	0.744	0.393	0.330
Biomass	0.058	0.053	0.131	0.050	0.111	0.094	0.144	0.104	0.146	0.371	0.353
Total	83.472	81.068	78.511	83.405	79.083	72.571	71.359	78.926	80.292	85.146	84.176

Table 6. (cont.) Fuel consumption [PJ] in 1.A.2.c category

Fuels	2021
Hard coal	45.948
Lignite	0.000
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.000
Crude oil	0.000
Natural gas	18.888
Fuel wood and wood waste	0.253
Biogas	0.001
Industrial wastes	0.028
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.000
Other petroleum products	0.002
Petroleum coke	0.000
Coke	2.111
Liquid petroleum gas (LPG)	0.329
Motor gasoline	0.000
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	0.339
Fuel oil	0.257
Feedstocks	0.000
Refinery gas	19.658
Coke oven gas	0.493
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	20.584
Gaseous fuels	18.888
Solid fuels	48.552
Other fuels	0.028
Biomass	0.255
Total	88.307

Table 7. Fuel consumption [PJ] in 1.A.2.d category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	1.639	1.940	1.548	1.741	1.379	4.524	3.836	22.318	22.233	23.979	18.936
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	0.103	0.162	0.101	0.061	0.026	0.061	0.250	0.232	0.455	1.096	0.563
Fuel wood and wood waste	0.352	0.205	0.001	0.000	0.000	1.585	1.610	15.437	16.243	16.472	16.476
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.331	0.247	0.243	0.271	0.242	0.298	0.269	0.267	0.245	0.135	0.081
Liquid petroleum gas (LPG)	0.046	0.046	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.095	0.189
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.085	0.085	0.043	0.086	0.043	0.043	0.086	0.129	0.602	0.989	1.118
Fuel oil	1.240	1.160	1.293	1.212	1.333	1.576	1.414	2.384	1.050	1.050	1.333
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.004	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.001	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.003	0.003	0.003	0.014	0.002	0.000	0.000	0.000	0.004	0.000	0.000
Fuels											
Liquid fuels	1.371	1.291	1.383	1.345	1.424	1.666	1.547	2.560	1.700	2.134	2.640
Gaseous fuels	0.103	0.162	0.101	0.061	0.026	0.061	0.250	0.232	0.455	1.096	0.563
Solid fuels	1.976	2.192	1.797	2.027	1.624	4.825	4.108	22.587	22.482	24.114	19.017
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.352	0.205	0.001	0.000	0.000	1.585	1.610	15.437	16.243	16.472	16.476
Total	3.803	3.850	3.282	3.434	3.074	8.137	7.515	40.816	40.881	43.816	38.697

Table 7. (cont.) Fuel consumption [PJ] in 1.A.2.d category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	17.528	15.696	15.564	14.317	14.050	13.797	13.430	11.592	9.452	7.850	8.515
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	1.007	1.211	1.445	1.461	2.094	2.657	2.288	2.976	4.087	4.822	4.973
Fuel wood and wood waste	15.545	15.938	15.138	16.622	17.950	18.957	18.611	19.379	18.644	19.729	19.171
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.040	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.000	0.027	0.026	0.028	0.055	0.028	0.027	0.028	0.028	0.028	0.000
Liquid petroleum gas (LPG)	0.095	0.142	0.095	0.047	0.047	0.095	0.047	0.095	0.189	0.047	0.092
Motor gasoline	0.000	0.000	0.000	0.000	0.089	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.817	0.602	0.473	0.430	0.473	0.473	0.344	0.387	0.430	0.301	0.303
Fuel oil	1.333	1.374	1.495	1.576	1.616	1.697	1.616	1.616	1.737	1.656	1.600
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	2.245	2.118	2.062	2.053	2.225	2.264	2.048	2.138	2.356	2.005	1.995
Gaseous fuels	1.007	1.211	1.445	1.461	2.094	2.657	2.288	2.976	4.087	4.822	4.973
Solid fuels	17.528	15.723	15.591	14.345	14.105	13.824	13.457	11.620	9.480	7.879	8.515
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	15.545	15.938	15.138	16.622	17.950	18.957	18.611	19.379	18.644	19.729	19.189
Total	36.325	34.989	34.236	34.480	36.374	37.703	36.403	36.113	34.567	34.435	34.671

Table 7. (cont.) Fuel consumption [PJ] in 1.A.2.d category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	10.086	11.301	10.643	11.460	11.291	10.922	9.628	8.744	7.024	7.751	6.637
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	5.135	4.587	5.535	6.271	6.994	7.166	7.991	8.709	8.513	9.935	9.314
Fuel wood and wood waste	19.581	19.402	20.358	27.152	26.987	27.070	30.415	33.742	36.138	38.625	40.403
Biogas	0.049	0.073	0.083	0.091	0.105	0.086	0.111	0.139	0.096	0.105	0.109
Industrial wastes	0.000	0.000	0.000	0.037	0.125	0.108	0.190	0.295	0.360	0.427	0.531
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.001
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Liquid petroleum gas (LPG)	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.107	0.111	0.122	0.137
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.019	0.021	0.001
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.260	0.217	0.173	0.260	0.173	0.258	0.473	0.574	0.478	0.591	0.434
Fuel oil	1.640	1.680	1.520	1.520	1.280	1.480	1.320	1.058	0.930	0.990	0.942
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	1.992	1.989	1.785	1.872	1.545	1.830	1.885	1.751	1.539	1.724	1.514
Gaseous fuels	5.135	4.587	5.535	6.271	6.994	7.166	7.991	8.709	8.513	9.935	9.314
Solid fuels	10.113	11.301	10.643	11.460	11.291	10.922	9.628	8.744	7.024	7.751	6.637
Other fuels	0.000	0.000	0.000	0.037	0.125	0.108	0.190	0.295	0.360	0.427	0.531
Biomass	19.630	19.475	20.441	27.243	27.092	27.156	30.526	33.881	36.234	38.730	40.512
Total	36.870	37.352	38.404	46.883	47.047	47.182	50.220	53.380	53.671	58.568	58.508

Table 7. (cont.) Fuel consumption [PJ] in 1.A.2.d category

Fuels	2021
Hard coal	7.194
Lignite	0.000
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.000
Crude oil	0.000
Natural gas	9.855
Fuel wood and wood waste	22.756
Biogas	0.170
Industrial wastes	0.406
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	1.374
Other petroleum products	0.001
Petroleum coke	0.000
Coke	0.000
Liquid petroleum gas (LPG)	0.158
Motor gasoline	0.001
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	0.775
Fuel oil	1.063
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	0.000
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	1.998
Gaseous fuels	9.855
Solid fuels	7.194
Other fuels	0.406
Biomass	24.300
Total	43.753

Table 8. Fuel consumption [PJ] in 1.A.2.e category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	25.200	31.694	31.914	35.940	32.724	55.643	53.801	73.024	88.777	78.207	64.659
Lignite	0.085	0.104	0.058	0.019	0.018	0.369	0.195	0.265	0.380	0.250	0.317
Hard coal briquettes (patent fuels)	0.023	0.023	0.000	0.000	0.000	0.163	0.162	0.046	0.025	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	1.965	1.910	1.970	1.985	2.339	3.171	7.180	3.839	15.051	12.927	10.694
Fuel wood and wood waste	0.114	0.105	0.091	0.094	0.072	0.151	0.056	0.082	0.094	0.075	0.101
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Industrial wastes	0.003	0.002	0.000	0.000	0.031	0.003	0.003	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.080	0.080	0.040
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	3.609	3.569	3.164	2.788	2.499	3.093	2.559	2.403	3.053	2.705	1.967
Liquid petroleum gas (LPG)	0.046	0.046	0.047	0.047	0.047	0.047	0.095	0.142	0.189	0.189	0.284
Motor gasoline	0.440	0.264	0.133	0.089	0.133	0.177	0.133	0.177	0.177	0.044	0.089
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	2.087	1.534	1.247	1.032	0.903	1.204	1.075	0.903	5.461	5.203	6.837
Fuel oil	1.840	1.640	1.656	1.495	1.333	3.313	3.959	6.181	2.747	2.424	2.707
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.336	0.120	0.111	0.125	0.124	0.102	0.003	0.025	0.004	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.027	0.032	0.051	0.014	0.001	0.001	0.000	0.000	0.003	0.000	0.000
Fuels											
Liquid fuels	4.413	3.484	3.084	2.663	2.416	4.741	5.262	7.403	8.655	7.941	9.956
Gaseous fuels	1.965	1.910	1.970	1.985	2.339	3.171	7.180	3.839	15.051	12.927	10.694
Solid fuels	29.280	35.542	35.298	38.886	35.366	59.370	56.721	75.762	92.241	81.162	66.942
Other fuels	0.003	0.002	0.000	0.000	0.031	0.003	0.003	0.000	0.000	0.000	0.000
Biomass	0.114	0.105	0.091	0.094	0.072	0.151	0.056	0.082	0.094	0.075	0.104
Total	35.775	41.043	40.443	43.627	40.224	67.436	69.222	87.087	116.041	102.104	87.696

Table 8. (cont.) Fuel consumption [PJ] in 1.A.2.e category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	46.327	43.417	40.020	41.803	39.030	36.095	35.894	30.864	31.164	26.777	25.813
Lignite	0.237	0.191	0.149	0.192	0.175	0.129	0.092	0.074	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	9.255	10.494	11.363	12.490	15.075	16.164	17.456	18.623	20.614	20.725	20.950
Fuel wood and wood waste	0.069	0.049	0.062	0.060	0.323	0.373	0.214	0.239	0.164	0.365	0.192
Biogas	0.020	0.063	0.042	0.037	0.063	0.074	0.068	0.072	0.084	0.094	0.109
Industrial wastes	0.000	0.001	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	1.637	1.526	1.259	1.491	1.293	1.186	0.911	0.841	0.907	0.650	0.632
Liquid petroleum gas (LPG)	0.473	0.710	0.899	1.466	1.419	1.608	1.466	1.230	0.946	1.041	0.966
Motor gasoline	0.044	0.133	0.044	0.089	0.089	0.000	0.044	0.044	0.044	0.044	0.045
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	7.482	7.353	7.267	6.880	6.880	6.192	5.418	4.515	4.085	4.515	3.161
Fuel oil	2.303	2.545	2.747	2.990	3.070	3.313	3.192	2.949	2.788	2.020	1.440
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	10.302	10.741	10.957	11.425	11.458	11.113	10.120	8.738	7.863	7.620	5.612
Gaseous fuels	9.255	10.494	11.363	12.490	15.075	16.164	17.456	18.623	20.614	20.725	20.950
Solid fuels	48.201	45.134	41.444	43.486	40.497	37.409	36.898	31.779	32.072	27.427	26.446
Other fuels	0.000	0.001	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.089	0.112	0.104	0.097	0.386	0.447	0.282	0.311	0.248	0.459	0.301
Total	67.847	66.481	63.883	67.498	67.416	65.133	64.756	59.451	60.796	56.231	53.309

Table 8. (cont.) Fuel consumption [PJ] in 1.A.2.e category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	25.903	25.613	26.172	24.724	24.429	22.011	22.555	22.972	23.170	23.123	21.423
Lignite	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.001	0.001
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	21.610	22.128	23.704	24.475	25.094	26.008	27.590	29.943	36.319	35.407	34.270
Fuel wood and wood waste	0.441	0.534	0.436	0.664	0.747	1.134	1.383	1.072	1.244	0.780	0.650
Biogas	0.101	0.145	0.199	0.202	0.350	0.345	0.407	0.422	0.374	0.546	0.601
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.600	0.509	0.306	0.361	0.448	0.624	0.646	0.726	0.759	0.740	0.679
Liquid petroleum gas (LPG)	0.828	0.782	0.690	0.828	0.966	0.966	1.104	1.195	1.135	1.005	1.044
Motor gasoline	0.045	0.000	0.000	0.000	0.000	0.000	0.043	0.016	0.041	0.018	0.007
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	2.901	2.382	2.944	1.992	1.516	1.290	1.419	1.473	1.358	1.233	0.942
Fuel oil	1.240	1.360	1.360	1.080	1.000	0.600	0.760	0.721	0.799	0.664	0.506
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	5.014	4.524	4.994	3.900	3.482	2.856	3.326	3.405	3.333	2.920	2.498
Gaseous fuels	21.610	22.128	23.704	24.475	25.094	26.008	27.590	29.943	36.319	35.407	34.270
Solid fuels	26.503	26.123	26.478	25.085	24.877	22.635	23.201	23.701	23.936	23.864	22.103
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.542	0.679	0.635	0.866	1.097	1.479	1.790	1.494	1.618	1.326	1.251
Total	53.669	53.453	55.811	54.325	54.549	52.978	55.907	58.543	65.207	63.518	60.122

Table 8. (cont.) Fuel consumption [PJ] in 1.A.2.e category

Fuels	2021
Hard coal	20.313
Lignite	0.001
Hard coal briquettes (patent fuels)	0.001
Brown coal briquettes	0.003
Crude oil	0.000
Natural gas	35.687
Fuel wood and wood waste	0.405
Biogas	0.501
Industrial wastes	0.000
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.006
Other petroleum products	0.000
Petroleum coke	0.000
Coke	0.704
Liquid petroleum gas (LPG)	1.143
Motor gasoline	0.003
Aviation gasoline	0.000
Jet kerosene	0.001
Diesel oil	0.883
Fuel oil	0.429
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	0.000
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	2.458
Gaseous fuels	35.687
Solid fuels	21.022
Other fuels	0.000
Biomass	0.912
Total	60.079

Table 9. Fuel consumption [PJ] in 1.A.2.f category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	102.301	98.072	72.637	72.514	68.894	76.924	83.926	79.647	86.930	81.562	66.639
Lignite	0.263	0.180	0.156	0.150	0.091	0.161	0.117	0.163	0.150	0.185	0.153
Hard coal briquettes (patent fuels)	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.035	0.018	0.017	0.018	0.000	0.000	0.000	0.000	0.000	0.035	0.035
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	28.729	28.108	24.575	22.704	22.246	21.986	21.506	25.518	26.650	25.655	27.097
Fuel wood and wood waste	1.778	1.924	1.155	0.455	0.042	0.033	0.004	0.010	0.010	0.005	0.006
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.382	0.446	0.068	0.023	0.267	0.250	0.145	0.197	0.144	0.047	0.207
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.407	1.206
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	18.984	18.997	13.225	10.745	10.479	10.200	10.774	9.477	10.657	8.223	9.537
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.095	0.142	0.047	0.095	0.237
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.133	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	1.321	1.108	0.946	0.817	0.774	0.774	0.946	1.333	1.806	2.795	2.021
Fuel oil	6.000	6.720	4.202	2.828	3.596	4.000	4.363	6.141	3.798	4.161	6.747
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	2.685	2.241	2.101	1.821	1.341	1.234	0.482	0.887	0.509	0.353	0.988
Blast furnace gas	0.140	0.118	0.101	0.106	0.079	0.108	0.120	0.053	0.053	0.036	0.010
Gas works gas	3.926	3.761	3.270	3.137	2.706	2.392	2.090	1.788	1.033	0.501	0.330
Fuels											
Liquid fuels	7.321	7.828	5.148	3.645	4.370	4.774	5.404	7.616	5.651	8.591	10.210
Gaseous fuels	28.729	28.108	24.575	22.704	22.246	21.986	21.506	25.518	26.650	25.655	27.097
Solid fuels	128.357	123.387	91.506	88.490	83.590	91.020	97.509	92.014	99.333	90.895	77.693
Other fuels	0.382	0.446	0.068	0.023	0.267	0.250	0.145	0.197	0.144	0.047	0.207
Biomass	1.778	1.924	1.155	0.455	0.042	0.033	0.004	0.010	0.010	0.005	0.006
Total	166.566	161.692	122.451	115.318	110.515	118.062	124.569	125.355	131.788	125.193	115.214

Table 9. (cont.) Fuel consumption [PJ] in 1.A.2.f category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	59.965	53.349	41.103	33.981	30.332	32.309	31.182	31.523	43.846	36.975	26.468
Lignite	0.069	0.057	0.009	0.019	0.000	0.000	0.000	0.000	0.000	0.063	0.000
Hard coal briquettes (patent fuels)	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.035	0.035	0.017	0.018	0.034	0.035	0.035	0.035	0.035	0.035	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	23.917	27.977	31.858	33.233	35.584	38.225	38.955	41.274	42.465	39.696	41.394
Fuel wood and wood waste	0.002	0.006	0.275	0.292	0.102	0.261	0.110	0.139	0.116	0.223	0.285
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.529	0.472	0.524	0.508	1.471	1.818	2.701	5.043	5.961	7.400	7.715
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.003	0.013	0.717	1.620	1.776	0.378	4.419
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.029
Other petroleum products	0.402	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	4.485	3.283	7.183	3.640	1.593	1.170	2.752
Coke	7.667	6.451	4.485	4.279	4.703	4.524	2.439	3.001	4.480	2.657	2.200
Liquid petroleum gas (LPG)	0.331	0.520	0.757	1.656	1.419	1.703	0.899	0.378	0.331	0.378	0.460
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.045
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	1.720	1.634	1.978	2.150	2.279	2.795	2.193	1.892	1.849	2.193	1.992
Fuel oil	5.979	3.919	4.363	4.646	4.565	4.525	4.121	2.909	2.141	2.424	1.960
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.804	0.413	0.897	0.767	0.746	1.505	1.370	1.465	1.614	1.523	1.233
Blast furnace gas	0.005	0.011	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Gas works gas	0.304	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	8.432	6.073	7.098	8.452	12.748	12.305	14.395	8.819	5.914	6.165	7.209
Gaseous fuels	23.917	27.977	31.858	33.233	35.584	38.225	38.955	41.274	42.465	39.696	41.394
Solid fuels	68.849	60.340	46.515	39.067	35.815	38.373	35.025	36.024	49.975	41.253	29.902
Other fuels	0.529	0.472	0.524	0.508	1.474	1.831	3.418	6.663	7.737	7.778	12.134
Biomass	0.002	0.006	0.275	0.292	0.102	0.261	0.110	0.139	0.117	0.224	0.314
Total	101.729	94.867	86.270	81.552	85.724	90.994	91.903	92.919	106.207	95.117	90.952

Table 9. (cont.) Fuel consumption [PJ] in 1.A.2.f category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	28.045	34.403	26.766	22.808	23.013	20.539	19.346	21.245	21.733	19.818	16.964
Lignite	0.224	0.283	0.549	0.347	0.487	0.545	0.584	0.646	0.688	0.721	0.598
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
Brown coal briquettes	0.000	0.000	0.000	0.157	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	42.872	44.492	42.349	40.911	40.873	40.514	43.984	44.575	43.117	46.329	44.359
Fuel wood and wood waste	0.299	0.348	0.407	0.498	0.724	0.623	0.511	0.176	0.216	0.208	0.295
Biogas	0.000	0.000	0.000	0.004	0.044	0.040	0.038	0.030	0.035	0.025	0.000
Industrial wastes	10.454	11.729	12.170	12.763	15.171	15.068	17.249	19.538	24.693	26.289	25.316
Municipal waste - non-biogenic fraction	4.512	5.017	3.913	3.752	4.060	4.011	8.179	8.588	7.682	6.982	7.193
Municipal waste – biogenic fraction	0.123	1.338	1.360	1.391	1.528	1.664	2.094	2.411	2.554	2.214	2.422
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	1.792	0.064	0.160	0.128	0.032	0.000	0.928	1.670	1.917	2.231	1.459
Coke	2.429	2.519	2.449	2.305	2.466	3.151	2.698	2.164	2.089	2.038	2.428
Liquid petroleum gas (LPG)	0.414	0.368	0.230	0.322	0.414	0.368	0.322	0.369	0.361	0.342	0.255
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.043	0.043	0.034	0.021	0.024	0.005
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	1.992	2.338	1.862	1.472	1.299	1.290	1.247	1.032	1.395	1.616	0.944
Fuel oil	1.840	1.640	1.400	1.320	0.680	0.280	0.200	0.212	0.182	0.094	0.170
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	1.614	1.866	1.687	1.552	1.951	1.841	2.006	1.940	1.689	1.688	1.644
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	6.038	4.410	3.652	3.242	2.425	1.981	2.740	3.318	3.876	4.306	2.833
Gaseous fuels	42.872	44.492	42.349	40.911	40.873	40.514	43.984	44.575	43.117	46.329	44.359
Solid fuels	32.311	39.070	31.450	27.169	27.917	26.075	24.634	25.996	26.200	24.266	21.635
Other fuels	14.966	16.746	16.083	16.515	19.231	19.079	25.428	28.126	32.375	33.271	32.509
Biomass	0.422	1.686	1.767	1.893	2.296	2.327	2.643	2.617	2.805	2.447	2.716
Total	96.609	106.405	95.301	89.730	92.741	89.977	99.429	104.632	108.373	110.619	104.052

Table 9. (cont.) Fuel consumption [PJ] in 1.A.2.f category

Fuels	2021
Hard coal	16.704
Lignite	0.985
Hard coal briquettes (patent fuels)	0.002
Brown coal briquettes	0.000
Crude oil	0.000
Natural gas	51.813
Fuel wood and wood waste	4.046
Biogas	0.000
Industrial wastes	23.737
Municipal waste - non-biogenic fraction	6.741
Municipal waste – biogenic fraction	0.041
Other petroleum products	0.002
Petroleum coke	1.322
Coke	2.920
Liquid petroleum gas (LPG)	0.288
Motor gasoline	0.007
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	1.113
Fuel oil	0.192
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	1.901
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	2.923
Gaseous fuels	51.813
Solid fuels	22.513
Other fuels	30.478
Biomass	4.087
Total	111.814

Table 10. Fuel consumption [PJ] in 1.A.2.g category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	56.386	49.492	38.515	36.641	29.690	80.735	73.256	81.015	105.124	88.132	65.259
Lignite	0.789	0.662	0.175	0.564	0.183	0.653	0.274	0.621	0.600	0.389	0.317
Hard coal briquettes (patent fuels)	0.210	0.139	0.069	0.027	0.000	0.000	0.000	0.000	0.025	0.000	0.000
Brown coal briquettes	0.088	0.071	0.035	0.036	0.035	0.035	0.035	0.035	0.035	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	24.039	22.347	15.645	11.756	13.811	17.922	17.337	15.177	14.210	16.061	17.640
Fuel wood and wood waste	8.335	7.545	5.826	5.518	5.035	4.995	3.410	4.968	6.519	8.194	8.231
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.001	0.002
Industrial wastes	0.082	0.058	0.022	0.012	0.134	0.298	1.593	2.294	2.675	1.133	2.080
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.121	0.442	0.523
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	20.610	18.284	12.143	9.527	10.371	9.902	6.276	5.259	5.370	3.760	1.913
Liquid petroleum gas (LPG)	0.184	0.138	0.142	0.095	0.095	0.095	0.142	0.047	0.142	0.426	0.473
Motor gasoline	1.716	1.584	1.108	1.285	0.886	0.930	0.532	1.019	0.620	2.171	0.753
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.088
Diesel oil	14.228	13.078	10.449	8.815	7.310	7.740	7.181	8.299	18.576	15.609	13.244
Fuel oil	3.720	3.240	2.182	1.858	2.424	3.353	3.757	5.090	3.232	3.313	3.798
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	2.499	2.357	1.674	0.984	0.734	0.475	0.055	0.049	0.022	0.010	0.011
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	1.457	1.056	0.732	0.458	0.212	0.022	0.063	0.016	0.001	0.001	0.000
Fuels											
Liquid fuels	19.848	18.040	13.880	12.053	10.715	12.118	11.612	14.456	22.691	21.960	18.879
Gaseous fuels	24.039	22.347	15.645	11.756	13.811	17.922	17.337	15.177	14.210	16.061	17.640
Solid fuels	82.038	72.062	53.343	48.237	41.225	91.821	79.959	86.995	111.176	92.291	67.499
Other fuels	0.082	0.058	0.022	0.012	0.134	0.298	1.593	2.294	2.675	1.133	2.080
Biomass	8.335	7.545	5.826	5.518	5.035	4.995	3.410	4.970	6.520	8.195	8.233
Total	134.342	120.051	88.715	77.575	70.920	127.154	113.910	123.892	157.271	139.641	114.331

Table 10. (cont.) Fuel consumption [PJ] in 1.A.2.g category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	49.965	40.661	31.997	26.863	25.046	21.926	20.047	18.023	16.541	14.069	10.977
Lignite	0.247	0.210	0.149	0.106	0.055	0.009	0.009	0.019	0.000	0.009	0.163
Hard coal briquettes (patent fuels)	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.070	0.095
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	16.352	18.545	18.320	19.273	21.156	22.582	23.324	23.290	23.540	26.264	22.861
Fuel wood and wood waste	8.604	10.105	10.716	12.300	11.897	12.184	12.193	11.624	13.235	14.043	14.004
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003
Industrial wastes	1.482	2.075	1.802	2.078	2.503	1.661	1.700	3.789	0.937	1.154	1.392
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.000	0.000
Other petroleum products	0.362	0.241	0.040	0.080	0.080	0.121	0.080	0.121	0.080	0.064	0.029
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	2.756	2.141	2.151	1.850	1.705	1.076	0.590	0.841	0.822	0.678	0.440
Liquid petroleum gas (LPG)	0.804	1.514	1.135	1.135	1.277	1.372	1.372	1.277	1.183	1.230	0.966
Motor gasoline	0.354	0.310	0.177	0.133	0.222	0.177	0.177	0.222	0.133	0.089	0.135
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.088	0.088	0.088	0.044	0.044	0.044	0.044	0.088	0.088	0.044	0.043
Diesel oil	11.481	10.793	9.890	9.804	10.191	9.632	10.492	11.094	9.976	9.159	9.093
Fuel oil	3.596	3.636	3.111	2.868	2.747	2.909	2.949	2.666	1.495	1.293	1.280
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.006	0.005	0.020	0.016	0.117	0.436	0.110	0.062	0.059	0.047	0.033
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.013	0.013	0.000	0.000	0.000	0.006
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	16.685	16.582	14.442	14.065	14.561	14.254	15.115	15.468	12.955	11.878	11.546
Gaseous fuels	16.352	18.545	18.320	19.273	21.156	22.582	23.324	23.290	23.540	26.264	22.861
Solid fuels	52.974	43.040	34.317	28.834	26.923	23.460	20.769	18.945	17.440	14.873	11.715
Other fuels	1.482	2.075	1.802	2.078	2.503	1.661	1.700	3.789	0.938	1.154	1.392
Biomass	8.604	10.105	10.716	12.300	11.897	12.184	12.193	11.626	13.240	14.044	14.007
Total	96.097	90.347	79.596	76.550	77.040	74.141	73.100	73.118	68.112	68.214	61.521

Table 10. (cont.) Fuel consumption [PJ] in 1.A.2.g category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	11.348	10.096	7.618	7.287	6.675	7.602	6.464	6.647	6.518	6.003	5.016
Lignite	0.089	0.363	0.269	0.431	0.159	0.182	0.319	0.659	0.649	0.569	0.668
Hard coal briquettes (patent fuels)	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.004	0.003	0.001	0.002
Brown coal briquettes	0.068	0.184	0.081	0.035	0.030	0.030	0.030	0.055	0.060	0.050	0.043
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	24.964	23.875	23.019	26.035	23.395	22.750	24.489	26.749	27.581	27.911	27.473
Fuel wood and wood waste	17.901	20.051	20.854	24.842	25.929	27.937	30.034	32.860	31.082	35.447	39.326
Biogas	0.000	0.000	0.000	0.000	0.000	0.044	0.042	0.013	0.033	0.022	0.026
Industrial wastes	0.070	0.052	0.069	0.098	0.064	0.045	0.037	0.105	0.107	0.050	0.043
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.090	0.090	0.093	0.064	0.096	0.065	0.065	0.074	0.084	0.024	0.017
Petroleum coke	0.000	0.000	1.024	0.320	0.736	0.832	0.128	0.000	0.000	0.000	0.000
Coke	0.355	0.214	0.167	0.194	0.140	0.085	0.140	0.086	0.080	0.069	0.119
Liquid petroleum gas (LPG)	1.150	1.196	0.966	1.150	1.334	1.150	1.380	1.539	1.605	1.639	1.601
Motor gasoline	0.270	0.135	0.090	0.090	0.176	0.086	0.086	0.187	0.117	0.209	0.044
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.043	0.043	0.000	0.043	0.043	0.000	0.043	0.022	0.020	0.012	0.016
Diesel oil	8.660	8.703	7.101	6.538	6.668	6.063	6.536	6.641	7.026	7.607	6.841
Fuel oil	1.480	1.480	0.960	0.560	0.560	0.200	0.240	0.391	0.359	0.293	0.280
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.020	0.025	0.010	0.010	0.005	0.003	0.005	0.128	0.084	0.003	0.002
Blast furnace gas	0.009	0.012	0.004	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	11.693	11.647	10.234	8.765	9.613	8.396	8.478	8.854	9.212	9.785	8.799
Gaseous fuels	24.964	23.875	23.019	26.035	23.395	22.750	24.489	26.749	27.581	27.911	27.473
Solid fuels	11.889	10.918	8.149	7.961	7.010	7.901	6.959	7.581	7.394	6.696	5.850
Other fuels	0.070	0.052	0.069	0.098	0.064	0.045	0.037	0.105	0.107	0.050	0.043
Biomass	17.901	20.051	20.854	24.842	25.929	27.981	30.076	32.873	31.115	35.469	39.353
Total	66.518	66.543	62.325	67.702	66.011	67.074	70.039	76.162	75.408	79.911	81.518

Table 10. (cont.) Fuel consumption [PJ] in 1.A.2.g category

Fuels	2021
Hard coal	5.497
Lignite	0.901
Hard coal briquettes (patent fuels)	0.009
Brown coal briquettes	0.048
Crude oil	0.000
Natural gas	30.170
Fuel wood and wood waste	37.596
Biogas	0.104
Industrial wastes	0.117
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.024
Other petroleum products	0.028
Petroleum coke	0.000
Coke	0.193
Liquid petroleum gas (LPG)	1.945
Motor gasoline	0.066
Aviation gasoline	0.000
Jet kerosene	0.015
Diesel oil	6.989
Fuel oil	0.394
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	0.002
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	9.437
Gaseous fuels	30.170
Solid fuels	6.649
Other fuels	0.117
Biomass	37.724
Total	84.098

Table 11. Fuel consumption [PJ] in 1.A.4.a category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	207.335	163.251	54.547	62.166	54.214	50.334	34.666	34.267	25.608	18.696	16.200
Lignite	0.540	0.390	0.000	0.000	0.000	0.017	0.091	0.025	0.026	0.009	0.009
Hard coal briquettes (patent fuels)	5.749	1.581	0.000	0.000	0.000	0.000	0.000	0.255	0.000	0.000	0.000
Brown coal briquettes	0.548	0.476	0.375	0.000	0.000	1.605	1.622	1.729	0.217	0.466	0.098
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	13.079	12.601	13.787	10.977	11.190	11.548	9.573	13.260	18.771	24.256	32.769
Fuel wood and wood waste	0.000	0.000	0.000	0.000	0.000	12.312	11.719	11.560	10.046	9.028	8.437
Biogas	0.084	0.123	0.379	0.187	0.206	0.062	0.249	0.423	0.579	0.599	0.648
Industrial wastes	2.135	0.144	0.504	0.081	0.011	0.352	0.089	0.000	0.124	0.000	0.003
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	80.500	77.450	33.714	27.952	39.634	32.890	26.880	25.224	25.627	28.355	12.621
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	1.372	0.804	0.804	1.797	1.608
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.989	4.300	6.235
Fuel oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.081	0.000
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	1.417	1.135	1.224	1.088	0.877	0.428	0.123	0.053	0.034	0.127	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.937	0.330	0.312	0.554	0.576	0.091	0.014	0.014	0.014	0.072	0.041
Fuels											
Liquid fuels	0.000	0.000	0.000	0.000	0.000	0.000	1.372	0.804	1.793	6.178	7.843
Gaseous fuels	13.079	12.601	13.787	10.977	11.190	11.548	9.573	13.260	18.771	24.256	32.769
Solid fuels	297.025	244.614	90.171	91.760	95.301	85.366	63.396	61.568	51.525	47.725	28.968
Other fuels	2.135	0.144	0.504	0.081	0.011	0.352	0.089	0.000	0.124	0.000	0.003
Biomass	0.084	0.123	0.379	0.187	0.206	12.374	11.968	11.983	10.625	9.627	9.085
Total	312.322	257.481	104.842	103.005	106.708	109.640	86.398	87.615	82.839	87.786	78.668

Fuel consumption from the 1.A.4.a.ii category is included in 1.A.3.b category

Table 11. (cont.) Fuel consumption [PJ] in 1.A.4.a category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	15.104	13.355	13.460	21.676	21.539	22.502	25.405	29.320	25.291	28.763	31.393
Lignite	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.474	0.341	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	37.697	38.567	49.971	61.001	67.057	69.564	68.410	63.517	65.489	71.250	75.746
Fuel wood and wood waste	8.553	8.514	5.736	5.747	5.752	6.028	6.171	4.580	5.482	5.020	7.104
Biogas	0.663	0.678	0.860	0.683	0.700	1.325	1.602	1.582	1.438	1.795	1.675
Industrial wastes	0.004	0.004	0.091	0.092	0.060	0.002	0.022	0.000	0.000	0.000	0.092
Municipal waste - non-biogenic fraction	0.000	0.020	0.000	0.009	0.011	0.000	0.000	0.000	0.000	0.037	0.031
Municipal waste – biogenic fraction	0.000	0.019	0.000	0.010	0.014	0.013	0.030	0.028	0.029	0.008	0.000
Other petroleum products	0.643	0.884	3.015	0.362	1.729	2.010	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	12.229	8.255	3.801	8.099	8.197	5.794	2.625	2.825	2.535	2.027	2.072
Liquid petroleum gas (LPG)	2.129	2.365	3.358	3.453	5.676	5.156	4.730	5.392	5.061	4.588	3.772
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	7.654	13.373	15.050	19.135	16.813	14.319	13.244	23.306	22.919	22.919	21.910
Fuel oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.005	0.005	0.004	0.003	0.004	0.003	0.003	0.003	0.014	0.018	0.017
Fuels											
Liquid fuels	10.426	16.622	21.423	22.950	24.218	21.485	17.974	28.698	27.980	27.507	25.682
Gaseous fuels	37.697	38.567	49.971	61.001	67.057	69.564	68.410	63.517	65.489	71.250	75.746
Solid fuels	27.821	21.956	17.265	29.795	29.740	28.299	28.032	32.148	27.840	30.808	33.484
Other fuels	0.004	0.024	0.091	0.101	0.071	0.002	0.022	0.000	0.000	0.037	0.123
Biomass	9.216	9.211	6.596	6.440	6.466	7.366	7.803	6.190	6.949	6.823	8.779
Total	85.163	86.380	95.346	120.287	127.552	126.716	122.241	130.553	128.257	136.426	143.814

Fuel consumption from the 1.A.4.a.ii category is included in 1.A.3.b category

Table 11. (cont.) Fuel consumption [PJ] in 1.A.4.a category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	34.504	31.119	32.855	30.116	27.068	25.958	27.222	27.017	24.319	19.663	20.801
Lignite	1.475	0.702	0.531	0.515	0.402	0.327	0.280	0.242	0.198	0.146	0.056
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.340	0.301	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	83.433	78.278	80.888	76.501	67.429	71.823	80.972	60.806	56.324	56.462	47.900
Fuel wood and wood waste	8.029	7.818	6.833	7.433	6.556	7.043	7.715	8.003	7.556	7.307	7.451
Biogas	1.830	1.963	2.280	2.123	2.118	2.361	2.700	2.502	2.568	2.797	2.742
Industrial wastes	0.021	0.011	0.009	0.388	0.079	0.145	0.116	0.119	0.123	0.137	0.171
Municipal waste - non-biogenic fraction	0.005	0.035	0.028	0.033	0.152	0.050	0.239	0.131	0.096	0.058	0.418
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.131	0.040	0.019	0.002	0.011
Other petroleum products	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	2.068	1.758	0.725	1.062	0.563	0.795	0.891	0.704	0.644	0.457	0.412
Liquid petroleum gas (LPG)	3.404	3.312	4.048	2.852	2.990	2.990	3.220	3.287	3.059	3.454	2.300
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	27.409	25.634	18.403	15.155	14.722	14.577	14.534	15.088	15.677	13.646	13.871
Fuel oil	0.080	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.583
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.017	0.018	0.014	0.010	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	30.953	28.986	22.451	18.007	17.712	17.567	17.754	18.376	18.735	17.101	16.171
Gaseous fuels	83.433	78.278	80.888	76.501	67.429	71.823	80.972	60.806	56.324	56.462	47.900
Solid fuels	38.065	33.598	34.126	31.703	28.036	27.080	28.394	27.963	25.502	20.567	21.852
Other fuels	0.026	0.046	0.037	0.421	0.231	0.195	0.355	0.250	0.219	0.195	0.589
Biomass	9.859	9.781	9.113	9.556	8.674	9.404	10.546	10.544	10.143	10.106	10.204
Total	162.336	150.689	146.614	136.188	122.081	126.068	138.021	117.939	110.924	104.431	96.716

Fuel consumption from the 1.A.4.a.ii category is included in 1.A.3.b category

Table 11. (cont.) Fuel consumption [PJ] in 1.A.4.a category

Fuels	2021
Hard coal	24.933
Lignite	0.024
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.001
Crude oil	0.000
Natural gas	67.306
Fuel wood and wood waste	8.391
Biogas	2.546
Industrial wastes	0.155
Municipal waste - non-biogenic fraction	0.576
Municipal waste – biogenic fraction	0.366
Other petroleum products	0.000
Petroleum coke	0.000
Coke	1.452
Liquid petroleum gas (LPG)	2.162
Motor gasoline	0.000
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	15.480
Fuel oil	0.000
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	0.385
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	17.642
Gaseous fuels	67.306
Solid fuels	26.794
Other fuels	0.731
Biomass	11.302
Total	123.775

Fuel consumption from the 1.A.4.a.ii category is included in 1.A.3.b category

Table 12. Fuel consumption [PJ] in 1.A.4.b category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	543.559	489.774	272.689	358.521	351.542	372.347	309.920	305.701	326.681	271.980	213.584
Lignite	2.911	1.180	0.526	0.042	0.000	2.956	4.403	4.279	3.420	2.626	1.772
Hard coal briquettes (patent fuels)	17.200	4.742	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	1.627	1.427	1.106	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	102.581	107.619	122.204	133.674	141.212	141.590	151.671	159.559	143.057	150.022	138.268
Fuel wood and wood waste	33.615	32.351	38.875	30.944	34.552	106.000	104.715	105.000	101.000	100.000	100.700
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	31.927	30.721	14.444	11.979	26.448	30.280	27.328	26.808	27.409	32.446	18.677
Liquid petroleum gas (LPG)	6.762	7.452	1.750	1.041	1.892	6.244	9.224	13.197	16.555	18.920	18.920
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.150	6.450	8.600
Fuel oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	15.996	15.134	15.155	13.706	11.334	6.779	3.560	1.723	0.226	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	4.655	3.697	3.088	1.307	0.739	0.431	0.418	0.258	0.222	0.181	0.164
Fuels											
Liquid fuels	6.762	7.452	1.750	1.041	1.892	6.244	9.224	13.197	18.705	25.370	27.520
Gaseous fuels	102.581	107.619	122.204	133.674	141.212	141.590	151.671	159.559	143.057	150.022	138.268
Solid fuels	617.874	546.675	307.009	385.556	390.063	412.793	345.629	338.768	357.959	307.233	234.197
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	33.615	32.351	38.875	30.944	34.552	106.000	104.715	105.000	101.000	100.000	100.700
Total	760.831	694.097	469.838	551.214	567.718	666.627	611.238	616.524	620.721	582.625	500.685

Fuel consumption from the 1.A.4.b.ii category is included in 1.A.3.b category

Table 12. (cont.) Fuel consumption [PJ] in 1.A.4.b category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	223.330	166.013	184.731	209.771	207.214	219.654	249.994	284.628	257.388	276.073	279.808
Lignite	1.286	1.169	1.373	1.482	1.605	1.919	2.006	2.168	1.972	2.565	2.219
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	135.995	127.611	133.737	127.093	127.629	126.376	135.111	138.686	132.622	131.450	134.857
Fuel wood and wood waste	95.000	95.000	104.500	104.500	103.075	103.360	100.700	104.500	102.000	102.500	102.500
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	18.528	11.671	11.912	8.525	8.569	6.964	2.932	3.216	1.393	1.111	5.747
Liquid petroleum gas (LPG)	19.866	20.812	21.285	21.995	26.015	24.596	23.650	23.650	24.596	25.069	25.254
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	9.804	17.200	21.500	23.005	23.005	21.500	19.350	19.350	15.480	11.610	8.011
Fuel oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.163	0.158	0.151	0.134	0.128	0.113	0.095	0.099	0.081	0.071	0.069
Fuels											
Liquid fuels	29.670	38.012	42.785	45.000	49.020	46.096	43.000	43.000	40.076	36.679	33.265
Gaseous fuels	135.995	127.611	133.737	127.093	127.629	126.376	135.111	138.686	132.622	131.450	134.857
Solid fuels	243.307	179.010	198.167	219.913	217.515	228.651	255.027	290.111	260.834	279.820	287.843
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	95.000	95.000	104.500	104.500	103.075	103.360	100.700	104.500	102.000	102.500	102.500
Total	503.972	439.633	479.189	496.505	497.239	504.483	533.838	576.297	535.532	550.449	558.465

Fuel consumption from the 1.A.4.b.ii category is included in 1.A.3.b category

Table 12. (cont.) Fuel consumption [PJ] in 1.A.4.b category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	319.753	275.817	291.964	280.095	257.420	252.837	268.841	267.709	251.533	205.184	216.037
Lignite	4.035	3.593	3.619	4.023	3.214	3.105	2.989	2.502	2.501	1.874	0.721
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	148.427	135.471	141.397	143.187	131.598	132.202	145.148	151.972	149.111	152.348	160.833
Fuel wood and wood waste	112.746	115.000	116.850	116.850	105.450	108.395	111.435	109.725	237.671	219.724	203.228
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	6.401	5.495	5.297	5.591	4.786	4.112	3.900	4.194	3.637	1.393	0.961
Liquid petroleum gas (LPG)	24.840	23.000	23.000	21.620	21.390	21.390	21.620	22.080	23.000	24.380	23.000
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	4.547	4.763	3.767	3.464	3.031	3.182	3.010	3.010	3.440	2.795	2.838
Fuel oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.067	0.059	0.040	0.047	0.036	0.003	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	29.387	27.763	26.767	25.084	24.421	24.572	24.630	25.090	26.440	27.175	25.838
Gaseous fuels	148.427	135.471	141.397	143.187	131.598	132.202	145.148	151.972	149.111	152.348	160.833
Solid fuels	330.255	284.965	300.920	289.756	265.455	260.056	275.731	274.404	257.671	208.452	217.719
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	112.746	115.000	116.850	116.850	105.450	108.395	111.435	109.725	237.671	219.724	203.228
Total	620.815	563.199	585.934	574.877	526.924	525.225	556.944	561.191	670.893	607.699	607.618

Fuel consumption from the 1.A.4.b.ii category is included in 1.A.3.b category

Table 12. (cont.) Fuel consumption [PJ] in 1.A.4.b category

Fuels	2021
Hard coal	201.600
Lignite	0.640
Hard coal briquettes (patent fuels)	0.000
Brown coal briquettes	0.000
Crude oil	0.000
Natural gas	191.171
Fuel wood and wood waste	207.755
Biogas	0.000
Industrial wastes	0.000
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.000
Other petroleum products	0.000
Petroleum coke	0.000
Coke	1.128
Liquid petroleum gas (LPG)	21.850
Motor gasoline	0.000
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	4.214
Fuel oil	0.000
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	0.000
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	26.064
Gaseous fuels	191.171
Solid fuels	203.368
Other fuels	0.000
Biomass	207.755
Total	628.358

Fuel consumption from the 1.A.4.b.ii category is included in 1.A.3.b category

Table 13. Fuel consumption [PJ] in 1.A.4.c category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal	38.608	38.489	36.365	57.356	62.959	62.501	60.542	58.583	62.611	52.483	46.050
Lignite	1.581	1.139	0.844	1.018	0.911	0.814	1.642	1.698	1.299	1.292	1.419
Hard coal briquettes (patent fuels)	0.598	0.527	0.506	0.114	0.065	0.047	0.045	0.000	0.000	0.000	0.000
Brown coal briquettes	0.106	0.106	0.036	0.017	0.018	0.000	0.000	0.000	0.000	0.000	0.000
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	0.507	0.445	0.448	0.275	0.055	0.132	0.212	0.243	0.428	0.571	0.869
Fuel wood and wood waste	0.039	0.113	0.000	0.000	0.000	20.057	18.367	18.500	17.567	17.000	17.100
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	1.786	1.754	1.532	1.158	0.677	0.561	3.952	3.917	4.011	5.079	5.336
Liquid petroleum gas (LPG)	0.000	0.000	0.000	0.000	0.000	0.000	0.473	0.710	1.183	1.419	1.419
Motor gasoline	0.000	0.000	0.000	0.000	0.000	0.665	1.108	1.108	1.108	1.196	1.108
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	53.967	51.972	54.094	52.116	60.802	75.164	81.571	85.656	94.600	109.736	99.330
Fuel oil	10.264	9.469	9.267	8.207	7.147	18.200	22.219	14.044	8.282	11.039	8.919
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.012	0.010	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.001	0.002	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.001
Fuels											
Liquid fuels	64.230	61.441	63.361	60.323	67.949	94.028	105.370	101.517	105.172	123.390	110.775
Gaseous fuels	0.507	0.445	0.448	0.275	0.055	0.132	0.212	0.243	0.428	0.571	0.869
Solid fuels	42.691	42.026	39.285	59.666	64.630	63.925	66.182	64.198	67.920	58.853	52.806
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	0.039	0.113	0.000	0.000	0.000	20.057	18.367	18.500	17.567	17.000	17.100
Total	107.467	104.025	103.094	120.264	132.634	178.142	190.131	184.458	191.087	199.814	181.550

Table 13. (cont.) Fuel consumption [PJ] in 1.A.4.c category

Fuels	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hard coal	49.162	33.232	36.976	30.820	29.693	31.728	35.673	42.074	37.748	41.640	41.538
Lignite	1.097	0.939	1.236	1.395	1.528	2.086	2.188	2.489	2.125	2.770	2.485
Hard coal briquettes (patent fuels)	0.000	0.000	0.000	0.000	0.000	0.023	0.000	0.000	0.000	0.046	0.023
Brown coal briquettes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.035	0.000	0.035	0.035
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	0.476	0.536	0.777	0.914	1.197	1.182	1.084	1.492	1.841	1.900	1.577
Fuel wood and wood waste	17.100	17.100	19.043	19.010	19.017	19.878	19.047	19.978	19.062	19.024	19.030
Biogas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.094	0.097
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.006	0.012	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.006	0.013	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	5.131	3.416	3.687	2.842	2.856	1.950	1.117	1.398	0.836	0.805	0.829
Liquid petroleum gas (LPG)	1.656	1.892	2.365	2.838	3.311	3.311	3.311	2.365	2.365	2.412	2.070
Motor gasoline	1.329	1.373	0.930	0.266	0.310	0.222	0.266	0.310	0.222	0.222	0.225
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	101.695	112.230	104.834	104.490	105.350	107.457	109.650	81.700	75.250	75.250	73.610
Fuel oil	8.729	8.484	8.273	6.844	8.254	8.665	9.527	3.863	3.409	3.487	4.311
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	113.408	123.979	116.402	114.438	117.225	119.655	122.754	88.238	81.245	81.371	80.216
Gaseous fuels	0.476	0.536	0.777	0.914	1.197	1.182	1.084	1.492	1.841	1.900	1.577
Solid fuels	55.390	37.586	41.898	35.057	34.078	35.787	38.979	45.996	40.708	45.296	44.910
Other fuels	0.006	0.012	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	17.106	17.113	19.053	19.010	19.017	19.878	19.047	19.978	19.062	19.118	19.127
Total	186.386	179.226	178.141	169.419	171.517	176.501	181.863	155.704	142.856	147.685	145.829

Table 13. (cont.) Fuel consumption [PJ] in 1.A.4.c category

Fuels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hard coal	47.291	41.488	43.715	41.611	39.003	36.305	38.963	38.844	36.541	29.571	31.148
Lignite	1.667	1.337	1.327	1.609	1.286	1.144	0.981	0.807	0.670	0.543	0.207
Hard coal briquettes (patent fuels)	0.024	0.046	0.163	0.233	0.209	0.118	0.301	0.273	0.302	0.211	0.002
Brown coal briquettes	0.000	0.000	0.018	0.461	1.195	0.618	0.350	0.407	0.350	0.340	0.059
Crude oil	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	1.486	1.531	1.796	1.501	1.438	1.144	1.305	1.519	1.267	1.558	1.806
Fuel wood and wood waste	21.088	23.931	20.948	20.937	19.310	20.256	21.458	21.276	20.735	19.618	20.068
Biogas	0.039	0.223	0.252	0.286	0.328	0.385	0.373	0.395	0.359	0.395	0.395
Industrial wastes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste - non-biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal waste – biogenic fraction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other petroleum products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petroleum coke	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke	0.922	0.962	0.279	0.559	0.619	0.247	0.279	0.252	0.224	0.111	0.163
Liquid petroleum gas (LPG)	2.300	2.346	2.300	2.300	2.438	2.622	2.760	2.852	2.852	2.990	2.852
Motor gasoline	0.045	0.045	0.045	0.045	0.044	0.043	0.043	0.038	0.044	0.049	0.046
Aviation gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jet kerosene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel oil	73.480	74.130	74.693	73.177	70.579	69.832	73.960	88.150	92.880	96.535	97.438
Fuel oil	3.451	3.926	4.039	3.436	3.096	3.145	3.498	3.658	3.467	3.561	3.420
Feedstocks	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Refinery gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coke oven gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blast furnace gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gas works gas	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fuels											
Liquid fuels	79.277	80.447	81.077	78.958	76.157	75.642	80.261	94.698	99.243	103.135	103.755
Gaseous fuels	1.486	1.531	1.796	1.501	1.438	1.144	1.305	1.519	1.267	1.558	1.806
Solid fuels	49.905	43.833	45.502	44.474	42.312	38.431	40.873	40.583	38.087	30.776	31.579
Other fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biomass	21.127	24.154	21.200	21.223	19.638	20.641	21.831	21.672	21.093	20.013	20.464
Total	151.794	149.965	149.575	146.156	139.545	135.858	144.271	158.472	159.690	155.481	157.603

Table 13. (cont.) Fuel consumption [PJ] in 1.A.4.c category

Fuels	2021
Hard coal	25.200
Lignite	0.160
Hard coal briquettes (patent fuels)	0.004
Brown coal briquettes	0.061
Crude oil	0.000
Natural gas	2.176
Fuel wood and wood waste	23.893
Biogas	0.349
Industrial wastes	0.000
Municipal waste - non-biogenic fraction	0.000
Municipal waste – biogenic fraction	0.000
Other petroleum products	0.000
Petroleum coke	0.000
Coke	0.474
Liquid petroleum gas (LPG)	2.668
Motor gasoline	0.064
Aviation gasoline	0.000
Jet kerosene	0.000
Diesel oil	97.864
Fuel oil	3.166
Feedstocks	0.000
Refinery gas	0.000
Coke oven gas	0.000
Blast furnace gas	0.000
Gas works gas	0.000
Fuels	
Liquid fuels	103.763
Gaseous fuels	2.176
Solid fuels	25.899
Other fuels	0.000
Biomass	24.241
Total	156.079

Table 14. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.1.a category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	95.58	95.57	95.27	95.12	94.95	94.96	94.97	94.98	94.94	94.96	94.91	94.93
Lignite	111.47	110.88	109.92	109.79	109.29	109.91	110.05	108.96	109.04	108.9	108.41	108.31
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.3	55.31	55.3	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.98	95.00	94.96	94.94	94.96	94.93	94.88	94.95	94.95	94.88	94.93	94.99
Lignite	108.72	108.21	108.64	108.56	108.84	107.83	107.88	107.54	107.2	107.52	108.62	109.56
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	94.95	94.95	94.93	94.89	94.94	95.03	94.99	94.96	94.89	94.85		
Lignite	109.76	109.91	110.77	110.69	110.88	110.33	111.28	112	111.71	110.06		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.40	76.56	77.75	77.62		

Table 15. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.1.b category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.76	94.76	94.76	94.57	94.75	94.82	94.89	94.44	94.72	94.65	94.80
Lignite	-	-	-	-	-	-	-	-	-	-	-	-
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.3	55.31	55.3	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.85	94.94	94.87	-	-	-	-	-	-	94.05	93.9	94.06
Lignite	-	-	-	-	-	-	-	-	-	-	-	109.61
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	93.96	94.04	94.05	94.06	94.05	94.00	94.22	94.40	94.24	94.19		
Lignite	111.18	111.17	111.22	110.53	-	-	-	-	-	-		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.4	76.56	77.75	77.62		

Table 16. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.1.c category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	95.3	95.37	94.76	94.76	94.57	94.75	94.77	94.86	94.4	94.68	94.62	94.75
Lignite	111.39	110.71	109.61	108.99	108.11	108.61	109.92	108.97	108.2	108.42	108.47	108.6
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.30	55.31	55.30	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.80	94.90	94.80	94.67	94.14	94.04	93.90	94.12	93.98	93.98	93.92	93.84
Lignite	108.78	108.56	107.93	108.97	109.67	108.09	108.14	108.92	102.12	107.25	109.71	109.61
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	93.66	93.69	93.66	93.70	93.66	93.63	93.68	93.86	93.67	93.65		
Lignite	111.18	111.17	111.22	110.53	105.35	111.04	102.96	103.44	109.96	111.41		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	-	-	-	77.38	77.40	76.56	77.75	77.62		

Table 17. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.2.a category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.68	94.70	94.73	94.65	94.81	94.71	94.86	94.63	94.58	94.58	94.54
Lignite	-	-	-	105.11	-	-	-	-	-	105.7	-	-
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.30	55.31	55.30	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.62	94.57	94.55	94.53	94.59	94.34	94.52	94.45	94.68	94.52	94.66	94.66
Lignite	-	-	-	-	-	-	-	-	-	-	-	-
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	94.68	94.74	94.71	94.62	94.70	94.01	93.92	94.20	93.96	93.80		
Lignite	-	-	-	-	-	-	-	-	-	-		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.40	76.56	77.75	77.62		

Table 18. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.2.b category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.7	94.68	94.7	94.73	94.65	94.81	94.71	94.86	94.63	94.59	94.58	94.55
Lignite	-	-	-	-	-	-	-	-	-	-	-	-
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.30	55.31	55.3	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.52	94.37	94.49	94.53	94.59	94.34	94.52	93.64	-	-	-	94.7
Lignite	-	-	-	-	-	-	-	-	-	-	-	-
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	94.70	94.74	94.73	94.67	94.70	94.46	94.61	94.60	94.48	94.41		
Lignite	-	-	-	-	-	-	-	-	-	-		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.4	76.56	77.75	77.62		

Table 19. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.2.c category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.68	94.70	94.73	94.65	94.81	94.71	94.86	94.63	94.59	94.58	94.55
Lignite	105.16	104.93	103.89	105.11	106.21	104.86	103.76	102.38	103.00	105.7	102.25	103.41
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.3	55.31	55.3	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.62	94.56	94.55	94.53	94.59	94.34	94.52	94.45	94.70	94.75	94.68	94.70
Lignite	-	-	-	-	-	-	-	-	-	-	-	-
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	94.70	94.74	94.73	94.67	94.70	94.65	94.64	94.56	94.65	94.62		
Lignite	-	-	-	-	-	-	-	-	-	-		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.4	76.56	77.75	77.62		

Table 20. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.2.d category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.68	94.70	94.73	94.65	94.81	94.71	94.86	94.63	94.59	94.58	94.55
Lignite	-	-	-	-	-	-	-	-	-	-	-	-
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.3	55.31	55.3	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.62	94.57	94.55	94.53	94.59	94.34	94.52	94.45	94.7	94.75	94.68	94.7
Lignite	-	-	-	-	-	-	-	-	-	-	-	-
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	94.70	94.74	94.73	94.67	94.7	94.7	94.69	94.61	94.66	94.65		
Lignite	-	-	-	-	-	-	-	-	-	-		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.4	76.56	77.75	77.62		

Table 21. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.2.e category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.68	94.70	94.73	94.65	94.81	94.71	94.86	94.63	94.58	94.58	94.55
Lignite	105.14	104.92	103.89	105.11	106.21	104.86	103.76	102.38	103.00	105.70	102.25	103.41
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.30	55.31	55.30	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.62	94.57	94.55	94.53	94.59	94.34	94.52	94.44	94.69	94.75	94.67	94.70
Lignite	104.60	105.50	104.31	105.93	105.99	105.80	105.70	-	-	-	-	-
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	94.70	94.74	94.73	94.66	94.69	94.69	94.68	94.61	94.65	94.64		
Lignite	-	-	-	-	-	100.93	-	-	-	94.17		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.40	76.56	77.75	77.62		

Table 22. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.2.f category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.68	94.70	94.73	94.65	94.81	94.71	94.86	94.63	94.58	94.58	94.55
Lignite	105.15	104.93	103.89	105.11	106.21	104.86	103.76	102.38	103.00	105.70	102.25	103.41
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.30	55.31	55.30	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.62	94.57	94.55	94.53	94.59	94.34	94.52	94.45	94.69	94.75	94.68	94.70
Lignite	104.60	105.50	104.31	-	-	-	-	-	106.86	-	99.41	102.67
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	94.70	94.74	94.73	94.67	94.61	94.56	94.54	94.50	94.54	94.53		
Lignite	99.37	101.31	99.04	98.97	99.87	100.93	98.65	99.25	96.31	94.17		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.40	76.56	77.75	77.62		

Table 23. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.2.g category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.68	94.70	94.73	94.65	94.81	94.71	94.86	94.63	94.58	94.58	94.55
Lignite	105.15	104.92	103.89	105.11	106.21	104.86	103.76	102.38	103.00	105.70	102.25	103.41
Natural gas	55.35	55.32	55.32	55.31	55.38	55.35	55.30	55.31	55.30	55.31	55.31	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.62	94.57	94.55	94.53	94.59	94.34	94.52	94.45	94.70	94.75	94.68	94.70
Lignite	104.60	105.50	104.31	105.93	105.99	105.80	105.70	-	106.86	106.41	99.41	102.67
Natural gas	55.32	55.31	55.32	55.29	55.29	54.85	54.84	55.06	55.36	55.41	55.33	55.32
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	94.70	94.74	94.73	94.67	94.70	94.70	94.68	94.61	94.66	94.65		
Lignite	99.37	101.31	99.04	98.97	99.87	100.93	98.65	99.25	96.31	94.17		
Natural gas	55.37	55.63	55.34	55.58	55.54	55.41	55.42	55.44	55.48	55.47		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.40	76.56	77.75	77.62		

Table 24. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.4.a category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.76	94.76	94.76	94.57	94.75	94.82	94.89	94.44	94.71	94.64	94.80
Lignite	111.07	110.71	-	-	-	108.61	109.92	108.97	108.20	108.42	108.47	108.60
Natural gas	55.23	55.24	55.23	55.23	55.22	55.23	55.23	55.22	55.22	55.22	55.23	55.21
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.84	94.94	94.87	94.68	94.34	94.14	93.99	94.20	94.04	94.05	93.90	94.06
Lignite	-	-	-	-	-	-	-	-	-	-	109.71	109.61
Natural gas	55.21	55.21	55.21	55.21	55.20	54.74	54.76	54.98	55.20	55.27	55.16	55.19
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	93.96	94.04	94.05	94.06	94.05	94.00	94.22	94.40	94.24	94.19		
Lignite	111.18	111.17	111.22	110.53	105.35	111.04	102.96	103.44	109.96	111.41		
Natural gas	55.25	55.51	55.22	55.43	55.43	55.33	55.35	55.33	55.39	55.37		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.40	76.56	77.75	77.62		

Table 25. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.4.b category

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.76	94.76	94.76	94.57	94.75	94.82	94.89	94.44	94.72	94.65	94.80
Lignite	111.07	110.71	109.61	108.99	-	108.61	109.92	108.97	108.20	108.42	108.47	108.60
Natural gas	55.23	55.24	55.23	55.23	55.22	55.23	55.23	55.22	55.22	55.22	55.23	55.21
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.85	94.94	94.87	94.68	94.34	94.14	93.99	94.20	94.04	94.05	93.90	94.06
Lignite	108.78	108.56	107.93	108.97	109.67	108.09	108.14	108.92	102.12	107.25	109.71	109.61
Natural gas	55.21	55.21	55.21	55.21	55.20	54.74	54.76	54.98	55.20	55.27	55.16	55.19
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	93.96	94.04	94.05	94.06	94.05	94.00	94.22	94.40	94.24	94.19		
Lignite	111.18	111.17	111.22	110.53	105.35	111.04	102.96	103.44	109.96	111.41		
Natural gas	55.25	55.51	55.22	55.43	55.43	55.33	55.35	55.33	55.39	55.37		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.40	76.56	77.75	77.62		

Table 26. CO₂ EFs [kg/GJ] for coal, lignite, natural gas and fuel oil in 1.A.4.c category (stationary sources)

Fuels	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hard coal	94.70	94.76	94.76	94.76	94.57	94.75	94.82	94.89	94.44	94.71	94.65	94.80
Lignite	111.07	110.71	109.61	108.99	108.11	108.61	109.92	108.97	108.20	108.42	108.47	108.60
Natural gas	55.23	55.24	55.23	55.23	55.22	55.23	55.23	55.22	55.22	55.22	55.23	55.21
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20	77.20
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hard coal	94.84	94.94	94.87	94.68	94.34	94.14	93.99	94.20	94.04	94.05	93.90	94.06
Lignite	108.78	108.56	107.93	108.97	109.67	108.09	108.14	108.92	102.12	107.25	109.71	109.61
Natural gas	55.21	55.21	55.21	55.21	55.20	54.74	54.76	54.98	55.20	55.27	55.16	55.19
Fuel oil	77.20	77.20	77.20	77.20	77.20	77.20	77.28	77.56	77.45	77.87	76.97	77.28
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Hard coal	93.96	94.04	94.05	94.06	94.05	94.00	94.22	94.40	94.24	94.19		
Lignite	111.18	111.17	111.22	110.53	105.35	111.04	102.96	103.44	109.96	111.41		
Natural gas	55.25	55.51	55.22	55.43	55.43	55.33	55.35	55.33	55.39	55.37		
Fuel oil	76.26	76.93	77.17	76.53	77.45	77.38	77.40	76.56	77.75	77.62		

Table 27. CO₂ EFs [kg/GJ] applied for other fuels in the years 1988-2021 for stationary sources in 1.A.1, 1.A.2 and 1.A.4 categories [IPCC 2006]

Fuels	EF
Hard coal briquettes (patent fuels)	97.50
Brown coal briquettes	97.50
Crude oil	73.30
Fuel wood and wood waste	112.00
Biogas	54.60
Industrial wastes	143.00
Municipal waste – non-biogenic fraction	91.70
Municipal waste – biogenic fraction	100.00
Other petroleum products	73.30
Petroleum coke	97.50
Coke	107.00
Liquid petroleum gas (LPG)	63.10
Motor gasoline	69.30
Aviation gasoline	70.00
Jet kerosene	71.50
Diesel oil	74.10
Feedstocks	73.30
Refinery gas	57.60
Coke oven gas	44.40
Blast furnace gas	260.00
Gas works gas	44.40

Table 28. CH₄ EFs [kg/GJ] applied for the years 1988-2021 for stationary sources (CS EFs [ENERGOPOMIAR 2022]; D EFs [IPCC 2006])

Fuels	1.A.1	1.A.2	1.A.4.a	1.A.4.b-c
Hard coal	0.00011*	0.0100	0.0100	0.3000
Lignite	0.000335*	0.0100	0.0100	0.3000
Hard coal briquettes (patent fuels)	0.0010	0.0100	0.0100	0.3000
Brown coal briquettes	0.0010	0.0100	0.0100	0.3000
Crude oil	0.0030	0.0030	0.0100	0.0100
Natural gas	0.0010	0.0010	0.0050	0.0050
Fuel wood and wood waste	0.0006*	0.0300	0.3000	0.3000
Biogas	0.0010	0.0010	0.0050	0.0050
Industrial wastes	0.0300	0.0300	0.3000	0.3000
Municipal waste – non-biogenic fraction	0.0300	0.0300	0.3000	0.3000
Municipal waste – biogenic fraction	0.0300	0.0300	0.3000	0.3000
Other petroleum products	0.0030	0.0030	0.0100	0.0100
Petroleum coke	0.0030	0.0030	0.0100	0.0100
Coke	0.0010	0.0100	0.0100	0.3000
Liquid petroleum gas (LPG)	0.0010	0.0010	0.0050	0.0050
Motor gasoline	0.0030	0.0030	0.0100	0.0100
Aviation gasoline	0.0030	0.0030	0.0100	0.0100
Jet kerosene	0.0030	0.0030	0.0100	0.0100
Diesel oil	0.0030	0.0030	0.0100	0.0100
Fuel oil	0.0030	0.0030	0.0100	0.0100
Feedstocks	0.0030	0.0030	0.0100	0.0100
Refinery gas	0.0010	0.0010	0.0050	0.0050
Coke oven gas	0.0010	0.0010	0.0050	0.0050
Blast furnace gas	0.0010	0.0010	0.0050	0.0050
Gas works gas	0.0010	0.0010	0.0050	0.0050

*CS EFs calculated based on Polish study [ENERGOPOMIAR 2022]

Table 29. N₂O EFs [kg/GJ] applied for the years 1988-2021 for stationary sources in 1.A.1, 1.A.2 and 1.A.4 categories [IPCC 2006]

Fuels	EF
Hard coal	0.0015
Lignite	0.0015
Hard coal briquettes (patent fuels)	0.0015
Brown coal briquettes	0.0015
Crude oil	0.0006
Natural gas	0.0001
Fuel wood and wood waste	0.0040
Biogas	0.0001
Industrial wastes	0.0040
Municipal waste – non-biogenic fraction	0.0040
Municipal waste – biogenic fraction	0.0040
Other petroleum products	0.0006
Petroleum coke	0.0006
Coke	0.0015
Liquid petroleum gas (LPG)	0.0001
Motor gasoline	0.0006
Aviation gasoline	0.0006
Jet kerosene	0.0006
Diesel oil	0.0006
Fuel oil	0.0006
Feedstocks	0.0006
Refinery gas	0.0001
Coke oven gas	0.0001
Blast furnace gas	0.0001
Gas works gas	0.0001

ANNEX 2.3. DIFFERENCES BETWEEN RA AND SA RELATED TO THE STATISTICAL DIFFERENCES AND DISTRIBUTION LOSSES IN ENERGY BALANCE

Table 30. Ratio of the statistical difference [TJ] to gross inland consumption [TJ] for Solid fuels

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Gross inland consumption	3 301 900	3 251 958	3 155 250	3 113 064	2 882 738	2 944 275	3 023 301	2 947 724	2 655 502	2 549 164	2 356 421	2 331 713	2 298 613	2 352 692	2 270 706	2 288 361
Statistical differences	172 667	117 017	108 453	81 972	-36 145	18 139	-13 556	72 274	49 142	60 453	-12 030	-14 300	17 361	-4 526	-62 797	-9 882
Ratio of the statistical difference to gross inland consumption	5.23%	3.60%	3.44%	2.63%	-1.25%	0.62%	-0.45%	2.45%	1.85%	2.37%	-0.51%	-0.61%	0.76%	-0.19%	-2.77%	-0.43%
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gross inland consumption	2 395 998	2 335 558	2 293 814	2 142 495	2 312 044	2 287 622	2 104 359	2 226 982	2 062 956	2 025 355	2 074 009	2 079 660	2 062 002	1 835 531	1 713 017	1 922 323
Statistical differences	-9 086	-22 821	8 099	-13 264	22 074	41 957	-95 614	20 454	-23 156	-47 228	-7 229	-17 973	15 162	-394	14 736	13 398
Ratio of the statistical difference to gross inland consumption	-0.38%	-0.98%	0.35%	-0.62%	0.95%	1.83%	-4.54%	0.92%	-1.12%	-2.33%	-0.35%	-0.86%	0.74%	-0.02%	0.86%	0.70%

Table 31. Ratio of the statistical difference [TJ] and distribution losses [TJ] to gross inland consumption [TJ] for Natural gas

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Gross inland consumption	374 206	348 944	324 987	341 385	343 987	376 592	395 454	394 289	398 345	387 833	416 993	434 447	423 419	471 462	497 416	512 234
Distribution losses	8 713	15 581	15 496	25 796	19 799	11 052	34 531	18 148	16 432	11 141	14 241	12 670	6 937	9 176	8 480	6 408
Statistical differences	3 987	11 077	0	9 900	-11 575	10 968	-5 786	-12 007	-1 928	2 064	0	6 440	4 502	6 071	2 947	-350
Ratio of the statistical difference and distribution losses to gross inland consumption	3.39%	7.64%	4.77%	10.46%	2.39%	5.85%	7.27%	1.56%	3.64%	3.40%	3.42%	4.40%	2.70%	3.23%	2.30%	1.18%
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gross inland consumption	526 764	523 124	526 109	505 027	536 108	537 434	572 766	575 092	561 217	576 764	612 671	646 647	675 084	679 430	730 192	763 282
Distribution losses	4 716	2 685	2 359	5 340	6 470	1 265	4 777	1 928	1 133	1 113	1 110	525	510	431	413	356
Statistical differences	13 014	9 567	6 882	31	-6 753	-2 451	-3 721	-3 060	1 316	-5 698	-2 232	2 064	23 714	9 634	39 020	22 235
Ratio of the statistical difference and distribution losses to gross inland consumption	3.37%	2.34%	1.76%	1.06%	-0.05%	-0.22%	0.18%	-0.20%	0.44%	-0.79%	-0.18%	0.40%	3.59%	1.48%	5.40%	2.96%

Table 32. Ratio of the statistical difference [TJ] and distribution losses [TJ] to gross inland consumption [TJ] for Oil and petroleum products

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Gross inland consumption	555 718	557 206	577 508	597 028	625 345	667 893	753 695	773 274	792 024	817 510	821 447	845 824	843 782	849 178	908 462	920 571
Distribution losses	479	478	700	529	1 088	352	353	0	0	0	0	0	0	0	0	0
Statistical differences	-7 586	-6 585	-10 863	-15 474	-29 728	-8 579	-5 360	-21 622	-22 372	-22 382	-21 699	30 718	24 073	18 825	19 444	-4 680
Ratio of the statistical difference and distribution losses to gross inland consumption	-1.28%	-1.10%	-1.76%	-2.50%	-4.58%	-1.23%	-0.66%	-2.80%	-2.82%	-2.74%	-2.64%	3.63%	2.85%	2.22%	2.14%	-0.51%
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gross inland consumption	991 081	1 015 566	1 053 649	1 028 436	1 086 650	1 095 635	1 045 376	955 198	949 359	1 007 895	1 112 316	1 254 767	1 289 318	1 310 491	1 232 441	1 309 420
Distribution losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Statistical differences	1 541	-4 187	5 076	-9 969	-7 494	939	-7 483	-8 535	-10 619	-2 626	-982	-807	5 345	1 439	-8 176	9 742
Ratio of the statistical difference and distribution losses to gross inland consumption	0.16%	-0.41%	0.48%	-0.97%	-0.69%	0.09%	-0.72%	-0.89%	-1.12%	-0.26%	-0.09%	-0.06%	0.41%	0.11%	-0.66%	0.74%

ANNEX 3.1. CALCULATION OF CO₂ EMISSION FROM 2.A.4.D SUBCATEGORY: OTHER PROCESSES USES OF CARBONATES - OTHER

Table 1. Estimation of CO₂ emission from calcite use as limestone sorbents to desulfurize the off-gases by wet method (lime WFGD) in the years 1988-2021 (all values in the table are expressed in kilotons [kt])

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Desulphurization plaster production in lime wet FGD	0	0	0	0	0	0	0	175	474	583	674	860	1140	1134	1038	1109	1250
Consumption of limestone sorbents to desulfurize the off-gases by wet method (lime WFGD)	0	0	0	0	0	0	0	104	282	346	400	511	677	673	617	659	742
Limestone consumption in lime WFGD	0	0	0	0	0	0	0	99	268	329	380	485	643	640	586	626	705
CO₂ emission from decomposition of calcium carbonate in WFGD	0	0	0	0	0	0	0	43	118	145	167	214	283	281	258	275	310
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Desulphurization plaster production in lime wet FGD	1177	1240	1338	1596	2076	2389	2505	2572	2768	2768	2768	2921	2937	2985	3040	2996	3084
Consumption of limestone sorbents to desulfurize the off-gases by wet method (lime WFGD)	699	736	795	948	1233	1418	1487	1527	1644	1644	1644	1735	1744	1772	1805	1779	1831
Limestone consumption in lime WFGD	664	700	755	900	1171	1347	1413	1451	1561	1561	1561	1648	1657	1684	1715	1690	1740
CO₂ emission from decomposition of calcium carbonate in WFGD	292	308	332	396	515	593	622	638	687	687	687	725	729	741	754	744	766

Table 2. Estimation of CO₂ emission from decomposition of calcite use to desulfurize the off-gases in fluid bed boilers (FGD in FBB) and in other method of flue gas desulfurization (FGD other than lime WFGD) in the years 1988-2021 (all values in the table are expressed in kilotons [kt])

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
SO ₂ emission captured by FGD in power plants and autoproductors CHP	916	924	766	786	857	900	990	1048	1178	1321	1379	1426	1620	1630	1699	1881	1939
SO ₂ captured with use of lime wet FGD method	0	0	0	0	0	0	0	65	176	217	251	320	424	422	386	413	465
SO ₂ captured with use of other FGD method	916	924	766	786	857	900	990	983	1002	1104	1128	1106	1196	1208	1313	1468	1474
Consumption of limestone sorbents to desulfurize the off-gases in FBB and in FGD other than lime wet FGD	1574	1588	1317	1351	1473	1547	1702	1689	1721	1898	1939	1901	2055	2076	2256	2524	2533
Limestone consumption in FGD in FBB and in FGD other than lime wet FGD	1543	1556	1290	1324	1444	1516	1668	1656	1687	1860	1900	1863	2014	2035	2211	2473	2482
CO₂ emission from calcium carbonate in FGD in FBB and in FGD other than lime WFGD	679	685	568	583	635	667	734	728	742	818	836	820	886	895	973	1088	1092
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
SO ₂ emission captured by FGD in power plants and autoproductors CHP	1967	2075	2091	2178	2136	2299	2524	2297	2302	2322	2275	2415	2438	2602	2748	2680	3061
SO ₂ captured with use of lime wet FGD method	438	461	498	594	773	889	932	957	1030	1030	1030	1087	1093	1111	1131	1115	1148
SO ₂ captured with use of other FGD method	1529	1614	1593	1584	1363	1410	1592	1340	1272	1292	1245	1328	1345	1491	1617	1565	1913
Consumption of limestone sorbents to desulfurize the off-gases in FBB and in FGD other than lime wet FGD	2628	2773	2738	2723	2343	2424	2736	2303	2186	2220	2140	2283	2312	2563	2779	2690	3289
Limestone consumption in FGD in FBB and in FGD other than lime wet FGD	2575	2718	2683	2668	2297	2375	2681	2257	2142	2176	2097	2237	2266	2512	2724	2636	3223
CO₂ emission from calcium carbonate in FGD in FBB and in FGD other than lime WFGD	1133	1196	1181	1174	1010	1045	1180	993	943	957	923	984	997	1105	1198	1160	1418

Table 3. CO₂ emission values from carbonate use in 2.A.4.d subcategory for the years 1988-2021 (all values in the table are expressed in kilotons [kt])

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Sum of limestone use presented in the tables 1-2	1543	1556	1290	1324	1444	1516	1668	1754	1954	2189	2281	2348	2657	2674	2797	3099	3188
CO₂ emission from carbonate use in 2.A.4.d subcategory	679	685	568	583	635	667	734	772	860	963	1003	1033	1169	1177	1231	1363	1403
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Sum of limestone use presented in the tables 1-2	3239	3417	3438	3569	3468	3723	4094	3708	3704	3737	3658	3885	3923	4196	4438	4326	4963
CO₂ emission from carbonate use in 2.A.4.d subcategory	1425	1504	1513	1570	1526	1638	1802	1631	1630	1644	1610	1709	1726	1846	1953	1904	2184

ANNEX 3.2. CALCULATION OF CO₂ PROCESS EMISSION FROM AMMONIA PRODUCTION (2.B.1)Table 1. Calculation of CO₂ process emission from ammonia production

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Activity/emission data	Unit												
Natural gas consumption	[10 ³ m ³]	2 184 552	2 230 523	1 447 064	1 447 326	1 337 619	1 401 804	1 688 887	1 942 704	1 907 689	1 937 127	1 789 006	1 587 228
Natural gas consumption	TJ	76 413	77 862	50 625	50 911	47 044	49 522	60 161	69 070	67 919	69 049	64 163	56 105
Coke oven gas consumption	[10 ³ m ³]	183 960	113 672	30 560									
Coke oven gas consumption	TJ	3 204	1 970	537									
CO ₂ emission from natural gas use	kt	4 357	4 449	2 886	2 887	2 668	2 796	3 369	3 875	3 805	3 864	3 568	3 166
CO ₂ emission from coke oven gas use	kt	142	87	24									
Process CO ₂ emission from ammonia production	kt	4 500	4 537	2 910	2 887	2 668	2 796	3 369	3 875	3 805	3 864	3 568	3 166
Ammonia production	kt	2389.353	2433.726	1531.552	1560.883	1480.798	1630.946	1945.470	2248.317	2185.188	2251.616	2047.948	1784.726
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Activity/emission data	Unit												
Natural gas consumption	[10 ³ m ³]	1 965 162	1 873 685	1 455 329	2 122 465	2 177 127	2 310 818	2 197 622	2 186 299	2 221 406	1 814 589	1 881 957	2 061 524
Natural gas consumption	TJ	70 483	68 096	52 144	76 053	77 817	82 219	78 591	78 072	79 351	63 478	67 234	73 798
Coke oven gas consumption	[10 ³ m ³]												
Coke oven gas consumption	TJ												
CO ₂ emission from natural gas use	kt	3 920	3 737	2 903	4 234	4 343	4 609	4 384	4 361	4 431	3 620	3 754	4 112
CO ₂ emission from coke oven gas use	kt												
Process CO ₂ emission from ammonia production	kt	3 920	3 737	2 903	4 234	4 343	4 609	4 384	4 361	4 431	3 620	3 754	4 112
Ammonia production	kt	2243.108	2103.805	1594.797	2246.505	2451.557	2523.790	2326.621	2417.543	2485.148	2010.891	2059.437	2321.849
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Activity/emission data	Unit												
Natural gas consumption	[10 ³ m ³]	2 242 281	2 207 620	2 295 270	2 363 754	2 286 461	2 371 634	2 180 709	2 078 609	2 262 887	2 243 340		
Natural gas consumption	TJ	81 150	79 269	83 391	86 145	83 951	87 446	80 952	75 787	82 978	82 180		
Coke oven gas consumption	[10 ³ m ³]												
Coke oven gas consumption	TJ												
CO ₂ emission from natural gas use	kt	4 473	4 403	4 565	4 720	4 625	4 797	4 414	4 194	4 592	4 540		
CO ₂ emission from coke oven gas use	kt												
Process CO ₂ emission from ammonia production	kt	4 473	4 403	4 565	4 720	4 625	4 797	4 414	4 194	4 592	4 540		
Ammonia production	kt	2467.458	2228.303	2634.506	2720.446	2625.757	2783.187	2535.233	2451.973	2647.356	2597.557		

Table 2. CO₂ amount connected with fertilizer urea production deducted from CO₂ process emission from ammonia production

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Activity/emission data	Unit												
Fertilizer urea production	kt	775.527	808.932	771.812	660.998	606.719	567.208	698.866	824.372	742.790	588.957	496.479	512.603
CO ₂ amount used in fertilizer urea production which is deducted from CO ₂ emission generated in ammonia production	kt	568.720	593.217	565.996	484.732	444.928	415.953	512.502	604.539	544.713	431.901	364.084	375.909
Total CO ₂ emission from 2.B.1	kt	3930.885	3943.317	2344.257	2402.200	2223.177	2380.178	2856.265	3270.508	3260.490	3432.021	3204.386	2790.081
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Activity/emission data	Unit												
Fertilizer urea production	kt	565.795	368.552	486.326	628.048	618.41	700.642	705.319	734.52	781.464	867.261	723.719	979.722
CO ₂ amount used in fertilizer urea production which is deducted from CO ₂ emission generated in ammonia production	kt	414.916	270.271	356.639	460.569	453.501	513.804	517.234	538.648	573.074	635.991	530.727	718.463
Total CO ₂ emission from 2.B.1	kt	3504.927	3467.105	2546.256	3773.041	3889.141	4095.508	3866.290	3822.291	3857.892	2983.509	3223.150	3393.590
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		
Activity/emission data	Unit												
Fertilizer urea production	kt	1078.683	1036.753	1122.85	1158.011	1106.873	1076.911	1267.135	1152.160	1216.202	1193.053		
CO ₂ amount used in fertilizer urea production which is deducted from CO ₂ emission generated in ammonia production	kt	791.034	760.286	823.423	849.208	811.707	789.735	929.232	844.917	891.881	874.906		
Total CO ₂ emission from 2.B.1	kt	3681.569	3643.181	3741.539	3870.485	3813.599	4006.834	3484.515	3349.124	3700.107	3665.424		

Fertilizer urea production amount was estimated according to data from [GUS 1989e-2022e]. CO₂ amount used in fertilizer urea production and deducted from CO₂ emission generated in ammonia production was calculated based on assumption on the complete conversion of NH₃ and CO₂ to urea, what means that 0.733 t of CO₂ per tonne of urea produced was required (2006 GLs, box 3.3, p. 3.16).

ANNEX 4. NATIONAL ENERGY BALANCE FOR 2021 IN EUROSTAT FORMAT

TJ 2021	Total	Solid fossil fuels	Anthracite	Coking coal	Other bituminous coal	Lignite	Patent fuel	Coke oven coke	Coal tar	Brown coal briquettes
+ Primary production	2 516 569.0	1 760 224.1		369 658.9	957 680.1	432 885.1				
+ Recovered & recycled products	9 124.1	7 017.8			7 017.8					
+ Imports	2 494 965.5	315 440.9	7 834.3	92 463.3	207 630.4	1 024.4	226.2	6 202.4	22.6	37.3
- Exports	633 312.6	384 891.9		99 693.1	68 145.1	78.4	423.6	203 519.3	13 032.4	
+ Change in stock	215 804.7	224 535.8	754.4	18 384.4	203 738.3	1 114.1	-4.4	785.4	-239.4	2.9
- International maritime bunkers	14 620.8									
- International aviation	23 605.6									
= Total energy supply	4 564 924.3	1 922 326.7	8 588.7	380 813.4	1 307 921.6	434 945.3	-201.8	-196 531.4	-13 249.3	40.3
Transformation input	3 424 251.0	1 810 704.3		372 138.1	949 035.5	433 502.9		56 020.4		7.4
+ Electricity & heat generation	1 752 684.1	1 384 955.2		2 659.7	948 743.6	433 502.9		41.6		7.4
+ Main activity producer electricity only	118 973.8	35 685.1			16 091.4	19 593.7				
+ Main activity producer CHP	1 366 225.1	1 214 997.9			801 291.8	413 706.1				
+ Main activity producer heat only	121 147.9	101 794.3		5.9	101 559.2	180.3		41.6		7.4
+ Autoproducer electricity only	14 170.4									
+ Autoproducer CHP	119 340.1	26 850.1		1 355.8	25 494.3					
+ Autoproducer heat only	7 723.5	5 627.7		1 298.0	4 306.9	22.8		0.0		
+ Electrically driven heat pumps	2.0									
+ Electricity for pumped storage	4 047.0									
+ Derived heat for electricity production	1 054.1									
+ Coke ovens	365 184.1	365 184.1		362 234.9				2 949.2		
+ Blast furnaces	55 925.1	55 925.1		7 243.5				48 681.6		
+ Refineries & petrochemical industry	1 184 801.5									
+ Patent fuel plants	292.0	292.0			292.0					
+ Liquid biofuels blended	40 393.3									
+ Gas-to-liquids plants										
+ Not elsewhere specified	24 971.0	4 348.0						4 348.0		
Transformation output	2 557 011.9	273 934.9					255.2	259 943.6	13 736.1	
+ Electricity & heat generation	955 045.9									
+ Main activity producer electricity only	88 124.7									
+ Main activity producer CHP	666 986.4									
+ Main activity producer heat only	105 631.9									
+ Autoproducer electricity only	14 170.4									
+ Autoproducer CHP	70 254.4									
+ Autoproducer heat only	5 775.0									
+ Electrically driven heat pumps	5.3									
+ Pumped hydro	2 741.7									
+ Other sources	1 355.9									
+ Coke ovens	343 909.8	273 679.7						259 943.6	13 736.1	
+ Blast furnaces	23 159.4									
+ Refineries & petrochemical industry	1 173 625.3									
+ Patent fuel plants	255.2	255.2					255.2			
+ Liquid biofuels blended	40 393.3									
+ Gas-to-liquids plants	20 623.0									
+ Not elsewhere specified										
Energy sector	262 944.8	3 777.3		2 406.2	1 309.8	60.9		0.4		
+ Own use in electricity & heat generation	51 415.5	1.6			1.5			0.1		
+ Coal mines	22 200.7	767.7			706.5	60.9		0.3		
+ Oil & natural gas extraction plants	22 457.2									
+ Patent fuel plants	6.2									
+ Coke ovens	47 314.8	2 406.2		2 406.2						
+ Gas works	79.7									
+ Petroleum refineries (oil refineries)	82 343.2	601.8			601.8					
+ Liquefaction & regasification plants (LNG)	1 860.7									
+ Not elsewhere specified (energy)	35 266.8									
Distribution losses	64 181.9									
Available for final consumption	3 370 558.5	381 780.1	8 588.7	6 269.1	357 576.2	1 381.5	53.4	7 391.4	486.8	32.9
Final non-energy consumption	219 461.8	4 654.9	172.8		2 382.0			1 613.3	486.8	
+ Non-energy use industry/transportation/energy	201 534.9	4 654.9	172.8		2 382.0			1 613.3	486.8	
Final energy consumption	3 105 658.5	363 665.6	5 105.7	520.1	344 959.1	2 710.7	17.7	10 301.8		50.5
+ Industry sector	680 983.7	108 050.1	5 105.7	499.5	93 246.7	1 886.6	13.2	7 247.9		50.5
+ Iron & steel	66 538.7	3 472.6	1 671.5	441.2	621.7		0.3	737.8		
+ Chemical & petrochemical	133 154.2	48 058.7	1 342.4		44 605.3		0.3	2 110.6		
+ Non-ferrous metals	20 062.9	1 043.8	103.7		357.8			582.3		
+ Non-metallic minerals	134 675.5	20 611.7	1 928.2	0.6	14 775.3	985.1	2.2	2 920.3		
+ Transport equipment	17 796.2	286.3			286.2			0.1		
+ Machinery	34 354.1	1 163.5		8.3	1 070.5		5.0	79.7		
+ Mining & quarrying	20 241.2	475.7			459.5			16.1		0.0
+ Food, beverages & tobacco	89 566.5	21 021.9	59.8	44.2	20 209.2	0.7	1.2	704.0		2.9
+ Paper, pulp & printing	64 887.5	7 194.1			7 193.7			0.4		
+ Wood & wood products	50 010.0	1 346.0			1 346.0					
+ Construction	7 637.0	1 406.8		1.1	374.0	888.2	1.6	94.4		47.4
+ Textile & leather	5 419.0	405.2			401.3	0.6	2.5	0.8		
+ Not elsewhere specified (industry)	36 640.8	1 563.8		4.1	1 546.1	12.0	0.1	1.3		0.1
+ Transport sector	985 463.4									
+ Rail	15 370.8									
+ Road	956 594.4									
+ Domestic aviation	1 257.6									
+ Domestic navigation	46.9									
+ Pipeline transport	12 193.5									
+ Not elsewhere specified (transport)										
+ Other sectors	1 439 211.5	255 615.5		20.6	251 712.4	824.0	4.5	3 053.9		
+ Commercial & public services	355 494.0	26 409.1		20.6	24 912.4	24.0		1 452.0		
+ Households	927 191.1	203 368.3			201 600.0	640.0		1 128.3		
+ Agriculture & forestry	156 459.0	25 835.9			25 197.9	160.0	4.5	473.6		
+ Fishing	66.2	2.1			2.1		0.0			
+ Not elsewhere specified (other)	1.1									
Statistical differences	45 438.1	13 459.6	3 310.2	5 749.0	10 235.1	-1 329.1	35.8	-4 523.7	0.0	-17.6

TJ	2021	Manufactured gases	Gas works gas	Coke oven gas	Blast furnace gas	Other recovered gases	Oil and petroleum products	Crude oil	Refinery feedstocks	Additives and oxygenates (excluding biofuel)	Other hydrocarbons
+ Primary production							38 164.9	37 874.9		290.0	
+ Recovered & recycled products							2 106.3				
+ Imports							1 445 851.8	1 003 854.5	31 439.5	2 439.3	
- Exports							169 574.5	7 703.4			
+ Change in stock							7 491.8	18 460.2	2 953.5	18.3	
- International maritime bunkers							14 620.8				
- International aviation							23 605.6				
= Total energy supply							1 285 814.0	1 052 486.2	34 393.0	2 747.6	
Transformation input		33 566.6		20 589.7	11 837.6	1 139.2	1 203 844.0	1 052 218.0	63 339.4	2 402.2	20 623.0
+ Electricity & heat generation		33 566.6		20 589.7	11 837.6	1 139.2	19 042.6				
+ Main activity producer electricity only							236.3				
+ Main activity producer CHP		22 994.4		10 386.7	11 755.5	852.2	5 248.1				
+ Main activity producer heat only		539.2		457.1	82.1		2 106.9				
+ Autoproducer electricity only											
+ Autoproducer CHP		9 924.9		9 637.9		287.1	11 419.0				
+ Autoproducer heat only		108.0		108.0			32.2				
+ Electrically driven heat pumps											
+ Electricity for pumped storage											
+ Derived heat for electricity production											
+ Coke ovens											
+ Blast furnaces											
+ Refineries & petrochemical industry							1 184 801.5	1 052 218.0	63 339.4	2 402.2	20 623.0
+ Patent fuel plants											
+ Liquid biofuels blended											
+ Gas-to-liquids plants											
+ Not elsewhere specified											
Transformation output		93 389.5		70 230.2	20 336.5	2 822.9	1 194 248.3		28 466.5		20 623.0
+ Electricity & heat generation											
+ Main activity producer electricity only											
+ Main activity producer CHP											
+ Main activity producer heat only											
+ Autoproducer electricity only											
+ Autoproducer CHP											
+ Autoproducer heat only											
+ Electrically driven heat pumps											
+ Pumped hydro											
+ Other sources											
+ Coke ovens		70 230.2		70 230.2							
+ Blast furnaces		23 159.4			20 336.5	2 822.9					
+ Refineries & petrochemical industry							1 173 625.3		28 466.5		
+ Patent fuel plants											
+ Liquid biofuels blended											
+ Gas-to-liquids plants							20 623.0				20 623.0
+ Not elsewhere specified											
Energy sector		41 444.2		41 444.2			37 701.9				
+ Own use in electricity & heat generation		0.5		0.5			223.3				
+ Coal mines							905.0				
+ Oil & natural gas extraction plants							50.5				
+ Patent fuel plants											
+ Coke ovens		41 443.7		41 443.7							
+ Gas works											
+ Petroleum refineries (oil refineries)							36 523.2				
+ Liquefaction & regasification plants (LNG)											
+ Not elsewhere specified (energy)											
Distribution losses											
Available for final consumption		18 378.7		8 196.2	8 498.9	1 683.6	1 238 516.3	268.2	-479.8	345.5	
Final non-energy consumption							132 857.4				
+ Non-energy use industry/transformation/energy							114 930.5				
Final energy consumption		18 378.7		8 196.2	8 498.9	1 683.6	1 095 916.4				
+ Industry sector		17 994.1		7 811.6	8 498.9	1 683.6	37 945.8				
+ Iron & steel		14 352.9		5 328.7	8 498.9	525.3	195.7				
+ Chemical & petrochemical		493.4		493.4			20 585.6				
+ Non-ferrous metals		1 245.0		86.6		1 158.3	344.5				
+ Non-metallic minerals		1 900.9		1 900.9			2 923.5				
+ Transport equipment							571.3				
+ Machinery		2.0		2.0			985.4				
+ Mining & quarrying							3 802.0				
+ Food, beverages & tobacco							2 458.5				
+ Paper, pulp & printing							1 997.8				
+ Wood & wood products							507.1				
+ Construction							2 509.0				
+ Textile & leather							165.2				
+ Not elsewhere specified (industry)							900.3				
+ Transport sector							913 405.3				
+ Rail							3 777.7				
+ Road							908 322.4				
+ Domestic aviation							1 257.6				
+ Domestic navigation							46.9				
+ Pipeline transport							0.6				
+ Not elsewhere specified (transport)											
+ Other sectors		384.7		384.7			144 565.3				
+ Commercial & public services		384.7		384.7			17 661.2				
+ Households							26 064.0				
+ Agriculture & forestry							100 817.0				
+ Fishing							22.0				
+ Not elsewhere specified (other)							1.1				
Statistical differences							9 742.5	268.2	-479.8	345.5	

TJ	2021	Refinery gas	Liquefied petroleum gases	Motor gasoline (excluding biofuel portion)	Aviation gasoline	Kerosene-type jet fuel (excluding biofuel portion)	Other kerosene	Naphtha	Gas oil and diesel oil (excluding biofuel portion)	Fuel oil
+ Primary production										
+ Recovered & recycled products										
+ Imports			105 325.4	34 114.9	19.7	114.0	67.3		232 711.9	1 205.9
- Exports			16 480.0	2 226.2	1 202.4	6 439.2	22.6	27 796.6	4 126.5	39 824.3
+ Change in stock			-481.9	-3 605.8	-71.5	-150.3	0.6	0.0	-10 278.0	595.9
- International maritime bunkers									12 048.0	2 572.8
- International aviation					1.1	23 604.6				
= Total energy supply			88 363.6	28 282.9	-1 255.2	-30 080.1	45.3	-27 796.6	206 259.4	-40 595.2
Transformation input		9 460.8	2 925.0					20 924.4	4 226.6	15 343.1
+ Electricity & heat generation		526.0	17.6						3 619.1	14 879.8
+ Main activity producer electricity only									236.3	
+ Main activity producer CHP									1 499.8	3 748.3
+ Main activity producer heat only			5.0						1 810.2	291.6
+ Autoproducer electricity only										
+ Autoproducer CHP		526.0	9.3						60.9	10 822.8
+ Autoproducer heat only			3.3						11.9	17.1
+ Electrically driven heat pumps										
+ Electricity for pumped storage										
+ Derived heat for electricity production										
+ Coke ovens										
+ Blast furnaces										
+ Refineries & petrochemical industry		8 934.8	2 907.4					20 924.4	607.5	463.3
+ Patent fuel plants										
+ Liquid biofuels blended										
+ Gas-to-liquids plants										
+ Not elsewhere specified										
Transformation output		46 579.1	30 578.3	167 555.0	1 422.4	31 186.9	1.7	92 152.3	562 156.8	77 536.9
+ Electricity & heat generation										
+ Main activity producer electricity only										
+ Main activity producer CHP										
+ Main activity producer heat only										
+ Autoproducer electricity only										
+ Autoproducer CHP										
+ Autoproducer heat only										
+ Electrically driven heat pumps										
+ Pumped hydro										
+ Other sources										
+ Coke ovens										
+ Blast furnaces										
+ Refineries & petrochemical industry		46 579.1	30 578.3	167 555.0	1 422.4	31 186.9	1.7	92 152.3	562 156.8	77 536.9
+ Patent fuel plants										
+ Liquid biofuels blended										
+ Gas-to-liquids plants										
+ Not elsewhere specified										
Energy sector		17 460.7	657.3	6.8			0.3		1 156.4	17 552.5
+ Own use in electricity & heat generation			0.9	5.7			0.1		207.4	9.2
+ Coal mines			0.6	1.2			0.2		892.8	
+ Oil & natural gas extraction plants			0.9						49.6	
+ Patent fuel plants										
+ Coke ovens										
+ Gas works										
+ Petroleum refineries (oil refineries)		17 460.7	654.9						6.5	17 543.3
+ Liquefaction & regasification plants (LNG)										
+ Not elsewhere specified (energy)										
Distribution losses										
Available for final consumption		19 657.6	115 359.5	195 831.1	167.2	1 106.8	46.8	43 431.3	763 033.2	4 046.1
Final non-energy consumption			3 198.6				0.3	46 036.5		
+ Non-energy use industry/transformation/energy			3 198.6				0.3	46 036.5		
Final energy consumption		19 657.6	114 109.2	195 831.1	167.2	1 106.8	25.1		760 779.5	2 833.8
+ Industry sector		19 657.6	3 939.2	77.4		16.4	4.8		10 253.0	2 591.4
+ Iron & steel			46.2	0.8					97.8	
+ Chemical & petrochemical		19 657.6	329.3	0.3			1.2		338.8	256.6
+ Non-ferrous metals			30.4	0.1			0.1		56.6	256.8
+ Non-metallic minerals			287.6	7.1		0.1	0.3		1 113.4	191.7
+ Transport equipment			240.0	7.0		10.5	1.5		308.4	3.8
+ Machinery			477.8	8.4		4.9	1.2		457.8	20.8
+ Mining & quarrying			303.6	0.5			0.0		3 484.1	
+ Food, beverages & tobacco			1 142.5	2.7		0.9	0.0		883.2	429.0
+ Paper, pulp & printing			158.1	0.7			0.3		774.5	1 063.3
+ Wood & wood products			149.1	4.0			0.0		225.2	128.6
+ Construction			158.9	30.7			0.0		2 118.5	200.8
+ Textile & leather			70.4	0.4					67.9	26.4
+ Not elsewhere specified (industry)			545.0	14.8			0.1		326.7	13.7
+ Transport sector			83 490.0	195 689.3	167.2	1 090.4			632 968.4	
+ Rail									3 777.7	
+ Road			83 490.0	195 689.3					629 143.1	
+ Domestic aviation					167.2	1 090.4				
+ Domestic navigation									46.9	
+ Pipeline transport									0.6	
+ Not elsewhere specified (transport)										
+ Other sectors			26 680.0	64.4			20.3		117 558.1	242.4
+ Commercial & public services			2 162.0				19.2		15 480.0	
+ Households			21 850.0						4 214.0	
+ Agriculture & forestry			2 667.1	64.4					97 843.0	242.4
+ Fishing			0.9						21.1	
+ Not elsewhere specified (other)							1.1			
Statistical differences			-1 948.3			0.0	21.4	-2 605.1	2 253.7	1 212.4

TJ	2021	White spirit and special boiling point industrial spirits	Lubricants	Bitumen	Petroleum coke	Paraffin waxes	Other oil products	Natural gas	Renewables and biofuels	Hydro	Wind
+ Primary production								139 833.8	535 751.7	8 421.1	58 440.8
+ Recovered & recycled products		2 106.3									
+ Imports		2 851.7	11 815.3	7 090.0	1 217.0	4 907.1	6 678.4	641 792.9	37 520.4		
- Exports		4 317.3	14 177.8	17 882.9	6 939.6	1 286.7	19 149.1	3 950.2	23 732.6		
+ Change in stock		85.3	-16.3	116.8	-60.5	-23.8	-50.9	-14 394.3	-1 828.6		
- International maritime bunkers											
- International aviation											
= Total energy supply		-1 380.3	-272.5	-10 676.0	-5 783.0	3 596.5	-12 521.6	763 282.2	547 710.9	8 421.1	58 440.8
Transformation input		2 948.2				524.3	8 909.1	149 513.8	210 685.0	8 421.1	58 440.8
+ Electricity & heat generation								128 890.8	170 291.7	8 421.1	58 440.8
+ Main activity producer electricity only									83 052.4	8 414.6	58 440.8
+ Main activity producer CHP								73 915.0	46 862.2		
+ Main activity producer heat only								9 824.5	6 841.9		
+ Autoproducer electricity only									14 170.4	6.4	
+ Autoproducer CHP								44 177.7	18 774.6		
+ Autoproducer heat only								973.6	590.2		
+ Electrically driven heat pumps											
+ Electricity for pumped storage											
+ Derived heat for electricity production											
+ Coke ovens											
+ Blast furnaces											
+ Refineries & petrochemical industry			2 948.2			524.3	8 909.1				
+ Patent fuel plants											
+ Liquid biofuels blended									40 393.3		
+ Gas-to-liquids plants											
+ Not elsewhere specified								20 623.0			
Transformation output		5 607.3	18 010.4	54 625.7	9 336.0	3 679.8	44 730.0		40 393.3		
+ Electricity & heat generation											
+ Main activity producer electricity only											
+ Main activity producer CHP											
+ Main activity producer heat only											
+ Autoproducer electricity only											
+ Autoproducer CHP											
+ Autoproducer heat only											
+ Electrically driven heat pumps											
+ Pumped hydro											
+ Other sources											
+ Coke ovens											
+ Blast furnaces											
+ Refineries & petrochemical industry		5 607.3	18 010.4	54 625.7	9 336.0	3 679.8	44 730.0				
+ Patent fuel plants											
+ Liquid biofuels blended									40 393.3		
+ Gas-to-liquids plants											
+ Not elsewhere specified											
Energy sector							867.9	58 088.1	18.9		
+ Own use in electricity & heat generation							0.0	17.8	0.1		
+ Coal mines							10.2	110.8	18.7		
+ Oil & natural gas extraction plants								21 561.0			
+ Patent fuel plants											
+ Coke ovens								19.0			
+ Gas works											
+ Petroleum refineries (oil refineries)							857.7	33 794.7			
+ Liquefaction & regasification plants (LNG)								1 702.1			
+ Not elsewhere specified (energy)								882.6			
Distribution losses								355.9			
Available for final consumption		4 227.0	14 789.8	43 949.6	3 553.0	6 752.0	22 431.3	555 324.4	377 400.3		
Final non-energy consumption		4 227.0	10 115.8	43 949.6		6 752.0	18 577.6	81 949.5			
+ Non-energy use industry/transformation/energy		325.2	892.2	43 949.6		1 950.4	18 577.6	81 949.5			
Final energy consumption					1 372.6		33.5	451 140.3	377 400.3		
+ Industry sector					1 372.6		33.5	177 517.5	67 285.5		
+ Iron & steel					50.4		0.5	23 122.7	7.7		
+ Chemical & petrochemical							1.9	18 887.6	255.3		
+ Non-ferrous metals					0.4			7 981.8			
+ Non-metallic minerals					1 321.8		1.6	51 813.0	4 086.7		
+ Transport equipment							0.1	4 633.6	29.7		
+ Machinery							14.4	11 007.9	91.8		
+ Mining & quarrying							13.7	1 535.6	3.7		
+ Food, beverages & tobacco							0.2	35 686.6	912.1		
+ Paper, pulp & printing							0.9	9 855.4	24 299.9		
+ Wood & wood products							0.2	2 081.2	32 601.1		
+ Construction								1 411.3	112.2		
+ Textile & leather							0.0	2 292.7	12.4		
+ Not elsewhere specified (industry)							0.0	7 208.1	4 872.9		
+ Transport sector								12 966.4	46 879.1		
+ Rail											
+ Road								1 163.5	46 879.1		
+ Domestic aviation											
+ Domestic navigation											
+ Pipeline transport								11 802.8			
+ Not elsewhere specified (transport)											
+ Other sectors								260 656.4	263 235.8		
+ Commercial & public services								67 305.9	12 530.5		
+ Households								191 170.8	226 464.1		
+ Agriculture & forestry								2 176.1	24 237.4		
+ Fishing								3.7	3.8		
+ Not elsewhere specified (other)											
Statistical differences		4 674.0			2 180.4		3 820.2	22 234.7			

TJ 2021	Solar photovoltaic	Solar thermal	Geothermal	Primary solid biofuels	Biogases	Renewable municipal waste	Pure biogasoline	Blended biogasoline	Pure biodiesels	Blended biodiesels
+ Primary production	14 164.0	3 566.4	1 189.2	371 823.1	13 372.0	5 867.0	6 811.6		36 512.5	
+ Recovered & recycled products										
+ Imports				19 122.1			768.9	1 367.3	14 275.1	1 987.1
- Exports				10 718.4			207.0		12 807.2	
+ Change in stock							-31.9		-1 797.2	
- International maritime bunkers										
- International aviation										
= Total energy supply	14 164.0	3 566.4	1 189.2	380 226.8	13 372.0	5 867.0	7 341.6	1 367.3	36 183.1	1 987.1
Transformation input	14 164.0			75 105.6	9 702.0	4 411.5	7 341.6		33 051.7	
+ Electricity & heat generation	14 164.0			75 105.6	9 702.0	4 411.5				
+ Main activity producer electricity only				16 197.0						
+ Main activity producer CHP				39 233.2	6 292.6	1 336.5				
+ Main activity producer heat only				6 832.8	9.1					
+ Autoproducer electricity only	14 164.0									
+ Autoproducer CHP				12 334.2	3 362.1	3 042.0				
+ Autoproducer heat only				508.4	38.3	33.0				
+ Electrically driven heat pumps										
+ Electricity for pumped storage										
+ Derived heat for electricity production										
+ Coke ovens										
+ Blast furnaces										
+ Refineries & petrochemical industry										
+ Patent fuel plants										
+ Liquid biofuels blended							7 341.6		33 051.7	
+ Gas-to-liquids plants										
+ Not elsewhere specified										
Transformation output							7 341.6		33 051.7	
+ Electricity & heat generation										
+ Main activity producer electricity only										
+ Main activity producer CHP										
+ Main activity producer heat only										
+ Autoproducer electricity only										
+ Autoproducer CHP										
+ Autoproducer heat only										
+ Electrically driven heat pumps										
+ Pumped hydro										
+ Other sources										
+ Coke ovens										
+ Blast furnaces										
+ Refineries & petrochemical industry										
+ Patent fuel plants										
+ Liquid biofuels blended							7 341.6		33 051.7	
+ Gas-to-liquids plants										
+ Not elsewhere specified										
Energy sector				18.9						
+ Own use in electricity & heat generation				0.1						
+ Coal mines				18.7						
+ Oil & natural gas extraction plants										
+ Patent fuel plants										
+ Coke ovens										
+ Gas works										
+ Petroleum refineries (oil refineries)										
+ Liquefaction & regasification plants (LNG)										
+ Not elsewhere specified (energy)										
Distribution losses										
Available for final consumption		3 566.4	1 189.2	305 102.3	3 670.0	1 455.5		8 708.9	3 131.4	35 038.8
Final non-energy consumption										
+ Non-energy use industry/transformation/energy										
Final energy consumption		3 566.4	1 189.2	305 102.3	3 670.0	1 455.5		8 708.9	3 131.4	35 038.8
+ Industry sector				65 064.0	775.8	1 445.2				
+ Iron & steel				7.7						
+ Chemical & petrochemical				253.5	1.5					
+ Non-ferrous metals										
+ Non-metallic minerals				4 045.7		41.0				
+ Transport equipment				29.7						
+ Machinery				91.8						
+ Mining & quarrying				3.7						
+ Food, beverages & tobacco				404.7	500.9	6.4				
+ Paper, pulp & printing				22 756.2	169.7	1 373.9				
+ Wood & wood products				32 541.1	36.1	23.9				
+ Construction				44.7	67.6					
+ Textile & leather				12.4						
+ Not elsewhere specified (industry)				4 872.9						
+ Transport sector								8 708.9	3 131.4	35 038.8
+ Rail										
+ Road								8 708.9	3 131.4	35 038.8
+ Domestic aviation										
+ Domestic navigation										
+ Pipeline transport										
+ Not elsewhere specified (transport)										
+ Other sectors		3 566.4	1 189.2	240 038.3	2 894.1	10.3				
+ Commercial & public services		228.2	297.3	8 390.6	2 545.6	10.3				
+ Households		3 338.2	891.9	207 755.0						
+ Agriculture & forestry				23 888.9	348.5					
+ Fishing				3.8						
+ Not elsewhere specified (other)										
Statistical differences									0.0	

TJ 2021	Pure bio jet kerosene	Blended bio jet kerosene	Other liquid biofuels	Ambient heat (heat pumps)	Non- renewable waste	Industrial waste (non- renewable)	Non- renewable municipal waste	Heat	Electricity
+ Primary production			88.6	15 495.5	41 216.6	26 132.8	15 083.8	1 377.9	
+ Recovered & recycled products									
+ Imports									54 359.4
- Exports									51 163.4
+ Change in stock			0.5						
- International maritime bunkers									
- International aviation									
= Total energy supply			89.1	15 495.5	41 216.6	26 132.8	15 083.8	1 377.9	3 196.0
Transformation input			41.5	5.3	9 456.2	1 688.9	7 767.3	2 432.1	4 049.1
+ Electricity & heat generation			41.5	5.3	9 456.2	1 688.9	7 767.3	2 432.1	4 049.1
+ Main activity producer electricity only									
+ Main activity producer CHP					2 207.5	629.5	1 578.0		
+ Main activity producer heat only					41.1	31.0	10.1		
+ Autoproducer electricity only									
+ Autoproducer CHP			36.3		6 815.8	735.4	6 080.4	1 377.9	
+ Autoproducer heat only			5.1	5.3	391.8	292.9	98.8		
+ Electrically driven heat pumps									2.0
+ Electricity for pumped storage									4 047.0
+ Derived heat for electricity production								1 054.1	
+ Coke ovens									
+ Blast furnaces									
+ Refineries & petrochemical industry									
+ Patent fuel plants									
+ Liquid biofuels blended									
+ Gas-to-liquids plants									
+ Not elsewhere specified									
Transformation output								308 372.4	646 673.4
+ Electricity & heat generation								308 372.4	646 673.4
+ Main activity producer electricity only									88 124.7
+ Main activity producer CHP								179 568.9	487 417.5
+ Main activity producer heat only								105 631.9	
+ Autoproducer electricity only									14 170.4
+ Autoproducer CHP								16 337.2	53 917.3
+ Autoproducer heat only								5 775.0	
+ Electrically driven heat pumps								5.3	
+ Pumped hydro									2 741.7
+ Other sources								1 054.1	301.8
+ Coke ovens									
+ Blast furnaces									
+ Refineries & petrochemical industry									
+ Patent fuel plants									
+ Liquid biofuels blended									
+ Gas-to-liquids plants									
+ Not elsewhere specified									
Energy sector					0.8	0.8		26 671.0	95 242.7
+ Own use in electricity & heat generation					0.1	0.1		4 983.7	46 188.3
+ Coal mines					0.7	0.7		3 309.8	17 088.0
+ Oil & natural gas extraction plants								31.7	814.0
+ Patent fuel plants									6.2
+ Coke ovens								808.3	2 637.6
+ Gas works								11.7	68.0
+ Petroleum refineries (oil refineries)								327.0	11 096.6
+ Liquefaction & regasification plants (LNG)									158.6
+ Not elsewhere specified (energy)								17 198.7	17 185.6
Distribution losses								30 526.3	33 299.7
Available for final consumption			47.7	15 490.2	31 759.6	24 443.2	7 316.5	250 121.0	517 277.9
Final non-energy consumption									
+ Non-energy use industry/transformation/energy									
Final energy consumption			47.7	15 490.2	31 759.6	24 443.2	7 316.5	250 121.0	517 276.6
+ Industry sector			0.4		31 028.8	24 287.9	6 740.9	38 457.0	202 705.0
+ Iron & steel								2 979.6	22 407.6
+ Chemical & petrochemical			0.4		27.5	27.5		14 443.1	30 402.9
+ Non-ferrous metals								916.7	8 531.2
+ Non-metallic minerals					30 478.0	23 737.1	6 740.9	1 234.5	21 627.2
+ Transport equipment					5.3	5.3		1 831.0	10 439.0
+ Machinery					9.4	9.4		2 384.5	18 709.6
+ Mining & quarrying					47.8	47.8		2 963.7	11 412.7
+ Food, beverages & tobacco					0.0	0.0		1 965.5	27 522.0
+ Paper, pulp & printing					406.3	406.3		3 785.6	17 348.5
+ Wood & wood products					44.6	44.6		3 801.7	9 628.3
+ Construction					0.4	0.4		191.5	2 005.8
+ Textile & leather					0.3	0.3		370.4	2 172.7
+ Not elsewhere specified (industry)					9.0	9.0		1 589.1	20 497.5
+ Transport sector									12 212.6
+ Rail									11 593.1
+ Road									229.4
+ Domestic aviation									
+ Domestic navigation									
+ Pipeline transport									390.0
+ Not elsewhere specified (transport)									
+ Other sectors			47.3	15 490.2	730.8	155.3	575.5	211 664.1	302 359.0
+ Commercial & public services			47.3	1 011.2	730.8	155.3	575.5	40 814.1	189 657.8
+ Households				14 478.9				170 000.0	110 124.0
+ Agriculture & forestry								850.0	2 542.6
+ Fishing									34.5
+ Not elsewhere specified (other)									
Statistical differences									1.4

ANNEX 5. METHODOICAL NOTES RELATED TO ELABORATION OF REPRESENTATIVE RESEARCH ON LIVESTOCK POPULATION PERFORMED BY STATISTICS POLAND

1. Sources of data

The data in this publication were compiled on the basis of:

- generalized results of sample surveys⁷ on cattle, sheep, poultry and pigs, as well as, the animal output in private farms,
- statistical reports in the scope of livestock in state and cooperative farms and companies with public and private property share,
- statistical reports from slaughterhouses of farm animals,
- statistical reports from poultry hatcheries,
- information on the livestock of poultry from voivodship experts,
- own estimates.

Surveys on cattle, sheep, poultry and animal output were conducted in private farms breeding the above-listed species of animals; this sample amounted to 40 thousand farms.

Surveys on pigs and production of pigs for slaughter were carried out in a sample of private farms breeding pigs; this sample amounted to 30 thousand farms.

The results of the survey of farm animal stocks and animal output were compiled by voivodship according to the residence of the farm user, i.e. for private farms - according to the official residence (place of residence) of the farm user, while for state owned farms, cooperative farms and companies – according to the official residence of the holding.

2. Major definitions, terms and enumeration rules

Agricultural holding is understood as an organised economic and technical unit with separate management (a holder or a manager), conducting agricultural activity.

Agricultural activity includes activity associated with crop production, which covers: all agricultural crops (including mushroom production), vegetable production and horticulture, arboriculture, agricultural and horticultural crop and seed production, as well as animal production in a holding, i.e. cattle, sheep, goats, horses, pigs, poultry, rabbits, other fur animals, game kept for slaughter, bees, and activity consisting of maintaining unused agricultural land for production purposes according to the rules of a good agricultural conditions in compliance with environmental protection requirements.

Natural person's holding (private farm) is understood as a holding used by a natural person with an area of 1.0 ha or more of agricultural land, or a holding of the area of less than 1.0 ha of agricultural land (including holdings without agricultural land), which meets at least one of the thresholds mentioned below:

0.5 ha of fruit trees plantation,

0.5 ha of fruit shrubs plantation, soil-grown vegetables, soil-grown strawberries, hop,

0.3 ha of fruit and ornamental nurseries,

0.1 ha of vegetables under cover,

0.1 ha of strawberries under cover, flowers and ornamental plants under cover, tobacco,

25 m² of edible mushrooms,

10 head of cattle in total,

5 head of cows in total,

50 head of pigs in total,

10 head of sows,

20 head of sheep in total, goats in total,

⁷The surveys on pigs, cattle, sheep and poultry stock are conducted twice a year, i.e. in June and in December.

100 head of poultry in total,
 5 head of horses in total,
 50 head of female rabbits,
 5 head of other female fur animals,
 10 head of game (e.g. wild boars, roe deer, fallow deer) kept for slaughter,
 20 beehives

or, regardless of the above thresholds, is an organic farm.

The holding of a legal person or an organisational unit without a legal personality is an agricultural holding run by legal person or an organisational unit without legal personality, the basic activity of which is classified, according to the Polish Classification of Activities, to Section A, division 01, group:

01.1 – growing of non perennial crops,

01.2 – growing of perennial crops,

01.3 – plant propagation,

01.4 – animal production,

01.5 – mixed farming,

01.6, class 01.61 – support activities for crop production (maintaining the land in accordance with cultivation principles with respect for environment protection requirements), and also, irrespective of the basic activity classification, when the area of agricultural land used by the holding is 1 ha or more or when livestock is reared or bred.

Holder of an agricultural farm is understood as a natural person or a legal person or an organisational unit without a legal personality actually using the farm, regardless of whether he or she is an owner or a leaseholder, or uses the farm in any other respect, and regardless of whether land constituting the farm is situated in one or in several gminas.

Livestocks

The survey covered the livestock staying in the agricultural holding during the survey, as well as animals sent to herding, grazing and shepherd's huts. All animals were registered, i.e. the ones owned by a holder or members of his/her household, as well as animals temporarily or permanently kept in the holding, i.e. taken for rearing, fattening, etc., irrespective whether they were taken from private holdings, state-owned holdings, cooperative entities, or companies.

Dairy cows are understood as cows which, due to their breed, variety or particular qualities, are kept in a holding exclusively or mainly for the production of milk to be consumed or to be processed into dairy products. Dairy cows culled from breeding herds which at the moment of performing the survey were kept in the holding as pre-slaughter pasturing, after which they are sent to slaughter, are also included in this group.

Suckling cows are understood as cows which, due to their breed (beef breed cows and cows born from a cross-breed with beef breeds) or particular qualities, are kept in a holding exclusively or mainly for calves for slaughter, and whose milk is used to feed calves or other animals. Suckling cows culled from breeding herds which at the moment of performing the survey were kept in the holding as pre-slaughter pasturing, after which they are sent to slaughter, are also included in this group.

In the case of holdings engaged in the production of poultry on a large scale (such as a large-scale holding producing broilers or hen eggs), in which no poultry has been recorded on the survey day due to the current technological break in production, whenever such break does not exceed 8 weeks, the poultry stocks from the period before emptying the rooms (poultry houses) have been adopted.

Information on the number of pigs, cattle, sheep and poultry contained in this publication refers to the stock in June and December 2020.

The percentages are presented with one decimal point and due to the electronic technique of rounding may not sum up into 100%. These figures are substantially correct.

Sampling scheme

Survey on cattle, sheep and poultry stock

1. Introductory notes

The purpose of the surveys conducted by the Central Statistical Office twice a year (i.e. in June and in December) is to obtain detailed information on the number of cattle and poultry, both by voivodships and for Poland, and on the number of sheep for Poland only.

Due to the coronavirus pandemic and the need to conduct the most of the surveys via the telephone channel (CATI method), in 2020 year the sample from the previous year was used. The sample size was about 23.5 thousand farms and it represented a population of about 413 thousand farms. A detailed description of the frame and the sampling scheme used in 2019 can be found in the Statistics Poland publication "Farm animals in 2019 year".

2. Results generalization and the accuracy assessment method

The sum of X variable value, such as cattle stock in total, is the basic parameter estimated in the survey of livestock of cattle, sheep and poultry.

This parameter for w-voivodship is calculated according to the formula:

$$(1) \hat{X}_w = \sum_h \sum_i W1_{whi} * x_{whi}, \quad (i = 1, 2, \dots, n_{wh}; h = 1, 2, \dots, h_{\max})$$

where:

x_{whi} – the value of X variable in i-farm (sampling unit) drawn from h-stratum in w-voivodship,

$W1_{whi}$ – the weight assigned to i-farm drawn from h-stratum of w-voivodship; this weight was determined for the sample realized in 2019,

n_{wh} – the number of sampling units drawn for the sample and surveyed in 2019 year from h-stratum of w-voivodship,

$h_{\max}$ – maximum number of strata.

The $W1_{whi}$ weight might be used to estimate the survey results only if the survey is complete. This weight must be corrected if some of the sampled farms refuse to participate in the survey. For this purpose, the drawn sample is divided into 4 groups based on information on the survey performance:

- (1) the surveyed farms,
- (2) farms which refused to participate in the survey,
- (3) closed down farms,
- (4) farms with which the contact was not established during the survey performance.

For each stratum separately in each voivodship, the size of the above groups, namely $n1_{wh}$, $n2_{wh}$, $n3_{wh}$ and $n4_{wh}$ is established, and then the likelihood function of surveyed and not surveyed among the farms with a determined status is established, that is:

$$(2) c_{wh} = \frac{n1_{wh} + n2_{wh}}{n_{wh} - n4_{wh}},$$

Then the number of the n_{awh} active farms in h-stratum of w-voivodship is calculated for the drawn sample:

$$(3) n_{awh} = n1_{wh} + n2_{wh} + c_{wh} * n4_{wh}$$

On this basis, the R_{wh} correction factor is calculated for a given stratum:

$$(4) R_{wh} = \frac{n_{awh}}{n1_{wh}},$$

The purpose of this factor is to correct the $W1_{whi}$ weight in order to obtain final W_{hi} weight:

$$(5) W_{whi} = R_{wh} * W1_{whi},$$

The sum of X variable value for Poland is the sum of values obtained for particular voivodships, i.e.:

$$(6) \hat{x} = \sum_w \hat{x}_w, (w = 1, 2, \dots, 16)$$

Original weights resulting from sampling (i.e. from the 2019 draw) and after appropriate adjustment in 2019 are corrected not only due to incompleteness of the survey but also due to the occurrence of so called unusual farms (outliers). This pertains to farms with high assigned weight (drawn with a high likelihood function) and, at the same time, with relatively high values for some of the analyzed variables. In this case, the weight correction is to prevent significant overestimation of the value of the surveyed variable.

In the last step weights were calibrated taking into account the data from the Agency for Restructuring and Modernization of Agriculture (ARMA) for the number of farms, number of cattle, and number of poultry in voivodships.

For the selected major assessments of the parameters, their variation coefficients were calculated as the accuracy measures. For an estimator expressed by formula (1) i.e. for w-voivodship, its variation coefficient estimation is expressed in the following formula:

$$(7) v(x_w) = \frac{\sqrt{d^2(\hat{x}_w)}}{\hat{x}_w} * 100,$$

while:

$$(8) d^2(\hat{x}_w) = \sum_h n_{awh} \left(1 - \frac{n_{wh}}{N_{wh}} \right) * s_{wh}^2,$$

where:

$$(9) s_{wh}^2 = \frac{1}{n_{awh} - 1} \sum_i \left(y_{whi} - \frac{1}{n_{awh}} * \hat{y}_{wh} \right)^2,$$

while:

$$(10) y_{whi} = W_{whi} * x_{whi},$$

and:

$$(11) \hat{y}_{wh} = \sum_i y_{whi},$$

For Poland the variation coefficient of the sum X estimated with the formula (6) is expressed by the following formula:

$$(12) v(\hat{x}) = \frac{\sqrt{d^2(\hat{x})}}{\hat{x}},$$

whereas:

$$(13) d^2(\hat{x}) = \sum_w d^2(\hat{x}_w)$$

Survey on pigs

1. Introductory notes

The purpose of the survey on pigs stocks, conducted by the Central Statistical Office two times a year in June and December is to obtain detailed information on the number of pigs by voivodships and for Poland.

Due to the coronavirus pandemic and the need to conduct the most of the surveys via the telephone channel (CATI method), in 2020 year the sample from the previous year was used. The sample size was about 25 thousand farms and it represented a population of about 198 thousand farms. A detailed description of the frame and the sampling scheme used in 2019 can be found in the Statistics Poland publication "Farm animals in 2019 year".

2. Results generalization and the accuracy assessment method

The sum of X variable value, such as pigs stock in total, is the basic parameter estimated during the survey on the livestock of pigs.

This parameter for w-voivodship is calculated according to the formula:

$$(1) \hat{x}_w = \sum_h \sum_i W1_{whi} * x_{whi}, \quad (i = 1, 2, \dots, n_{wh}; h = 1, 2, \dots, h_{max})$$

where:

x_{whi} – the value of X variable in i-farm (sampling unit) drawn from h-stratum in w-voivodship,

$W1_{whi}$ – the weight assigned to i-farm drawn from h-stratum in w-voivodship; this weight was determined for the sample realized in 2019,

n_{wh} – the number of sampling units drawn for the sample and surveyed in 2019 year from h-stratum of w-voivodship,

h_{max} – maximum number of strata.

Weight $W1_{whi}$ can be used for the estimation of survey results only when the survey is complete. The weight must be adjusted when a part of farms drawn for the survey refuse to participate in the survey. For this purpose, the drawn sample is divided into 4 groups on the basis of information on carrying out the survey:

- (1) the surveyed farms,
- (2) farms which refused to participate in the survey,
- (3) closed down farms,
- (4) farms with which the contact was not established during the survey performance.

For each stratum, separately for each voivodship, the size of the above groups, i.e. $n1_{wh}$, $n2_{wh}$, $n3_{wh}$ and $n4_{wh}$ is established, then the likelihood function of surveyed and not surveyed among the farms with a determined status is established, i.e.:

$$(2) c_{wh} = \frac{n1_{wh} + n2_{wh}}{n_{wh} - n4_{wh}},$$

Next, the number of the n_{awh} active farms in h-stratum of w-voivodship is calculated for the drawn sample:

$$(3) n_{awh} = n1_{wh} + n2_{wh} + c_{wh} * n4_{wh}$$

On the basis of this, the R_{wh} correction factor is calculated for a given stratum:

$$(4) R_{wh} = \frac{n_{awh}}{n1_{wh}},$$

The function of this factor is the correction of the $W1_{whi}$ weight in order to achieve final weight W_{hi} :

$$(5) W_{whi} = R_{wh} * W1_{whi},$$

The evaluation of the sum of X variable value for Poland is the sum of values obtained for particular voivodships, i.e.:

$$(6) \hat{X} = \sum_w \hat{x}_w, \quad (w = 1, 2, \dots, 16)$$

Primary weights resulting from sample drawing (i.e. from the 2019 draw) and after appropriate adjustment in 2019 are corrected not only due to the incompleteness of the survey but also due to the occurrence of the so called outlier farms. This pertains to farms with high assigned weight (drawn with a high likelihood function) and, at the same time, with relatively high values for some of the analysed variables. Weight correction is aimed at preventing substantial overestimation of the value of the analysed variable.

For the selected major assessments of the parameters, their variation coefficients were estimated as the accuracy measures. For an estimator expressed by formula (1), i.e. for w-voivodship, its variation coefficient is estimated with the following formula:

$$(7) v(x_w) = \frac{\sqrt{d^2(\hat{x}_w)}}{\hat{x}_w} * 100,$$

while:

$$(8) d^2(\hat{x}_w) = \sum_h n_{awh} \left(1 - \frac{n_{wh}}{N_{wh}} \right) * s_{wh}^2,$$

where:

$$(9) s_{wh}^2 = \frac{1}{n_{awh} - 1} \sum_i \left(y_{whi} - \frac{1}{n_{awh}} * \hat{y}_{wh} \right)^2,$$

while:

$$(10) y_{whi} = W_{whi} * x_{whi},$$

and:

$$(11) \hat{y}_{wh} = \sum_i y_{whi},$$

For Poland the variation coefficient of the sum X estimated with the formula (6) is expressed by the following formula:

$$(12) \ v(\hat{x}) = \frac{\sqrt{d^2(\hat{x})}}{\hat{x}},$$

whereas:

$$(13) \ d^2(\hat{x}) = \sum_w d^2(\hat{x}_w)$$

The values of the relative standard error of selected characteristics for Poland – based on the results of a sample survey of the livestock of cattle, sheep and poultry as well as the results of a survey of pigs – conducted in December 2020.

No. of the attribute	Name of characteristics	Relative standard error
1.	Cattle total	0.77
2.	Cows	1.00
3.	Pigs total	0.63
4.	Sows total	1.13
5.	Hens	3.08
6.	Laying hens	4.02

ANNEX 6. LULUCF LAND TRANSITION MATRIX

Table 6.A.1. Annual land use changes for the 1988-2005

LULUCF category	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Forest land (managed)																		
Remaining Forest land (managed)	kha	8656.01	8663.14	8674.71	8690.37	8702.59	8714.45	8714.35	8723.82	8741.11	8778.13	8808.94	8860.84	8876.42	8903.03	8915.21	8967.47	9030.44
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	1.32	0.68	0.61	0.36	0.53	0.57	0.67	0.40	0.42	0.58	0.49	0.40	0.72	0.53	0.42	0.69	0.65
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	8657.32	8663.82	8675.32	8690.72	8703.12	8715.02	8715.02	8724.22	8741.53	8778.71	8809.43	8861.25	8877.14	8903.56	8915.63	8968.16	9031.09
Final area	kha	8663.82	8675.32	8690.72	8703.12	8715.02	8715.02	8724.22	8741.53	8778.71	8809.43	8861.25	8877.14	8903.56	8915.63	8968.16	9031.09	9106.37
Forest land (unmanaged)																		
Remaining Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 6.A.1. Annual land use changes for the 1988-2005 (cont.)

LULUCF category	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Cropland																		
Remaining Cropland	kha	14705.18	14682.18	14658.41	14648.03	14624.13	14607.17	14581.06	14567.42	14536.31	14518.16	14446.69	14467.35	14435.14	14405.47	14345.31	14282.04	14331.26
Converted to Forest land (managed)	kha	6.02	9.38	12.33	9.82	9.57	0.28	7.60	13.64	28.95	24.10	40.27	12.55	20.89	9.70	40.77	48.99	58.47
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	20.12	5.69	4.45	4.24	7.96	15.51	13.03	6.32	1.67	0.93	34.79	8.44	9.81	NO	17.63	35.89	5.67
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	7.66	7.33	5.94	5.22	6.58	7.69	6.37	1.42	1.21	0.98	1.32	1.72	1.50	1.88	1.77	1.88	2.24
Converted to Other land	kha	3.20	0.60	1.05	NO	NO	NO	NO	NO	NO	NO	NO	5.98	NO	25.62	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	14742.18	14705.18	14682.18	14667.31	14648.24	14630.65	14608.05	14588.80	14568.14	14544.17	14523.07	14496.04	14467.35	14442.66	14405.47	14368.79	14397.64
Final area	kha	14705.18	14682.18	14667.31	14648.24	14630.65	14608.05	14588.80	14568.14	14544.17	14523.07	14496.04	14467.35	14442.66	14405.47	14368.79	14397.64	14370.97
Grassland (managed)																		
Remaining Grassland (managed)	kha	4310.08	4317.52	4305.06	4297.67	4292.90	4291.37	4300.37	4306.19	4301.80	4298.48	4287.19	4308.30	4298.42	4287.29	4272.16	4260.53	4273.86
Converted to Forest land (managed)	kha	1.80	2.80	3.68	2.94	2.86	0.30	2.27	4.07	8.65	7.20	12.03	3.75	6.24	2.90	12.18	14.63	17.46
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	8.90	NO	NO	NO	NO	NO	NO	NO	NO	NO	7.52	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	1.41	5.03	1.57	2.45	0.97	1.61	0.03	3.15	2.07	0.20	0.92	4.30	3.57	1.05	2.95	14.62	5.09
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	2.41	4.86	3.99	6.45	5.18	7.59	4.21	NO	NO	NO	4.04	5.63	0.99	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	17.00	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	4315.70	4330.20	4323.20	4309.50	4301.91	4300.86	4306.88	4313.41	4312.51	4305.88	4304.18	4321.98	4316.74	4308.24	4287.29	4289.79	4296.42
Final area	kha	4330.20	4323.20	4309.50	4301.91	4300.86	4306.88	4313.41	4312.51	4305.88	4304.18	4321.98	4316.74	4308.24	4287.29	4289.79	4296.42	4279.53

Table 6.A.1. Annual land use changes for the 1988-2005 (cont.)

LULUCF category	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Grassland (unmanaged)																		
Remaining Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wetlands (managed)																		
Remaining Wetlands (managed)	kha	1322.09	1323.47	1328.42	1329.97	1332.41	1333.36	1334.92	1334.49	1337.57	1338.05	1338.15	1338.34	1341.96	1341.24	1341.20	1343.30	1356.72
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.39	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	0.01	0.03	0.08	0.02	0.01	0.03	0.04	0.47	0.07	0.20	0.10	0.74	0.68	1.05	1.09	0.85	1.21
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	3.24	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	1322.10	1323.50	1328.50	1329.99	1332.42	1333.39	1334.97	1334.95	1337.63	1339.64	1338.25	1339.08	1342.63	1345.53	1342.30	1344.15	1357.93
Final area	kha	1323.50	1328.50	1329.99	1332.42	1333.39	1334.97	1334.95	1337.63	1339.64	1338.25	1339.08	1342.63	1345.53	1342.30	1344.15	1357.93	1361.82

Table 6.A.1. Annual land use changes for the 1988-2005 (cont.)

LULUCF category	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Wetlands (unmanaged)																		
Remaining Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Settlements																		
Remaining Settlements	kha	1948.10	1959.50	1972.40	1983.02	1995.06	2007.36	2023.24	2034.53	2034.41	2032.71	2034.47	2040.41	2048.90	2028.08	2019.17	2006.87	1998.92
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	12.36	15.58	11.37
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	0.00	2.41	3.39	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	28.64	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	1948.10	1959.50	1972.40	1983.02	1995.06	2007.36	2023.24	2034.54	2036.82	2036.10	2034.47	2040.41	2048.90	2056.72	2031.53	2022.45	2010.29
Final area	kha	1959.50	1972.40	1983.02	1995.06	2007.36	2023.24	2034.54	2036.82	2036.10	2034.47	2040.41	2048.90	2056.72	2031.53	2022.45	2010.29	2003.02

Table 6.A.1. Annual land use changes for the 1988-2005 (cont.)

LULUCF category	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Other land																		
Remaining Other land	kha	286.64	289.84	290.44	291.28	284.76	283.87	276.13	275.41	267.54	262.64	213.29	213.29	215.34	215.34	278.71	178.68	150.34
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	0.21	6.53	0.88	7.75	0.72	7.86	4.90	49.35	NO	NO	NO	11.12	100.03	28.34
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	3.94	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	286.64	289.84	290.44	291.49	291.28	284.76	283.87	276.13	275.41	267.54	262.64	213.29	219.28	215.34	289.83	278.71	178.68
Final area	kha	289.84	290.44	291.49	291.28	284.76	283.87	276.13	275.41	267.54	262.64	213.29	219.28	215.34	289.83	278.71	178.68	150.34
Total unmanaged land																		
Remaining Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 6.A.1. Annual land use changes for the 1988-2005 (cont.)

LULUCF category	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net change																		
Forest land (managed)	kha	6.50	11.50	15.40	12.40	11.90	0.00	9.19	17.31	37.18	30.72	51.82	15.90	26.41	12.07	52.53	62.93	75.28
Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cropland	kha	-37.00	-23.00	-14.87	-19.07	-17.58	-22.60	-19.25	-20.66	-23.97	-21.11	-27.03	-28.69	-24.69	-37.19	-36.68	28.86	-26.67
Grassland (managed)	kha	14.50	-7.00	-13.70	-7.59	-1.05	6.02	6.52	-0.89	-6.63	-1.70	17.79	-5.23	-8.51	-20.95	2.50	6.63	-16.88
Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wetlands (managed)	kha	1.40	5.00	1.49	2.43	0.97	1.58	-0.01	2.68	2.01	-1.39	0.82	3.56	2.90	-3.24	1.86	13.77	3.89
Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Settlements	kha	11.40	12.90	10.62	12.04	12.30	15.88	11.29	2.28	-0.72	-1.63	5.94	8.49	7.82	-25.19	-9.08	-12.16	-7.27
Other land	kha	3.20	0.60	1.05	-0.21	-6.53	-0.88	-7.75	-0.72	-7.86	-4.90	-49.35	5.98	-3.94	74.49	-11.12	-100.03	-28.34
Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total																		
Initial area	kha	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04
Final area	kha	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04
Net change	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.A.2. Annual land use changes for the 2006-2021

LULUCF category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Forest land (managed)																		
Remaining Forest land (managed)	kha	9105.89	9152.32	9163.49	9223.49	9250.76	9275.23	9304.16	9328.68	9353.23	9368.63	9381.84	9381.53	9380.89	9425.23	9433.55	9438.77	9442.44
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	0.47	0.59	0.60	0.62	0.64	0.55	0.60	0.49	0.50	0.77	0.74	13.64	1.09	0.50	0.53	0.35	0.43
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	9106.37	9152.91	9164.08	9224.11	9251.40	9275.78	9304.76	9329.17	9353.73	9369.40	9382.58	9395.17	9381.98	9425.73	9434.08	9439.12	9442.87
Final area	kha	9152.91	9164.08	9224.11	9251.40	9275.78	9304.76	9329.18	9353.73	9369.40	9382.58	9395.17	9381.98	9425.73	9434.08	9439.12	9442.87	9450.11
Forest land (unmanaged)																		
Remaining Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 6.A.2. Annual land use changes for the 2006-2021 (cont.)

LULUCF category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cropland																		
Remaining Cropland	kha	14331.99	14329.35	14278.75	14281.42	14261.48	14216.30	14182.92	14138.13	14103.69	14011.29	13998.72	13979.03	13941.50	13917.88	13884.34	13847.97	13816.06
Converted to Forest land (managed)	kha	36.20	9.06	46.68	21.49	19.27	22.74	19.26	19.29	12.45	10.74	10.27	0.34	34.53	6.81	4.29	3.16	5.91
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	4.18	NO	10.20	12.25	11.46	7.92	6.80	6.85	NO	NO	30.17	NO	25.40	26.23	30.41	18.49
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	2.78	6.40	3.92	3.44	2.06	10.99	6.20	18.71	15.14	81.66	2.31	13.72	3.00	3.06	3.23	3.48	10.00
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	14370.97	14348.99	14329.35	14316.56	14295.06	14261.48	14216.30	14182.92	14138.13	14103.69	14011.29	14023.26	13979.03	13953.14	13918.09	13885.01	13850.46
Final area	kha	14348.99	14329.35	14316.56	14295.06	14261.48	14216.30	14182.92	14138.13	14103.69	14011.29	14023.26	13979.03	13953.15	13918.09	13885.01	13850.46	13816.06
Grassland (managed)																		
Remaining Grassland (managed)	kha	4262.09	4234.58	4210.11	4182.43	4171.28	4167.52	4165.11	4162.78	4155.28	4153.20	4150.13	4159.35	4165.41	4148.37	4155.26	4156.52	4175.91
Converted to Forest land (managed)	kha	10.81	2.71	13.94	6.42	5.76	6.79	5.75	5.76	3.72	3.21	3.07	0.10	10.31	2.03	1.28	0.94	1.77
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	2.71	NO	0.24	13.64	NO	NO	NO	NO	NO	NO	NO	NO	11.65	0.21	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	1.75	1.47	5.39	3.78	1.22	4.66	2.16	1.03	3.13	NO	NO	1.62	2.38	0.18	0.10	1.93	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	2.17	6.69	10.06	3.85	14.38	7.34	5.95	3.46	1.13	5.72	NO	11.90	13.28	17.26	19.54	22.09	9.25
Converted to Other land	kha	NO	16.64	NO	NO	NO	NO	NO	NO	6.32	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	4279.53	4262.09	4239.75	4210.11	4192.63	4186.32	4178.98	4173.03	4169.58	4162.12	4153.20	4172.97	4203.04	4168.05	4176.19	4181.49	4186.93
Final area	kha	4262.09	4239.75	4210.11	4192.63	4186.32	4178.98	4173.03	4169.58	4162.12	4153.20	4172.97	4203.04	4168.05	4176.19	4181.49	4186.93	4205.42

Table 6.A.2. Annual land use changes for the 2006-2021 (cont.)

LULUCF category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Grassland (unmanaged)																		
Remaining Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wetlands (managed)																		
Remaining Wetlands (managed)	kha	1360.55	1359.85	1359.72	1363.15	1362.92	1363.03	1366.64	1367.75	1367.74	1366.39	1366.39	1369.75	1371.36	1373.75	1373.92	1374.02	1364.94
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	0.99	NO	NO	2.80	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	11.02
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	1.27	1.47	1.60	1.96	1.22	1.10	1.06	1.05	1.05	4.48	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	1361.82	1362.31	1361.32	1365.11	1366.93	1364.14	1367.70	1368.80	1368.78	1370.86	1366.39	1369.75	1371.36	1373.75	1373.92	1374.02	1375.96
Final area	kha	1362.31	1361.32	1365.11	1366.93	1364.14	1367.70	1368.80	1368.78	1370.86	1366.39	1369.75	1371.36	1373.75	1373.92	1374.02	1375.96	1364.94

Table 6.A.2. Annual land use changes for the 2006-2021 (cont.)

LULUCF category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Wetlands (unmanaged)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Remaining Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	kha																	
Settlements		2003.02	2009.71	2024.86	2041.03	2060.04	2080.44	2104.30	2120.23	2145.62	2157.31	2199.20	2209.03	2248.29	2265.66	2286.47	2307.28	2335.70
Remaining Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	24.55	NO	NO	NO	NO	2.49	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	22.84	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	3.36	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	6.13	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Total unmanaged land	kha	2003.02	2009.71	2024.86	2041.03	2060.04	2080.44	2104.30	2120.23	2145.62	2163.44	2249.94	2209.03	2248.29	2265.66	2286.47	2309.77	2335.70
Initial area	kha	2009.71	2024.86	2041.03	2060.04	2080.44	2104.30	2120.23	2145.62	2163.44	2249.94	2209.03	2248.29	2265.66	2286.47	2309.77	2335.70	2355.39
Final area	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 6.A.2. Annual land use changes for the 2006-2021 (cont.)

LULUCF category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Other land																		
Remaining Other land	kha	136.05	136.05	115.13	105.98	103.88	100.01	97.88	96.20	96.20	102.52	101.86	88.34	85.71	83.29	82.62	80.12	80.12
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	14.29	NO	37.56	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.68	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	13.52	2.63	2.42	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	9.14	2.11	3.87	2.13	1.68	NO	NO	6.78	NO	NO	NO	NO	2.49	NO
Converted to Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area	kha	150.34	136.05	152.69	115.13	105.98	103.88	100.01	97.88	96.20	102.52	108.65	101.86	88.34	85.71	83.29	82.62	80.12
Final area	kha	136.05	152.69	115.13	105.98	103.88	100.01	97.88	96.20	102.52	108.65	101.86	88.34	85.71	83.29	82.62	80.12	80.12
Total unmanaged land																		
Remaining Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Cropland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (managed)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Settlements	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Initial area (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 6.A.2. Annual land use changes for the 2006-2021 (cont.)

LULUCF category	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Net change																		
Forest land (managed)	kha	46.54	11.18	60.03	27.29	24.38	28.98	24.41	24.56	15.67	13.18	12.59	-13.19	43.75	8.35	5.04	3.75	7.24
Forest land (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cropland	kha	-21.98	-19.64	-12.80	-21.50	-33.57	-45.18	-33.38	-44.79	-34.44	-92.40	11.97	-44.23	-25.89	-35.06	-33.08	-34.55	-34.39
Grassland (managed)	kha	-17.45	-22.34	-29.63	-17.49	-6.31	-7.34	-5.95	-3.46	-7.45	-8.93	19.77	30.07	-34.99	8.14	5.31	5.43	18.49
Grassland (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wetlands (managed)	kha	0.49	-0.99	3.79	1.83	-2.80	3.56	1.10	-0.01	2.08	-4.48	3.36	1.62	2.38	0.18	0.10	1.93	-11.02
Wetlands (unmanaged)	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Settlements	kha	6.69	15.15	16.17	19.01	20.40	23.86	15.94	25.39	17.82	86.50	-40.92	39.26	17.38	20.81	23.30	25.93	19.69
Other land	kha	-14.29	16.64	-37.56	-9.14	-2.11	-3.87	-2.13	-1.68	6.32	6.13	-6.78	-13.52	-2.63	-2.42	-0.68	-2.49	0.00
Total unmanaged land	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total																		
Initial area	kha	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04
Final area	kha	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04	31272.04
Net change	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ANNEX 7. QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance/Quality Control and Verification programme for the Polish annual greenhouse gas inventory has been elaborated and updated if needed. It has been elaborated in line with the 2006 *IPCC Guidelines for National GHG Inventories*. The QA/QC programme aiming at improving and assuring the high quality of GHG inventories contains tasks, responsibilities as well as time schedule for performance of the QA/QC procedures. Detailed domestic QA/QC plan is a part of QA/QC programme.

Quality Control (QC) activities are carried out by the personnel directly responsible for the inventory and are aimed at keeping its high standards and quality.

Within the national inventory the main activities underlying Quality Control process are conducted using *Tier 1* method and relate to all source/sink categories. Tier 2 procedures are carried out for main key categories with special attention to the energy sector.

Following the Chapter 6 of the 2006 *IPCC Guidelines for National GHG Inventories*, Quality control (QC) covers routine technical activities carried out with the aim of quality control of national emissions and removals inventories allowing for:

- Maintaining the correctness and completeness of data,
- Elimination of errors and determination of potential deficiencies.

Quality Control activities contain: checks for accuracy of data and estimations acquiring as well as application of approved procedures for calculation of emissions, uncertainty, archiving of information and reporting.

Activities aiming at **quality assurance (QA)** cover procedural system for control carried out by experts not involved directly in elaborating GHG inventory in a given sector. QA activities are conducted over a completed inventory and allow to ensure that national inventory represents top level of emissions and removals assessment at the present knowledge and available data and effectively support quality control (QC).

Verification activities – where possible – include comparisons with external emission analyses estimates and databases conducted by independent bodies or teams. They allow to improve inventory methods and outcomes in both short and long terms.

The Polish inventory is directly based on sectoral activity data and carried out in two main steps. First, calculations are produced around 12 months after the end of the inventoried year (n-1) depending primarily on the availability of required activity data. Initial check of activity data and estimation procedures is then done. When the official statistics are available the revision of data is made and final inventory is produced up to 15 months after given year. Additionally the recalculations of the previous inventories for selected categories are performed because of methodological changes and improvements. The timetable for inventory preparation and QA/QC activities conducted at respective stages of the inventory preparation are presented in Table 1.

The basic elements of QA/QC plan are implemented and co-ordinated by the National Centre for Emission and Management (KOBIZE), the unit responsible for Polish GHG inventory preparation. It follows the 2006 *IPCC Guidelines for National GHG Inventories* recommendations. The main procedures for QA/QC activities are described in the *National Quality Assurance / Quality Control and Verification Programme of the Polish Greenhouse Gas Inventory* and the detail check procedures are contained below as the examples of QC procedures performed by KOBIZE experts.

General timeframes of annual inventory preparation (including checking procedures), approval and submission are presented in the table 1. The dates for particular stages are established based on country specific availability of statistical data as well as national (legal) and international obligations.

Table 1. Timetable for inventory preparation and check (n – submission year)

Timing	Activity
June -15 December (year n–1)	→ Data and emission factors collection (estimation) → Check for consistency and correctness of the emission data, trends and factors, using all the relevant methods of both QC and verification outlined in the Programme (points 6-8 and 10) → Initial calculations and checks of GHG emissions considering ERT recommendations → Submission to the Ministry of Climate for acceptance
15 January (year n–2)	→ Submission of PL GHG inventory for the year n-2 and elements of NIR to the EIONET CDR (required by regulation (EU) No 525/2013 Article 7.1)
15 December – 15 February (year n–2)	→ Emission results and methodology verification based on remarks and comments made by ministerial emission experts (QA methods applied) → Elaboration of final inventory, additional checks and final corrections to the inventory, preparation of NIR and CRF tables (QC and verification methods applied) → Additional CRF and NIR quality upgrading on the basis of EEA control questions and remarks - corrections of any possible mistakes or deficiencies if found (QA methods applied) → Submission to the Ministry of the Climate for acceptance
15 March (year n–2)	→ Emission results and methodology verification based on remarks and comments made by external sectoral experts within inter-ministerial and inter-institutional check of the report (QA methods applied) → Submission of complete National Inventory Report and CRF tables to the EIONET CDR (required by regulation (EU) No 525/2013 Article 7.3)
15 April (year n–2)	→ Submission of GHG inventory for the year n-2 to the UNFCCC Secretariat (CRF and NIR) (required by decision 24/CP.19)

Each IPCC sector undergoes detail QC procedure which is carried out by expert responsible for given category/subcategory. Check for correctness of data, emission factors and calculation results are performed several times during the following stages of inventory elaboration: during its preparation, after completing the calculations, after CRF tables generation and after NIR report completing. Additionally part of the data, especially for Energy sector, are checked by other KOBiZE experts than those making inventory who are responsible for other sectors. As a part of QA activity the inventory team cooperates with specialists from different institutes, associations and individual experts who are involved in verification of data and assumptions to the inventory.

Procedures for quality assurance of the national inventories cover both actions performed by domestic agencies as well as by foreign (EU, UNFCCC). The National Inventory Report is delivered to the Ministry of Climate, where it is consulted in two stages: internally, among suitable departments, and externally - in inter-ministerial dialogue. In this second stage branch institutes supervised by ministers are engaged to review the inventory.

After including obtained comments and amendments into the NIR, according to recommendations delivered during the inter-ministerial compliance, the Ministry of Climate initiates the procedure for governmental acceptance of the NIR by the Committee for the European Affairs after which both NIR and underlying CRF tables are conveyed to the UNFCCC. The same report and data are sent earlier to the European Commission pursuant to the timeline determined in the regulation (EU) No 525/2013.

The inventory results and methodology applied for emission estimation are also subject to wide discussions during domestic conferences and seminars. Additionally National Inventory Reports are available, in Polish, at the website of KOBIZE. Broader participation of academic circles in reviewing the overall inventory is planned under the QA procedures. For the time being such reviews were conducted occasionally.

The national inventory results are also verified by the European Union. Since 2012 this verification, being the element of inventory quality control, is performed in a wide range using the *EEA Emission Review Tool (EMRT)* available through the website. This verification is made in February and March after submission of emission results following Article 7.1 of the regulation (EU) No 525/2013. In the given time detail explanations are prepared what is accompanied by additional check of data and calculations. If the problem is acknowledged as solved, such information is set in the communication table. Potential corrections of data resulting from EU verification are introduced into emission inventory.

Two-stage procedures controlling the results of the national inventory submitted in the form of CRF files performed by the UNFCCC Secretariat also constitute important element for quality assurance of the Polish emission inventory. When analysis of questions sent is prepared under the stage 2 of the UNFCCC check, the inventory experts perform additional check of data and results and prepare the response for comments. This is the first step for international review performed by Expert Review Team. The international review of the Polish GHG inventory made on an annual basis under UNFCCC constitutes one of the key elements in the process of further improvement the quality of reported data.

There are also internal deliberations on the usefulness of an idea to engage systemically external reviewers from R&D Institutes, Branch Associations, Industrial Chambers, individual plants as well as independent experts in verification of the inventory assumptions and results. Such a scrutiny should help find cost-utility balance of this kind of an extensive review process.

Depending on methodology used for emission estimation within categories Tier 1 or Tier 2 check procedures are carried out. The extended QC procedure for checking the correctness of emissions estimations is used for these categories where country specific emission factors are established. This concerns the key categories especially for such sectors like: fuel combustion (1.A), transport (1.A.3), cement production (2.A.1), enteric fermentation (3.A), manure management (3.B), and others. For GHG emission sources for which Tier 1 method is used for emission calculation also Tier 1 method is applied for inventory checks.

Data Management Manual has been elaborated in KOBiZE for the purpose of efficient governance with all important information containing databases, software, worksheets, final reports as well as QA/QC documentation regarding to inventory process. For the purposes of documentation of data and calculations QC the files are archived in electronic and hardcopy forms.

ANNEX 8. UNCERTAINTY ASSESSMENT OF THE 2021 INVENTORY

Uncertainty analysis for the year 2021 was performed with use of Approach 1 provided in *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Chosen methodology is based on the assumptions that every value is independent (there is no correlation between values) and probability of underestimation and overestimation is the same. Conclusions from the previous centralized reviews and in-country review in 2013 were taken into account.

Latest major changes applied to uncertainties follow the changes in estimation methodology and new revised classification in CRF reporting tables. Uncertainty calculation model was extended to provide separate result for assessments including and excluding LULUCF sector. Another improvement triggered by ERT recommendation was calculation of overall uncertainty of inventory including information about uncertainties involved in estimation of Global Warming Potentials.

Additionally, since submission 2015 was provided uncertainty analysis of emission trend with use of 1988 emission inventory as a base year.

Since submission 2023 indirect emission from solvents use is excluded from IPPU sector and reported separately as indirect emission. Uncertainty analysis for base year and latest reported year takes into account indirect emission when estimating total uncertainty of the inventory.

Uncertainty analysis for industrial gases for HFC, PFC and SF₆ was significantly improved in submission 2018, in response to recommendations of the previous UNFCCC reviews. Previously uncertainty assumptions were applied directly to emission values of each pollutant due to lack of available information. Present calculation model was revised and extended to include uncertainties applied to activity data and emission factors. Uncertainty assessment is now performed taking into account information given on for different subcategories and single f-gases. Uncertainty is also assessed separately for manufacture, operating and decommissioning of f-gases containing equipment. Some of the assumptions for uncertainty of activity data were revised in submission 2018 and 2019.

Since submission 2023 overall results expressed in CO₂ equivalent are estimated using GWP potential given in IPCC 5th Assessment Report. To ensure consistency with the approach taken in the NIR uncertainty assessment model for f-gases covers complete set of categories resulting in emission of gases (2.C *Metal production*, 2.F *Product uses as substitutes for ODS* and 2.G. *Other product manufacture and use*). No NF₃ emission sources were identified in Poland thus, it was excluded from the analysis.

General approach

First stage of the estimates was to assign uncertainty to each activity data and emission factor. Next step was to estimate error propagation and its influence on national total emissions. To estimate error propagation from activity and emission factor to emission values, formula (1) was used.

$$U_{\text{emission}} = \text{square root } (U_{\text{act}}^2 + U_{\text{EF}}^2) \quad (1)$$

where: U_{emission} – uncertainty of emission value

U_{act} – uncertainty of activity value

U_{ef} – uncertainty of emission factor value

To estimate error propagation from sectoral emissions to national total, formula (2) was used

$$U_{\text{emission}} = \text{square root } (\sum (\text{Emission} * U_{\text{emission}})^2) / \sum \text{Emission} \quad (2)$$

where: U_{emission} – uncertainty of emission value in sector

Emission – emission from sector

As the base bottom level of analysis the following sectors were chosen:

- sector 1. *Energy*: categories on levels 1.A.1, 1.A.2, 1.A.3, 1.A.4, 1.A.5 with disaggregation by fuel type (liquid, solid, gaseous, biomass etc.)
- sector 2. *IPPU*: subcategories 2.A.1, 2.A.2 ... 2.C.3
- sector 3. *Agriculture*: subcategories 3.A.1, 3.A.2 ... 3.F.5 with further disaggregation
- sector 4. *LULUCF*: main subcategories 4.A, 4.B ... 4.E
- sector 5. *Waste*: 5.A.1, 5.A.2; 5.B with further disaggregation

Most of the estimates were based on default assumption described in methodology, but after investigation of socio-economic parameters literature data was applied to selected activities in sector 1. *Energy* and for activities and emission factors in sector 2. *Industrial processes and product use*. Selected uncertainties for activities and factors in 5.C *Waste/Waste Incineration* were estimated with help expert's opinion in Emission Balancing and Reporting Unit (former National Emission Centre).

Results of analysis of error propagation of uncertainty of national totals for 2021 were shown below:

	CO ₂	CH ₄	N ₂ O	HFC	PFC	SF ₆	All GHG recalculated to CO ₂ eq.
Total uncertainty Including IPCC 4. <i>LULUCF</i>	3.1%	20.8%	42.7%	13.4%	20.6%	6.2%	4.3%
Emission recalculated to CO ₂ eq [kt] Including IPCC 4. <i>LULUCF</i>	309 731.76	42 712.42	22 358.76	4 937.26	10.08	9.26	379 759.55
Total uncertainty Excluding IPCC 4. <i>LULUCF</i>	1.8%	20.8%	45.7%	13.4%	20.6%	6.2%	3.6%
Emission recalculated to CO ₂ eq [kt] Excluding IPCC 4. <i>LULUCF</i>	331 576.28	42 704.71	20 616.67	4 937.26	10.08	9.26	399 854.27

Activity data

Most uncertain values of activity were assigned in category 3.F *Agriculture/Field Burning of Agricultural Residues* and in 5.B *Waste/Domestic and Commercial Wastewater* (30%). Lowest uncertainty values were assigned to 1.A.1 *Energy/Fuel Combustion*, especially in subsector 1.A.1 *Energy Industries* (2%). In general Polish energy sector is responsible for 90% of GHG emission and is covered with detailed national statistics, which allows to keep overall uncertainty of inventory at low level.

CO₂ emission factors

Most uncertain values for CO₂ emission factors were assigned in sector 5.C *Waste incineration* (30%), 4.G *LULUCF/Other* (30%), 2.A.4 *Mineral industry/Other* (15%) and 2.C *Metal Industry* (10%), the most precise values were reported in 1.A *Fuel Combustion* (1-2%).

Low level of uncertainty of national total of CO₂ (1.8%) comes from the fact, that major part of emission comes from sector 1.A *Fuel Combustion* where input data for activities and factors is the most precise (relatively 1-5% and 1-3%, excluding biomass).

CH₄ emission factors

Most uncertain values for CH₄ emission factors were assigned in sector 5.A *Solid Waste Disposal* (100%), 5.B *Biological treatment of solid waste* (100%) and 5.C *Waste incineration* (100%), 1.B *Fugitive Emission from fuels* (50%), 3.A *Enteric Fermentation* and 3.B *Manure Management* (50%). The most precise values were identified in 1.A *Energy/Fuel Combustion* (10-24%), 2. *Industrial Processes and Product Use* (20%) and 3.F *Field Burning of Agricultural Residues* (20%). In 2009 new sources were included to analysis in 2.C *Metal Production (sinter, electric furnaces, pig iron and basic oxygen furnaces)* as a result of incorporating to national emission inventories data from reporting for EU Emission Trading Scheme. Uncertainty of CH₄ emission is app. 20.9% which is result of share of agriculture and waste sectors in national totals – emission factors in those sectors have high relatively uncertainty.

N₂O emission factors

Most uncertain values for N₂O emission factors were assigned in sector 3.D *Agricultural Soils* (150%), 3.F *Agriculture/Field Burning of Agricultural Residues* (150%) and in 3.B *Manure management* (100%), most precise values were applied in sector 1.A *Energy/Fuel combustion* for liquid fuels (20%). Data available from polish part of EU Emission Trading Scheme reporting were taken into account during this analysis with relatively low uncertainty.

Highest value of uncertainty of national total was identified for N₂O (45.7%) and is a result of high uncertainty of the emission factors in most contributing sector of *Agriculture*.

Industrial Gases

As mentioned in introduction to this annex, uncertainty assessment model for f-gases was redesigned and extended to cover subcategories, f-gases types, and circumstances of occurring of the emission (production, operation and decommissioning of equipment). Results of the analysis are presented by category and by gas in tables below. More details on assumptions applied are given in the detailed table on next pages. Some of the assumptions regarding uncertainty of the activity data were revised to better reflect national circumstances – in result uncertainty of the f-gases slightly increased. According to new model results lowest uncertainty was identified for manufacturing activities and the highest one for decommissioning, what is in line with observation of the national market.

Uncertainty of f-gases by categories	From manufacturing	From stocks	From disposal	Total	Contributing f-gases
TOTAL	2.68%	13.40%	15.80%	13.31%	HFC, PFC, SF₆
C. Metal production	-	-	-	-	SF ₆
F. Product uses as substitutes for ODS	2.79%	13.42%	15.80%	13.33%	HFC, PFC
G. Other product manufacture and use	5.39%	7.07%	-	6.15%	SF ₆

Uncertainty of f-gases by gases	From manufacturing	From stocks	From disposal	Total	Contributing categories
TOTAL	2.68%	13.40%	15.80%	13.31%	2.C, 2.F, 2.G
HFCs	2.80%	13.46%	15.80%	13.37%	2.F
PFCs	2.83%	20.62%	18.03%	20.62%	2.C, 2.F
SF ₆	5.39%	7.07%	11.18%	6.15%	2.C, 2.G

Uncertainty introduced into the trend in total national emissions

In response to previous review recommendations uncertainty analysis is now providing information on uncertainty introduced into the trend in total national emissions. First step of the analysis was assessing of level uncertainty introduced to national total in base year (1988). Methodology used to assess trend uncertainties is the same as mentioned for analysis for latest reported year. Results of level uncertainty analysis for base year with and without IPCC 4. *LULUCF* are presented below.

Base year	CO ₂	CH ₄	N ₂ O	HFC	PFC	SF ₆	All GHG recalculated to CO ₂ eq.
Total uncertainty Including IPCC 4. <i>LULUCF</i>	2.6%	25.4%	39.3%	-	5.4%	-	4.6%
Emission recalculated to CO ₂ eq [kt] Including IPCC 4. <i>LULUCF</i>	452 685.79	76 371.79	31 508.33	-	132.31	-	560 698.22
Total uncertainty Excluding IPCC 4. <i>LULUCF</i>	2.0%	25.4%	41.2%	-	5.4%	-	4.3%
Emission recalculated to CO ₂ eq [kt] Excluding IPCC 4. <i>LULUCF</i>	472 037.75	76 316.70	29 801.12	-	132.31	-	578 287.88

On the basis of results of analysis made for the base year and latest reported year analysis for trend was done and results are presented below:

	CO ₂	CH ₄	N ₂ O
Trend uncertainty with IPCC 4. <i>LULUCF</i>	1.25%	1.22%	2.30%
Trend uncertainty without IPCC 4. <i>LULUCF</i>	1.19%	1.22%	2.27%

Uncertainty related to IPCC Sector 4. *LULUCF*

Methodology used for this assessment were based on the “IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories”, but also takes into account additional information given in the chapter 2.4.3 of the “IPCC 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol” and in the chapter 5.2 of the “IPCC Good Practice Guidance for LULUCF”

One of the main assumption of the applied approach was to be consistent with with sector IPCC 3. *Agriculture*.

Assumptions for the main LULUCF category 4.A *Forest Land* were based on the study made among EU countries (Laitat et al., 2000) where reported uncertainty vary between 1-15%. Regarding CO₂ emission factor GPG for LULUCF gives uncertainty varying between 10-50% (Chapter 3.2.1.1.1.4, page 3.50; Chapter 3.2.2.1.1.4, page 3.56). After analysis Poland decided to apply 5% uncertainty for activity data and 30% for CO₂ emission factor. Regarding non-CO₂ emissions GPG for LULUCF suggests to apply 70% uncertainty for emission factors (Chapter 3.2.1.4.2.4, page 3.50).

In category 4.B *Cropland* Poland applied default uncertainty for CO₂ emission factor given in GPG for LULUCF, which is 75% (Chapter 3.3.1.1.1.4, page 3.73).

For category 4.C *Grassland* uncertainty for CO₂ emission factor (75%) was applied on the basis of the default data given in table 3.4.2 of the IPCC GPG for LULUCF (Chapter 3.4.1.1.1.2, page 3.109).

Regarding category 4.D *Wetland* – 75% uncertainty of CO₂ emission factor was based on information on default uncertainty for that category given in IPCC GPG for LULUCF (Chapter 3.5.2.1.1.4, page 3.139) 4.E *Settlements* – second contributing category in the LULUCF sector, where following the instruction given in chapter 3.6.2 of IPCC GPG for LULUCF – the same approach as taken in category 4.A *Forest Land* was introduced. Thus applied assumption are 5% for activity data and 30% for emission factors.

Regarding Harvested Wood Product reported in category 4.G *Other* – assumptions for the CO₂ emission factor uncertainty (50%) were made on the basis of information given in table 3.A.1.4 in the chapter 3.A.1.3 (page 3.268) of the IPCC GPG for LULUCF.

Use of uncertainty analysis results to improve inventory process

Results of uncertainty analysis are evaluated with regard to finding potential for further improvements in the inventory process. To identify areas for potential improvement uncertainty analysis is investigated together with key category analysis – this approach allows to prioritize the needs their importance. As a result of this process Poland identified category 2.F.1 *Refrigeration and air conditioning equipment*, which has potential for future improvement and according to key category analysis has relatively high share in total emission. Depending on the availability of budget selected category will be subject to further investigation.

Planned improvements for next years

- improving accuracy of estimates for industrial gases

GHG inventory 2021 – Uncertainty analysis, part 1, sector IPCC 1. *Energy*

2021	Activity [TJ]	Activity uncertainty [%]	EF CO2 Uncertainty [%]	EF CH4 Uncertainty [%]	EF N2O Uncertainty [%]	CO2 [kt]	CH4 [kt]	N2O [kt]	CO2 Emission uncertainty [%]	CH4 Emission uncertainty [%]	N2O Emission uncertainty [%]	CO2 Emission absolute uncertainty [kt]	CH4 Emission absolute uncertainty [kt]	N2O Emission absolute uncertainty [kt]
TOTAL (without LULUCF, including indirect emission)						331 576.28	1 525.17	77.80	1.8%	20.8%	45.7%	6 062.26	317.99	35.53
TOTAL (with LULUCF, including indirect emission)						309 731.76	1 525.44	84.37	3.1%	20.8%	42.7%	9 596.12	317.99	36.03
1. Energy						310 508.39	823.51	9.83	1.9%	31.7%	11.6%	6013.25	261.08	1.14
A. Fuel Combustion						306 225.28	152.59	9.82	2.0%	13.9%	11.6%	5999.27	21.14	1.14
1. Energy Industries						159 531.72	1.12	2.49	2.6%	9.3%	29.9%	4086.49	0.10	0.74
Liquid Fuels	56 744	2.0%	1.0%	10.0%	20.0%	4 013.86	0.13	0.02	2.2%	10.2%	20.1%	89.75	0.01	0.00
Solid Fuels	1 463 743	2.0%	2.0%	13.5%	35.0%	144 191.74	0.33	2.09	2.8%	13.6%	35.1%	4078.36	0.04	0.73
Gaseous Fuels	186 979	2.0%	1.0%	17.0%	40.0%	10 372.25	0.19	0.02	2.2%	17.1%	40.0%	231.93	0.03	0.01
Other fossil fuels	9 457	5.0%	5.0%	25.0%	75.0%	953.88	0.28	0.04	7.1%	25.5%	75.2%	67.45	0.07	0.03
Peat	NO					NO	NO	NO						
Biomass	89 238	10.0%	5.0%	24.0%	37.0%	9 384.82	0.19	0.32	11.2%	26.0%	38.3%	1049.25	0.05	0.12
2. Manufacturing Industries and Construction						29 829.41	4.31	0.59	2.3%	12.3%	25.6%	698.83	0.53	0.15
Liquid Fuels	37 941	3.0%	1.0%	10.0%	20.0%	2 484.54	0.07	0.01	3.2%	10.4%	20.2%	78.57	0.01	0.00
Solid Fuels	130 392	3.0%	2.0%	13.5%	35.0%	13 406.16	1.14	0.17	3.6%	13.8%	35.1%	483.37	0.16	0.06
Gaseous Fuels	177 518	4.0%	1.0%	17.0%	40.0%	9 847.40	0.18	0.02	4.1%	17.5%	40.2%	406.02	0.03	0.01
Other fossil fuels	31 029	5.0%	5.0%	25.0%	75.0%	4 091.31	0.93	0.12	7.1%	25.5%	75.2%	289.30	0.24	0.09
Peat	NO					NO	NO	NO						
Biomass	67 285	10.0%	5.0%	20.0%	37.0%	7 474.05	2.00	0.27	11.2%	22.4%	38.3%	835.62	0.45	0.10
3. Transport						67 559.43	3.69	2.60	5.8%	9.7%	19.1%	3884.98	0.36	0.49
Liquid Fuels	913 235.68	3.0%	5.0%	10.0%	20.0%	66 620.48	3.37	2.43	5.8%	10.4%	20.2%	3884.61	0.35	0.49
Solid Fuels	NO	3.0%	5.0%	13.5%	35.0%				5.8%	13.8%	35.1%			
Gaseous Fuels	12 966.38	4.0%	5.0%	17.0%	40.0%	803.57	0.07	0.00	6.4%	17.5%	40.2%	51.45	0.01	0.00
Other fossil fuels	1 774.86	10.0%	5.0%	25.0%	75.0%	135.39	0.00	0.00	11.2%	26.9%	75.7%			
Biomass	54 339.07	10.0%	5.0%	24.0%	37.0%	3 989.98	0.25	0.16	11.2%	26.0%	38.3%	446.09	0.06	0.06
4. Other Sectors						49 304.71	143.47	4.15	3.9%	14.7%	16.6%	1926.24	21.13	0.69
Liquid Fuels	147 468.87	4.0%	5.0%	10.0%	20.0%	10 644.16	0.77	2.77	6.4%	10.8%	20.4%	681.56	0.08	0.57
Solid Fuels	256 061.61	4.0%	5.0%	13.5%	35.0%	24 153.11	69.05	0.38	6.4%	14.1%	35.2%	1546.55	9.72	0.14
Gaseous Fuels	260 652.71	4.0%	5.0%	17.0%	40.0%	14 432.47	1.30	0.03	6.4%	17.5%	40.2%	924.13	0.23	0.01
Other fossil fuels	730.83	4.0%	5.0%	25.0%	75.0%	74.98	0.22	0.00	6.4%	25.3%	75.1%	4.80	0.06	0.00
Peat	NO					NO	NO	NO						
Biomass	243 298.51	10.0%	5.0%	24.0%	37.0%	27 078.92	72.14	0.96	11.2%	26.0%	38.3%	3027.52	18.76	0.37
5. Other						0.00	0.00	0.00	0.0%	0.0%	0.0%	0.00	0.00	0.00
Liquid Fuels	NO	5.0%	3.0%	10.0%	20.0%				5.8%	11.2%	20.6%	0.00	0.00	0.00
Solid Fuels	NO	5.0%	5.0%	13.5%	35.0%				7.1%	14.4%	35.4%	0.00	0.00	0.00
Gaseous Fuels	NO	5.0%	5.0%	17.0%	40.0%				7.1%	17.7%	40.3%	0.00	0.00	0.00
Biomass	NO	20.0%	5.0%	24.0%	37.0%				20.6%	31.2%	42.1%	0.00	0.00	0.00
B. Fugitive Emissions from Fuels						4283.11	670.92	0.00	9.6%	38.8%	74.94%	409.82	260.22	0.00
1. Solid Fuels						2449.08	565.76		15.0%	45.8%		367.16	259.36	0.00
1. B. 1. a. Coal Mining and Handling												0.00	0.00	0.00
i. Underground Mines [Activity in Mt, EF in kg/t]	55.01	2.0%		50.0%			516.28			50.0%		0.00	258.35	0.00
ii. Surface Mines [Activity in Mt, EF in kg/t]	52.36	2.0%		50.0%			45.60			50.0%		0.00	22.82	0.00
1. B. 1. b. Solid Fuel Transformation [Activity in Mt, EF in kg/t]	NA					2447.70	0.00		15.0%	25.0%		367.16	0.00	
1. B. 1. c. Other [CO2 Emission from Coking Gas Subsystem]	630.01	2.0%	10.0%	50.0%		1.38	3.88		10.2%	50.0%		0.14	1.94	
2. Oil and Natural Gas						1834.03	105.16	0.00	9.9%	20.1%	74.94%	182.07	21.15	0.00
1. B. 2. a. Oil												0.00	0.00	
1. Exploration [Activity in Gg, EFs in kg/PJ]	888.08	2.0%	6.6%	50.0%		9.388	0.20		6.9%	50.0%		0.65	0.10	
2. Production [Activity in PJ, EFs in kg/PJ]	41.33	2.0%	6.6%	50.0%		0.192	2.66		6.9%	50.0%		0.01	1.33	
3. Transport [Activity in kt]	24 507.63	2.0%	6.6%	50.0%		0.014	0.15		6.9%	50.0%		0.00	0.08	
4. Refining/storage [kt]	24 755.16	2.0%	6.6%	50.0%		NA	1.178817		6.9%	50.0%			0.59	
1. B. 2. b. Natural Gas												0.00	0.00	
1. Exploration [Activity in PJ, EF in kg/PJ]	NA	2.0%	6.6%			NA	NA							
2. Production [Activity in PJ, EF in kg/PJ]	4 312.90	2.0%	6.6%	50.0%		0.352	9.87		6.9%	50.0%		0.02	4.94	
3. Processing [Activity in PJ, EF in kg/PJ]	4 312.90	2.0%	6.6%	50.0%		1.380	4.44		6.9%	50.0%		0.10	2.22	
4. Transmission and storage [Activity in PJ, EF in kg/PJ]	23 541.94	2.0%	6.6%	50.0%		0.023	11.89		6.9%	50.0%		0.00	5.95	
5. Distribution [Activity in PJ, EF in kg/PJ]	23 541.94	2.0%	6.6%	50.0%		1.201	25.90		6.9%	50.0%		0.08	12.96	
6. Other leakage [Activity in PJ, EF in kg/PJ]	NO	2.0%	6.6%	50.0%					6.9%	50.0%		0.00	0.00	
1. B. 2. c. Venting - Oil	888.08	5.0%	6.6%	50.0%		0.150	1.35		8.3%	50.2%		0.01	0.68	
1. B. 2. c. Venting and flaring - oil [kt]	888.08	5.0%	6.6%	50.0%	100.0%	0.026	42.29	0.00	8.3%	50.2%	100.1%			0.00
1. B. 2. c. Venting and flaring - natural gas [10*6 m3]	4 312.90	5.0%	6.6%	50.0%	100.0%	84.754	5.23	0.00	8.3%	50.2%	100.1%			0.00
1. B. 2. d. Other (Process emission from refineries and flaring)			NA			1 736.55			10.0%					

GHG inventory 2021 – Uncertainty analysis, part 2, sector IPCC 2. *Industrial processes and product use*

2. Industrial processes and product use						18 882.09	2.03	2.18	3.8%	26.5%	44.8%	722.29	0.54	0.98
A. Mineral Industry						11 914.85			5.8%			685.28	0.00	0.00
1. Cement Production [Activity in kt, EF in t/t]	13 996.13	5.0%	5.0%			7 365.52			7.1%			520.82	0.00	0.00
2. Lime Production [Activity in kt, EF in t/t]	1 972.00	5.0%	10.0%			1 457.52			11.2%			162.96	0.00	0.00
3. Glass production [activity in kt, EFs in t/t]	3 918.68	8.0%	10.0%			626.99			12.8%					
4.a Ceramics [Activity in kt, EF in t/t]	2 670.09	5.0%	10.0%			122.04			11.2%					
4.b Other uses of soda ash [Activity in kt, EF in t/t]	383.69	10.0%	15.0%			159.20			18.0%			28.70	0.00	0.00
4.d Other [Activity in kt, EF in t/t]	4 962.69	10.0%	15.0%			2 183.58			18.0%			393.65	0.00	0.00
B. Chemical Industry						4 553.47	1.61	1.73	4.4%	33.1%	55.5%	200.87	0.53	0.96
1. Ammonia Production [Activity in kt, EF in t/t]	2 597.56	2.0%	5.0%			3 665.42			5.4%			197.39	0.00	0.00
2. Nitric Acid Production [Activity in kt, EF in t/t]	2 459.97	2.0%	5.0%	60.0%				1.60			60.0%	0.00	0.00	0.96
3. Adipic Acid Production [Activity in kt, EF in t/t]	NO	2.0%						NO						
4. Caprolactam production [Activity in kt, EF in t/t]	169.99	2.0%	10.0%	60.0%				0.14			60.0%		0.00	0.08
5. Calcium carbide production [Activity in kt, EF in t/t]	NO					NO								
6. Titanium oxide production [Activity in kt, EF in t/t]	34.65	2.0%	10.0%			NO								
7. Soda ash production [Activity in kt, EF in t/t]	1 289.54	2.0%	10.0%			IE								
8.a Methanol [Activity in kt, EF in t/t]	NO	2.0%	5.0%	50.0%						50.0%				
8.b Ethylene [Activity in kt, EF in t/t]	348.59	2.0%	5.0%	50.0%		663.37	1.05		5.4%	50.0%				
8.c Ethylene Dichloride and Vinyl Chloride Monomer [Activity in kt, EF in t/t]	218.84	2.0%	5.0%	30.0%		64.40	0.00		5.4%	30.1%				
8.d Ethylene oxide [Activity in kt, EF in t/t]	24.91	2.0%	5.0%	25.0%		21.49	0.04		5.4%	25.1%				
8.e Acrylonitrile [Activity in kt, EF in t/t]	NO													
8.f Carbon black production [Activity in kt, EF in t/t]	52.97	5.0%	5.0%	20.0%		138.78	0.00		7.1%	20.6%		9.81	0.00	0.00
8.g Other / Styrene [Activity in kt, EF in t/t]	127.70	2.0%		20.0%			0.51			20.1%		0.00	0.10	0.00
C. Metal Industry						2 072.75	0.42		4.9%	17.4%		100.63	0.07	0.00
1. Iron and Steel Production												0.00	0.00	0.00
1.b Pig iron [Activity in kt, EF in t/t]	3 586.90	5.0%	10.0%			505.20			11.2%			56.48	0.00	0.00
1.d Sinter [Activity in kt, EF in t/t]	5 021.00	5.0%	10.0%	20.0%		280.34	0.35		11.2%	20.6%	NA	NA		0.00
1.f Open-heart Steel [Activity in kt, EF in t/t]	NO													
1.f. Basic Oxygen Furnace Steel [Activity in kt, EF in t/t]	4 083.34	5.0%	10.0%			553.92			11.2%			61.93	0.00	0.00
1.f. Electric Furnace Steel [Activity in kt, EF in t/t]	4 469.17	5.0%	10.0%			226.78			11.2%			25.35	0.00	0.00
2. Ferroalloys Production [Activity in kt, EF in t/t]	73.37	5.0%	10.0%	20.0%		293.48	0.07		11.2%	20.6%		32.81	0.02	0.00
3. Aluminium Production [Activity in kt, EF in t/t]	NO											0.00	0.00	0.00
4. Magnesium production [Activity in kt, EF in t/t]	NO	5.0%	10.0%			NA							0.00	0.00
6. Lead production [Activity in kt, EF w t/t]	74.16	5.0%	10.0%			38.56			11.2%			4.31		
7. Zinc production [Activity in kt, EF w t/t]	101.44	5.0%	10.0%			174.47			11.2%			19.51		
D. Non-energy Products from Fuels and Solvent Use						341.023			11.8%			40.29	0.00	0.00
1. Lubricant use	240.85					148.36			20.0%					
2. Paraffin Wax Use	160.76					99.03			20.0%					
3.a Solvents use (reported as indirect)	IE								20.0%					
3.b Urea used as catalyst	352.92					93.63			20.0%					
G. Other Product Manufacture and Use							0.45				40.3%	0.00	0.00	0.18
3. N2O from product uses [Activity in N2O used, EF in t/t]	0.45	20.0%		35.0%			0.45				40.3%			

GHG inventory 2021 – Uncertainty analysis, part 3, sector IPCC 3. Agriculture

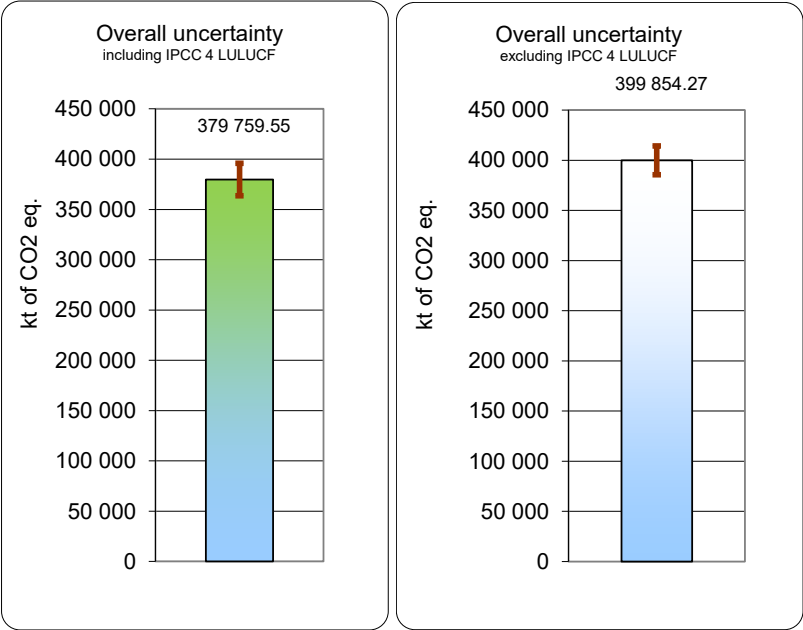
3. Agriculture						1 412.12	571.58	62.71		16.1%	28.9%	56.2%		165.21	35.27
A. Enteric Fermentation							520.95				31.3%			163.25	0.00
1. Cattle														0.00	0.00
Dairy Cattle [Activity in 1000 heads, EF in kg/head]	2 388.5	5.0%	50.0%				296.90				50.2%			149.19	0.00
Non-dairy young cattle (younger than 1 year) [Activity in 1000 heads, EF in kg/head]	1 788.8	5.0%	50.0%				72.83				50.2%			36.60	0.00
Non-dairy young cattle 1-2 years [Activity in 1000 heads, EF in kg/head]	1 856.0	5.0%	50.0%				107.57				50.2%				
Non-dairy heifers (older than 2 years) [Activity in 1000 heads, EF in kg/head]	254.7	5.0%	50.0%				11.76				50.2%				
Bulls (older than 2 years)	113.0	5.0%	50.0%				9.95				50.2%				
2. Sheep [Activity in 1000 heads, EF in kg/head]	289.1	5.0%	50.0%				2.31				50.2%			1.16	0.00
3. Swine [Activity in 1000 heads, EF in kg/head]	11 033.3	5.0%	50.0%				16.55				50.2%			8.32	0.00
4.a Goats [Activity in 1000 heads, EF in kg/head]	54.1	5.0%	50.0%				0.27				50.2%			0.14	0.00
4.b Horses [Activity in 1000 heads, EF in kg/head]	156.5	5.0%	50.0%				2.82				50.2%			1.42	0.00
B. Manure Management							49.50	9.73			51.3%	33.9%		25.38	3.30
1. Cattle														0.00	0.00
Dairy Cattle [Activity in 1000 heads, EF in kg/head]	2 388	5.0%	50.0%	100.0%			19.26	1.99			50.2%	100.1%		9.68	1.99
Non-Dairy Cattle [Activity in 1000 heads, EF in kg/head]	4 012	5.0%	50.0%	100.0%			6.91	1.41			50.2%	100.1%		3.47	1.42
2. Sheep [Activity in 1000 heads, EF in kg/head]	289	5.0%	50.0%	100.0%			0.05	0.01			50.2%	100.1%		0.03	0.01
3. Swine [Activity in 1000 heads, EF in kg/head]	11 033	5.0%	50.0%	100.0%			14.65	0.95			50.2%	100.1%		7.36	0.95
4.a Fur bearing animals [Activity in 1000 heads, EF in kg/head]	4 380	5.0%	50.0%	100.0%			2.98	0.09			50.2%	100.1%		1.50	0.09
4.b Rabbits [Activity in 1000 heads, EF in kg/head]	730	5.0%	50.0%	100.0%			0.06	0.02			50.2%	100.1%		0.03	0.02
4.c Goats [Activity in 1000 heads, EF in kg/head]	54	5.0%	50.0%	100.0%			0.01	0.00			50.2%	100.1%		0.00	0.00
4.d Horses [Activity in 1000 heads, EF in kg/head]	157	5.0%	50.0%	100.0%			0.24	0.05			50.2%	100.1%		0.12	0.05
4.e Poultry [Activity in 1000 heads, EF in kg/head]	190 264	5.0%	50.0%	100.0%			5.34	0.22			50.2%	100.1%		2.68	0.22
5.a Indirect emission [emission in kt]	NA							4.99				40.0%			2.00
D. Agricultural Soils								52.94				66.3%			35.12
a. Direct Soil Emissions															0.00
1. Inorganic N fertilizers [Activity in kg N, EF in kg N ₂ O-N/kg N]	1 038 000 000	5.0%	150.0%				16.31					150.1%			24.48
2. Organic N fertilizers [Activity in kg N, EF in kg N ₂ O-N/kg N]	433 246 732	5.0%	150.0%				6.81					150.1%			10.22
3. Urine and dung deposited by grazing animals [Activity in kg N, EF in kg N ₂ O-N/kg N]	56 840 770	5.0%	150.0%				1.74					150.1%			2.60
4. Crop residues [Activity in kg N, EF in kg N ₂ O-N/kg N]	401 459 339	5.0%	150.0%				6.31					150.1%			9.47
5. Mineralization/immobilization associated with loss/gain of soil org	10 279 328	5.0%	150.0%				0.16					150.1%			0.24
6. Cultivation of organic soils (i.e. histosols) [Activity in kg N, EF in kg N ₂ O-N/kg N]	921 333	5.0%	150.0%				11.58					150.1%			17.38
b. Indirect N₂O Emissions from managed soils															
1. Atmospheric deposition [Activity in kg N, EF in kg N ₂ O-N/kg N]	201 817 501	20.0%	150.0%				3.17					151.3%			4.80
2. Nitrogen leaching and run-off [Activity in kg N/yr, EF in kg N ₂ O-N/kg N]	581 947 851	20.0%	150.0%				6.86					151.3%			10.38
F. Field Burning of Agricultural Residues							1.13	0.04			22.0%	118.2%		0.25	0.05
1. Cereals														0.00	0.00
Wheat [Activity in t of crop production, EF in kg/t dm]	41.398	30.0%	20.0%	150.0%			0.13	0.00			36.1%	153.0%		0.05	0.00
Barley [Activity in t of crop production, EF in kg/t dm]	9.343	30.0%	20.0%	150.0%			0.03	0.00			36.1%	153.0%		0.01	0.00
Maize [Activity in t of crop production, EF in kg/t dm]	9.078	30.0%	20.0%	150.0%			0.03	0.00			36.1%	153.0%		0.01	0.00
Oats [Activity in t of crop production, EF in kg/t dm]	5.639	30.0%	20.0%	150.0%			0.02	0.00			36.1%	153.0%		0.01	0.00
Rye [Activity in t of crop production, EF in kg/t dm]	13.652	30.0%	20.0%	150.0%			0.04	0.00			36.1%	153.0%		0.02	0.00
Triticale [Activity in t of crop production, EF in kg/t dm]	23.204	30.0%	20.0%	150.0%			0.08	0.00			36.1%	153.0%			
Cereals mixed [Activity in t of crop production, EF in kg/t dm]	6.218	30.0%	20.0%	150.0%			0.02	0.00			36.1%	153.0%		0.01	0.00
Millet and buckwheat [Activity in t of crop production, EF in kg/t dm]	0.469	30.0%	20.0%	150.0%			0.00	0.00			36.1%	153.0%			
2 Pulses	0.673	30.0%	20.0%	150.0%			0.00	0.00			36.1%	153.0%		0.00	0.00
3 Tuber and Root														0.00	0.00
Potatoes [Activity in t of crop production, EF in kg/t dm]	15	30.0%	20.0%	150.0%			0.04	0.00			36.1%	153.0%		0.02	0.01
5 Other														0.00	0.00
All straw and hay [Activity in t of crop production, EF in kg/t dm]	1	30.0%	20.0%	150.0%			0.00	0.00			36.1%	153.0%		0.00	0.00
Rape and other oil-bearing [Activity in t of crop production, EF in kg/t dm]	95	30.0%	20.0%	150.0%			0.28	0.01			36.1%	153.0%		0.10	0.01
Fruits [Activity in t of crop production, EF in kg/t dm]	148	30.0%	20.0%	150.0%			0.45	0.02			36.1%	153.0%		0.16	0.04
Vegetables [Activity in t of crop production, EF in kg/t dm]	2.36	30.0%	20.0%	150.0%			0.01	0.00			36.1%	153.0%		0.00	0.00
G. Liming							871.08			21.5%					
Limestone CaCO ₃ [Activity in t, EF in t CO ₂ -C/t]	977 716.52	30.0%	5.0%				430.20			30.4%					
Dolomite CaMg(CO ₃) ₂ [Activity in t, EF in t CO ₂ -C/t]	924 930.08	30.0%	5.0%				440.88			30.4%					
H. Urea application	544 285.71	30.0%	5.0%				399.14			30.4%					
I. Other carbon-containing fertilizers	322 500.00	30.0%	5.0%				141.90			30.4%					

GHG inventory 2021 – Uncertainty analysis, part 4, sector IPCC 4. *Land use, land-use change and forestry*, IPCC sector 5. *Waste and indirect emission*

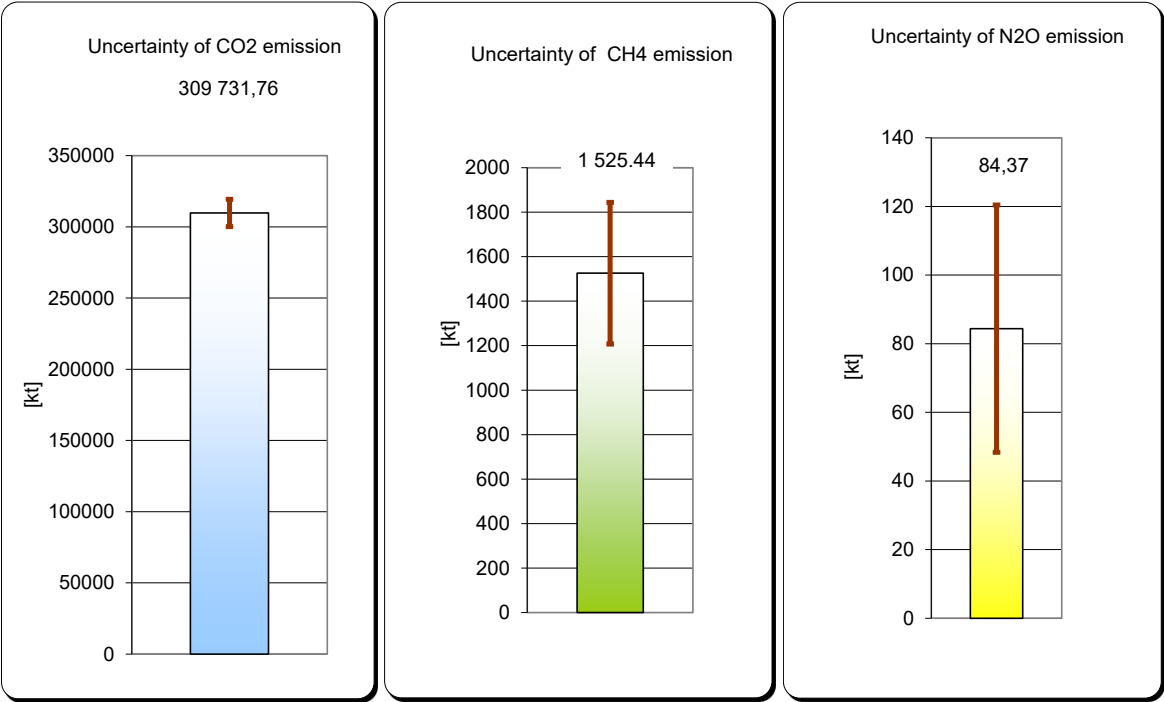
4. Land-Use, land-use change and forestry						-21 844.52	0.28	6.57	34.1%	59.4%	91.1%	-7438.72	0.16	5.989
A. Forest Land [Activity in kha, EF in kt/kha]	9 450.11	5.0%	30.0%	70.0%	70.0%	-22 240.28	0.23	0.56	30.4%	70.2%	70.2%	-6764.12	0.16	0.395
B. Cropland [Activity in kha, EF in kt/kha]	13 816.06	5.0%	75.0%		100.0%	1 699.99		0.04	75.2%		100.1%	1277.83	0.00	0.040
C. Grassland [Activity in kha, EF in kt/kha]	4 205.42	5.0%	75.0%	70.0%	100.0%	-282.60	0.05	0.00	75.2%	70.2%	100.1%	0.00	0.03	0.003
D. Wetlands [Activity in kha, EF in kt/kha]	1 364.94	5.0%	75.0%		100.0%	1 585.91		0.00	75.2%		100.1%	1192.07	0.00	0.000
E. Settlements [Activity in kha, EF in kt/kha]	2 355.39	5.0%	30.0%		100.0%	2 269.49		5.9683	30.4%		100.1%	690.24	0.00	5.976
F. Other Land [Activity in kha, EF in kt/kha]	80.12	10.0%	75.0%						75.7%				0.00	0.000
G. Other [Activity in kt C, EF in kt/kha]	NA	5.0%	50.0%			-4 877.03			50.2%			-2450.68		
5. Waste						274.56	128.04	3.08	33.5%	58.8%	129.2%	92.09	75.25	3.97
A. Solid Waste Disposal							46.55			82.6%		0.00	38.44	0.00
1. Managed waste disposal sites [Activity in kt, EF in t/t MSW]	28 796.54	23.0%		100.0%			36.43			102.6%		0.00	37.38	0.00
2. Unmanaged waste disposal sites [Activity in kt, EF in t/t MSW]	NO	23.0%		100.0%			1.51			102.6%		0.00	1.55	0.00
3. Uncategorized waste disposal sites [Activity in kt, EF in t/t MSW]	NO	23.0%		100.0%			8.61			102.6%		0.00	8.84	0.00
B. Biological treatment of solid waste							7.55	0.45		104.4%	153.0%	0.00	7.88	0.69
1. Composting [Activity in kt DC(1), EF in kg/kg DC]	1 131.95	30.0%		100.0%	150.0%		7.55	0.45		104.4%	153.0%	0.00	7.88	0.69
2. Anaerobic digestion in biogas installations [Activity in kt DC(1), EF in kg/kg DC]	IE, NA	30.0%										0.00	0.00	0.00
C. Waste Incineration						274.56		0.02	33.5%		150.7%			
1. Waste incineration [Activity in kt, EF in kg/t waste]	211.17	15.0%	30.0%	100.0%	150.0%	274.56		0.02	33.5%		150.7%	92.09		0.03
2. Open burning of waste [Activity in kt, EF in kg/t waste]	NA													
D. Wastewater treatment and discharge							73.95	2.60		86.8%	150.3%	0.00	64.22	3.91
1. Domestic wastewater [Activity in kt DC(1), EF in kg/kg DC]	1 035.43	10.0%		100.0%	150.0%		62.94	2.60		100.5%	150.3%	0.00	63.25	3.91
2. Industrial wastewater [Activity in kt DC(1), EF in kg/kg DC]	393.63	10.0%		100.0%			11.01			100.5%		0.00	11.06	0.00
Indirect CO2	NA			20.0%		499.12			20.0%			99.82		

F- gases inventory 2021 – Uncertainty analysis for HFC, PFC and SF₆.

		Activity data			Uncertainty of activity data			Emission factors			Uncertainty of emission factors			Emission in t			Emission in t of CO2 equivalent				Uncertainty of emission			
		Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning	Uncertainty of amount filled into new manufactured products	Uncertainty of amount in operating systems	Uncertainty of amount remaining in products at decommissioning	Product manufacturing factor	Product life factor	Disposal loss factor	Uncertainty of product manufacturing factor	Uncertainty of life factor	Uncertainty of disposal loss factor	From manufacturing	From stocks	From disposal	From manufacturing	From stocks	From disposal	Total	From manufacturing	From stocks	From disposal	Total
Total	CO2 equivalent [kt] →																29 223.56	4 923 090.15	4 292.19	4 956 605.90	2.68%	13.40%	15.80%	13.31%
C. Metal production																	0.00	0.00	0.00	0.00				0.00%
3. Production of aluminium														0.00			0.00			0.00	0.00%			0.00%
CF4 [t]	CF4	NO			2%			NO			5%			0.00			0.00			0.00	5.39%			5.39%
C2F6 [t]	C2F6	NO			2%			NO			5%			0.00			0.00			0.00	5.39%			5.39%
4. Magnesium production(6)														0.00			0.00			0.00	0.00%			0.00%
SF6 [t]	SF6	NO			5%			NO			5%			0.00			0.00			0.00	7.07%			7.07%
F. Product uses as substitutes for ODS																	27 962.11	4 915 091.98	4 292.19	4 947 346.28	2.79%	13.42%	15.80%	13.33%
1. Refrigeration and airconditioning [kt of CO2 eq.]																								
Commercial refrigeration [kt of CO2 eq.]																								
HFC-32 [t]	HFC-32	25.05	91.43	NO	2%	30%	15%	0.50	8.95	NO	2%	15%	25%	0.13	8.18	0.00	84.81	5 538.26	0.00	5 623.07	2.83%	33.54%	29.15%	33.04%
HFC-125 [t]	HFC-125	32.08	2543.16	1.38	2%	30%	15%	0.50	9.98	3.48	2%	15%	25%	0.16	253.90	0.05	508.46	804 856.26	152.49	805 517.20	2.83%	33.54%	29.15%	33.51%
HFC-134a [t]	HFC-134a	42.38	2539.96	1.38	2%	30%	15%	0.50	9.96	3.48	2%	15%	25%	0.21	253.01	0.05	275.46	328 914.18	62.53	329 252.17	2.83%	33.54%	29.15%	33.51%
HFC-143a [t]	HFC-143a	9.18	3293.85	1.63	2%	30%	15%	0.50	9.92	3.48	2%	15%	25%	0.05	326.77	0.06	220.36	1 568 508.94	272.07	1 569 001.37	2.83%	33.54%	29.15%	33.53%
Domestic refrigeration [kt of CO2 eq.]																								
HFC-134a [t]	HFC-134a	NO	NO	NO	2%	15%	30%				2%	15%	25%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.83%	21.21%	39.05%	
Industrial refrigeration [kt of CO2 eq.]																								
HFC-125 [t]	HFC-125	IE	IE	IE	2%	30%	15%	IE	IE	IE	2%	15%	25%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.83%	33.54%	29.15%	
HFC-134a [t]	HFC-134a	IE	IE	IE	2%	30%	15%	IE	IE	IE	2%	15%	25%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.83%	33.54%	29.15%	
HFC-143a [t]	HFC-143a	IE	IE	IE	2%	30%	15%	IE	IE	IE	2%	15%	25%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.83%	33.54%	29.15%	
Transport refrigeration [kt of CO2 eq.]																								
HFC-32 [t]	HFC-32	85.64	150.30	0.07	5%	20%	30%	0.60	12.00	15.00	5%	15%	30%	0.51	18.04	0.01	347.88	12 210.70	6.67	12 565.25	7.07%	25.00%	42.43%	24.30%
HFC-125 [t]	HFC-125	349.71	1420.31	1.45	5%	20%	30%	0.60	12.00	15.00	5%	15%	30%	2.10	170.44	0.22	6 651.51	540 285.54	687.71	547 624.76	7.07%	25.00%	42.43%	24.67%
HFC-134a [t]	HFC-134a	78.51	253.18	0.20	5%	20%	30%	0.60	12.00	15.00	5%	15%	30%	0.47	30.38	0.03	612.35	39 495.46	38.45	40 146.26	7.07%	25.00%	42.43%	24.60%
HFC-143a [t]	HFC-143a	92.78	1261.55	1.71	5%	20%	30%	0.60	12.00	15.00	5%	15%	30%	0.56	151.39	0.26	2 672.08	728 650.50	1 230.65	730 553.22	7.07%	25.00%	42.43%	24.87%
Mobile air-conditioning [kt of CO2 eq.]																								
HFC-134a [t]	HFC-134a	85.01	4237.04	2.44	2%	20%	30%	0.50	8.21	15.00	5%	15%	30%	0.43	347.81	0.37	552.59	452 158.25	475.15	453 185.99	5.39%	25.00%	42.43%	24.94%
Stationary air-conditioning [kt of CO2 eq.]																								
HFC-32 [t]	HFC-32	2.60	2322.43	3.65	2%	50%	15%	0.50	4.85	9.03	2%	15%	15%	0.01	112.56	0.33	8.78	76 202.49	222.94	76 434.22	2.83%	52.20%	21.21%	52.04%
HFC-125 [t]	HFC-125	0.50	1039.93	3.68	2%	50%	15%	0.50	4.73	9.04	2%	15%	15%	0.00	49.19	0.33	7.89	155 931.19	1 053.95	156 993.03	2.83%	52.20%	21.21%	51.85%
HFC-134a [t]	HFC-134a	0.58	723.84	0.77	2%	50%	15%	0.50	4.70	8.97	2%	15%	15%	0.00	33.99	0.07	3.77	44 184.74	89.58	44 278.09	2.83%	52.20%	21.21%	52.09%
HFC-143a [t]	HFC-143a	NO	NO	NO	2%	50%	15%	NO	NO	NO	2%	15%	15%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.83%	52.20%	21.21%	
2. Foam blowing agents [kt of CO2 eq.]																								
Closed cells																								
HFC-134a [t]	HFC-134a	0.79	617.89	NO	5%	10%	15%	50.00	2.50	NO	2%	10%	30%	0.40	15.45	0.00	516.49	20 081.41	0.00	20 597.90	5.39%	14.14%	33.54%	13.79%
HFC-152a [t]	HFC-152a	97.78	1525.69	NO	5%	10%	15%	50.00	2.50	NO	2%	10%	30%	48.89	38.14	0.00	6 746.96	5 263.63	0.00	12 010.59	5.39%	14.14%	33.54%	6.90%
HFC-227ea [t]	HFC-227ea	25.67	224.25	NO	5%	10%	15%	10.00	4.50	NO	2%	10%	30%	2.57	10.09	0.00	8 600.27	33 806.05	0.00	42 406.32	5.39%	14.14%	33.54%	11.33%
Open cells																								
HFC-134a [t]	HFC-134a	NO	NO		4%	10%		NO	NO		5%	10%		0.00	0.00		0.00	0.00		0.00	6.40%	14.14%		
3. Fire protection [kt of CO2 eq.]																								
HFC-227ea [t]	HFC-227ea	4.55	296.22	NO	2%	20%	10%	1.00	5.00	NO	2%	5%	15%	0.05	14.81	0.00	152.44	49 616.73	0.00	49 769.17	2.83%	20.62%	18.03%	20.55%
HFC-236fa [t]	HFC-236fa	NO	101.55	NO	2%	20%	10%	NO	5.00	NO	2%	5%	15%	0.00	5.08	0.00	0.00	40 923.16	0.00	40 923.16	2.83%	20.62%	18.03%	20.62%
C4F10 [t]	C4F10	NO	21.92	NO	2%	20%	10%	NO	5.00	NO	2%	5%	15%	0.00	1.10	0.00	0.00	10 081.76	0.00	10 081.76	2.83%	20.62%	18.03%	20.62%
4. Aerosols [kt of CO2 eq.]																								
Metered dose inhalers																								
HFC-134a [t]	HFC-134a	NO	NO		2%	30%		NO	NO		2%	5%		0.00	0.00		0.00	0.00		0.00	2.83%	30.41%		
HFC-152a [t]	HFC-134a	NO	0.60		2%	30%		NO	100.00		2%	5%		0.00	0.60		0.00	82.69		82.69	2.83%	30.41%		
Other (please specify - one row per substance)																								
Technical aerosols																								
HFC-134a [t]	HFC-134a	NO	NO		5%	30%		NO	NO		2%	5%		0.00	0.00		0.00	0.00		0.00	5.39%	30.41%		
5. Solvents [kt of CO2 eq.]																								
HFC-43-10mee [t]	HFC-43-10mee	NO	0.18	NO	2%	5%	10%	NO	100.00	NO	5%	10%	30%	0.00	0.18	0.00	0.00	300.05	0.00	300.05	5.39%	11.18%	31.62%	11.18%
HFC-365mfc [t]	HFC-365mfc	NO	NO	NO	0.02	5%	10%	NO	NO	NO	5%	10%	30%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.39%	11.18%	31.62%	
G. Other product manufacture and use																	1 261.46	7 998.16		9 259.62	5.39%	7.07%		6.15%
1. Electrical equipment [kt of CO2 eq.]																								
SF6 [t]	SF6	8.95	170.17	NO	0.05	5%	10%	6.00	2.00	NO	2%	5%	5%	0.54	3.40	0.00	1 261.46	7 998.16	0.00	9 259.62	5.39%	7.07%	11.18%	6.15%



Overall emission results for 2021 including and excluding IPCC 4. *LULUCF* with uncertainties bars



Emission results for 2021 including IPCC 4. *LULUCF* with uncertainties bars

ANNEX 9. COMPARISON OF DATA ON FUEL CONSUMPTION FROM THE EUROSTAT DATABASE WITH THE IEA DATABASE

Table 1. Analysis of consistency between data from Eurostat and IEA databases for *Other bituminous coal* consumption [kt]

	1990	1991	1992	1993	1994	1995
Production - IEA	118 700	114 236	105 616	103 639	106 610	107 476
Production - EUROSTAT	118 700	114 236	105 616	103 639	106 610	107 476
Production - difference	0	0	0	0	0	0
Imports - IEA	0	0	0	0	428	64
Imports - EUROSTAT	0	0	0	0	428	64
Imports - difference	0	0	0	0	0	0
Exports - IEA	16 839	12 697	11 761	10 139	17 001	19 572
Exports - EUROSTAT	16 839	12 697	11 761	10 139	17 001	19 572
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	0	0	0	2875	-2278	1474
Stock changes - EUROSTAT	0	0	0	2 875	-2 278	1 474
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	552	-1625	-2110	15	-3254	-2495
Statistical differences - EUROSTAT	552	-1 625	-2 110	15	-3 254	-2 495
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	78 013	74 921	69 788	63 293	60 780	55 911
Transformation input - EUROSTAT	78 013	74 921	69 788	63 293	60 780	55 911
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	460	354	273	1 065	2 540	2 718
Energy sector - EUROSTAT	460	354	273	1 065	2 540	2 718
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	23 079	28 238	26 211	32 434	28 499	34 284
Final consumption - EUROSTAT	23 079	28 238	26 211	32 434	28 499	34 284
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	6 740	6 869	6 074	10 861	10 266	16 114
Final consumption - Industry - EUROSTAT	6 740	6 869	6 074	10 861	10 266	16 114
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	147	77	17	14	7	7
Final consumption - Transport - EUROSTAT	147	77	17	14	7	7
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	16 178	21 270	20 101	21 534	18 208	18 144
Final consumption - Other sectors - EUROSTAT	16 178	21 270	20 101	21 534	18 208	18 144
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	12 133	15 952	15 076	16 526	13 929	13 917
Final consumption - Residential - EUROSTAT	12 133	15 952	15 076	16 526	13 929	13 917
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	2 427	2 766	2 325	2 234	1 558	1 560
Final consumption - Commercial and public services - EUROSTAT	2 427	2 766	2 325	2 234	1 558	1 560
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	1 618	2 552	2 700	2 774	2 721	2 667
Final consumption - Agriculture/forestry - EUROSTAT	1 618	2 552	2 700	2 774	2 721	2 667
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 1. (cont.) Analysis of consistency between data from Eurostat and IEA databases for *Other bituminous coal* consumption [kt]

	2000	2005	2010	2015	2016	2017
Production - IEA	84 997	83 039	64 514	59 191	57 181	52 999
Production - EUROSTAT	84 997	83 039	64 514	59 191	57 181	52 999
Production - difference	0	0	0	0	0	0
Imports - IEA	189	2762	10448	5597	5791	8813
Imports - EUROSTAT	189	2 762	10 448	5 597	5 791	8 813
Imports - difference	0	0	0	0	0	0
Exports - IEA	17 955	16 218	8 150	6 888	6 638	4 283
Exports - EUROSTAT	17 955	16 218	8 150	6 888	6 638	4 283
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	1696	-1096	5084	54	4546	2462
Stock changes - EUROSTAT	1 696	-1 096	5 084	54	4 546	2 462
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	-2358	-158	1375	-875	-32	-1325
Statistical differences - EUROSTAT	-2 358	-158	1 375	-875	-32	-1 325
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	51 627	50 945	50 470	42 385	43 748	44 339
Transformation input - EUROSTAT	51 627	50 945	50 470	42 385	43 748	44 339
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	1 459	517	101	80	76	64
Energy sector - EUROSTAT	1 459	517	101	80	76	64
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	19 311	17 977	20 506	16 874	17 486	17 409
Final consumption - EUROSTAT	19 311	17 977	20 506	16 874	17 486	17 409
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	9 697	5 683	5 479	4 559	4 434	4 584
Final consumption - Industry - EUROSTAT	9 697	5 683	5 479	4 559	4 434	4 584
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	0	0	0	0
Final consumption - Transport - EUROSTAT	0	0	0	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	9 602	12 208	14 943	12 151	12 898	12 709
Final consumption - Other sectors - EUROSTAT	9 602	12 208	14 943	12 151	12 898	12 709
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	7 500	9 811	11 900	9 750	10 350	10 200
Final consumption - Residential - EUROSTAT	7 500	9 811	11 900	9 750	10 350	10 200
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	602	997	1 283	1 001	1 048	1 029
Final consumption - Commercial and public services - EUROSTAT	602	997	1 283	1 001	1 048	1 029
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	1 500	1 400	1 760	1 400	1 500	1 480
Final consumption - Agriculture/forestry - EUROSTAT	1 500	1 400	1 760	1 400	1 500	1 480
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 2. Analysis of consistency between data from Eurostat and IEA databases for *Coking coal* consumption [kt]

	1990	1991	1992	1993	1994	1995
Production - IEA	28 793	25 791	25 697	26 408	26 517	28 714
Production - EUROSTAT	28 793	25 791	25 697	26 408	26 517	28 714
Production - difference	0	0	0	0	0	0
Imports - IEA	560	54	126	129	616	1433
Imports - EUROSTAT	560	54	126	129	616	1 433
Imports - difference	0	0	0	0	0	0
Exports - IEA	11 226	9 767	10 781	12 829	10 694	12 296
Exports - EUROSTAT	11 226	9 767	10 781	12 829	10 694	12 296
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	0	0	0	69	-77	-446
Stock changes - EUROSTAT	0	0	0	69	-77	-446
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	-247	756	109	-6	1038	2017
Statistical differences - EUROSTAT	-247	756	109	-6	1 038	2 017
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	18 374	15 322	14 933	13 783	15 324	15 388
Transformation input - EUROSTAT	18 374	15 322	14 933	13 783	15 324	15 388
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	0	0	0	0	0	0
Energy sector - EUROSTAT	0	0	0	0	0	0
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	0	0	0	0	0	0
Final consumption - EUROSTAT	0	0	0	0	0	0
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	0	0	0	0	0	0
Final consumption - Industry - EUROSTAT	0	0	0	0	0	0
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	0	0	0	0
Final consumption - Transport - EUROSTAT	0	0	0	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	0	0	0	0	0	0
Final consumption - Other sectors - EUROSTAT	0	0	0	0	0	0
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	0	0	0	0	0	0
Final consumption - Residential - EUROSTAT	0	0	0	0	0	0
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	0	0	0	0	0	0
Final consumption - Commercial and public services - EUROSTAT	0	0	0	0	0	0
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	0	0	0	0	0	0
Final consumption - Agriculture/forestry - EUROSTAT	0	0	0	0	0	0
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 2. (cont.) Analysis of consistency between data from Eurostat and IEA databases for *Coking coal* consumption [kt]

	2000	2005	2010	2015	2016	2017
Production - IEA	17 222	14 071	11 658	12 985	13 204	12 481
Production - EUROSTAT	17 222	14 071	11 658	12 985	13 204	12 481
Production - difference	0	0	0	0	0	0
Imports - IEA	1263	610	3155	2692	2210	3630
Imports - EUROSTAT	1 263	610	3 155	2 692	2 210	3 630
Imports - difference	0	0	0	0	0	0
Exports - IEA	5 290	3 151	1 815	2 303	2 438	2 753
Exports - EUROSTAT	5 290	3 151	1 815	2 303	2 438	2 753
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	137	-373	-662	83	202	-303
Stock changes - EUROSTAT	137	-373	-662	83	202	-303
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	839	-302	-783	54	-85	-7
Statistical differences - EUROSTAT	839	-302	-783	54	-85	-7
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	12 435	11 373	13 107	13 337	13 176	12 980
Transformation input - EUROSTAT	12 435	11 373	13 107	13 337	13 176	12 980
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	40	86	1	64	84	78
Energy sector - EUROSTAT	40	86	1	64	84	78
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	18	0	11	2	3	3
Final consumption - EUROSTAT	18	0	11	2	3	3
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	16	0	10	2	3	3
Final consumption - Industry - EUROSTAT	16	0	10	2	3	3
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	0	0	0	0
Final consumption - Transport - EUROSTAT	0	0	0	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	2	0	1	0	0	0
Final consumption - Other sectors - EUROSTAT	2	0	1	0	0	0
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	0	0	0	0	0	0
Final consumption - Residential - EUROSTAT	0	0	0	0	0	0
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	1	0	1	0	0	0
Final consumption - Commercial and public services - EUROSTAT	1	0	1	0	0	0
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	1	0	0	0	0	0
Final consumption - Agriculture/forestry - EUROSTAT	1	0	0	0	0	0
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 3. Consistency analysis between Eurostat and IEA data for *Lignite* consumption [kt]

	1990	1991	1992	1993	1994	1995
Production - IEA	67 584	69 406	66 852	68 105	66 770	63 547
Production - EUROSTAT	67 584	69 406	66 852	68 105	66 770	63 547
Production - difference	0	0	0	0	0	0
Imports - IEA	0	0	18	1	1	13
Imports - EUROSTAT	0	0	18	1	1	13
Imports - difference	0	0	0	0	0	0
Exports - IEA	193	1275	1063	909	719	368
Exports - EUROSTAT	193	1 275	1 063	909	719	368
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	0	-183	-415	24	-18	4
Stock changes - EUROSTAT	0	-183	-415	24	-18	4
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	0	0	-85	0	-205	-158
Statistical differences - EUROSTAT	0	0	-85	0	-205	-158
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	67 172	67 721	65 326	66 614	65 405	62 468
Transformation input - EUROSTAT	67 172	67 721	65 326	66 614	65 405	62 468
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	8	14	8	34	31	33
Energy sector - EUROSTAT	8	14	8	34	31	33
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	211	213	143	573	803	853
Final consumption - EUROSTAT	211	213	143	573	803	853
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	44	84	35	130	63	145
Final consumption - Industry - EUROSTAT	44	84	35	130	63	145
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	2	2	2	0	0	0
Final consumption - Transport - EUROSTAT	2	2	2	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	164	125	105	442	740	707
Final consumption - Other sectors - EUROSTAT	164	125	105	442	740	707
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	63	5	0	345	531	504
Final consumption - Residential - EUROSTAT	63	5	0	345	531	504
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	0	0	0	2	11	3
Final consumption - Commercial and public services - EUROSTAT	0	0	0	2	11	3
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	101	120	105	95	198	200
Final consumption - Agriculture/forestry - EUROSTAT	101	120	105	95	198	200
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 3. (cont.) Analysis of consistency between data from Eurostat and IEA databases for *Lignite* consumption [kt]

	2000	2005	2010	2015	2016	2017
Production - IEA	59 484	61 636	56 510	63 128	60 246	61 161
Production - EUROSTAT	59 484	61 636	56 510	63 128	60 246	61 161
Production - difference	0	0	0	0	0	0
Imports - IEA	0	0	24	281	289	328
Imports - EUROSTAT	0	0	24	281	289	328
Imports - difference	0	0	0	0	0	0
Exports - IEA	9	8	115	198	212	256
Exports - EUROSTAT	9	8	115	198	212	256
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	13	-39	174	-164	67	-49
Stock changes - EUROSTAT	13	-39	174	-164	67	-49
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	0	1	-160	2	0	86
Statistical differences - EUROSTAT	0	1	-160	2	0	86
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	59 149	61 075	55 733	62 411	59 846	60 526
Transformation input - EUROSTAT	59 149	61 075	55 733	62 411	59 846	60 526
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	44	19	129	10	7	8
Energy sector - EUROSTAT	44	19	129	10	7	8
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	295	494	891	624	537	563
Final consumption - EUROSTAT	295	494	891	624	537	563
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	48	11	28	64	82	123
Final consumption - Industry - EUROSTAT	48	11	28	64	82	123
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	0	0	0	0
Final consumption - Transport - EUROSTAT	0	0	0	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	247	483	861	560	455	440
Final consumption - Other sectors - EUROSTAT	247	483	861	560	455	440
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	137	231	484	380	320	310
Final consumption - Residential - EUROSTAT	137	231	484	380	320	310
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	0	0	177	40	30	30
Final consumption - Commercial and public services - EUROSTAT	0	0	177	40	30	30
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	110	252	200	140	105	100
Final consumption - Agriculture/forestry - EUROSTAT	110	252	200	140	105	100
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 4. Analysis of consistency between data from Eurostat and IEA databases for *Coke oven coke* consumption [kt]

	1990	1991	1992	1993	1994	1995
Production - IEA	13 516	11 356	11 066	10 275	11 455	11 578
Production - EUROSTAT	13 516	11 356	11 066	10 275	11 455	11 578
Production - difference	0	0	0	0	0	0
Imports - IEA	0	0	1	3	27	34
Imports - EUROSTAT	0	0	1	3	27	34
Imports - difference	0	0	0	0	0	0
Exports - IEA	3 662	3 467	2 566	1 892	3 105	3 331
Exports - EUROSTAT	3 662	3 467	2 566	1 892	3 105	3 331
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	0	-9	158	143	-60	13
Stock changes - EUROSTAT	0	-9	158	143	-60	13
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	0	4	0	191	-403	-150
Statistical differences - EUROSTAT	0	4	0	191	-403	-150
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	6 052	4 311	4 206	3 745	4 173	4 281
Transformation input - EUROSTAT	6 053	4 312	4 206	3 746	4 174	4 282
Transformation input - difference	-1	-1	0	-1	-1	-1
Energy sector - IEA	6	11	9	18	43	31
Energy sector - EUROSTAT	6	11	9	18	43	31
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	3 796	3 554	4 444	4 575	4 504	4 132
Final consumption - EUROSTAT	3 795	3 553	4 444	4 574	4 503	4 131
Final consumption - difference	1	1	0	1	1	1
Final consumption - Industry - IEA	1 694	1 830	1 841	2 031	2 261	1 996
Final consumption - Industry - EUROSTAT	1 693	1 829	1 841	2 030	2 260	1 995
Final consumption - Industry - difference	1	1	0	1	1	1
Final consumption - Transport - IEA	139	115	119	107	0	0
Final consumption - Transport - EUROSTAT	139	115	119	107	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	1 715	1 436	2 358	2 271	2 075	2 014
Final consumption - Other sectors - EUROSTAT	1 715	1 436	2 358	2 271	2 075	2 014
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	499	419	935	1 079	975	965
Final consumption - Residential - EUROSTAT	499	419	935	1 079	975	965
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	1 161	976	1 399	1 172	959	908
Final consumption - Commercial and public services - EUROSTAT	1 161	976	1 399	1 172	959	908
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	55	41	24	20	141	141
Final consumption - Agriculture/forestry - EUROSTAT	55	41	24	20	141	141
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 4. (cont.) Analysis of consistency between data from Eurostat and IEA databases for *Coke oven coke* consumption [kt]

	2000	2005	2010	2015	2016	2017
Production - IEA	8 972	8 404	9 844	9 792	9 718	9 418
Production - EUROSTAT	8 972	8 404	9 844	9 792	9 718	9 418
Production - difference	0	0	0	0	0	0
Imports - IEA	16	117	137	94	123	209
Imports - EUROSTAT	16	117	137	94	123	209
Imports - difference	0	0	0	0	0	0
Exports - IEA	3 691	4 624	6 347	6 459	6 970	6 494
Exports - EUROSTAT	3 691	4 624	6 347	6 459	6 970	6 494
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	465	-498	-469	-98	45	95
Stock changes - EUROSTAT	465	-498	-469	-98	45	95
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	-122	-1	420	-113	-292	-9
Statistical differences - EUROSTAT	-122	-1	420	-113	-292	-9
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	3 732	2 344	2 141	2 602	2 468	2 441
Transformation input - EUROSTAT	3 732	2 344	2 141	2 602	2 468	2 441
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	6	1	0	0	0	0
Energy sector - EUROSTAT	6	1	0	0	0	0
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	2 146	1 055	604	840	740	795
Final consumption - EUROSTAT	2 146	1 055	604	840	740	795
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	1 224	758	267	652	558	611
Final consumption - Industry - EUROSTAT	1 224	758	267	652	558	611
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	0	0	0	0
Final consumption - Transport - EUROSTAT	0	0	0	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	820	239	336	188	182	184
Final consumption - Other sectors - EUROSTAT	820	239	336	188	182	184
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	410	105	229	150	140	150
Final consumption - Residential - EUROSTAT	410	105	229	150	140	150
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	290	94	74	29	32	25
Final consumption - Commercial and public services - EUROSTAT	290	94	74	29	32	25
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	120	40	33	9	10	9
Final consumption - Agriculture/forestry - EUROSTAT	120	40	33	9	10	9
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 5. Analysis of consistency between data from Eurostat and IEA databases for *Natural gas* consumption [TJ] (GCV)

	1990	1991	1992	1993	1994	1995
Production - IEA	110 621	123 660	119 082	152 164	144 181	147 432
Production - EUROSTAT	110 621	123 660	119 082	152 164	144 181	147 432
Production - difference	0	0	0	0	0	0
Imports - IEA	315 104	265 645	248 080	217 866	232 581	271 470
Imports - EUROSTAT	315 104	265 645	248 080	217 866	232 581	271 470
Imports - difference	0	0	0	0	0	0
Exports - IEA	35	23	116	602	929	1 184
Exports - EUROSTAT	35	23	116	602	929	1 184
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	-9 906	-1 566	-5 949	9 889	6 375	718
Stock changes - EUROSTAT	-9 906	-1 566	-5 949	9 889	6 375	718
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	4 430	12 308	0	11 000	-12 861	12 187
Statistical differences - EUROSTAT	4 430	12 308	0	11 000	-12 861	12 187
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	28 361	22 629	14 581	5 324	4 674	5 264
Transformation input - EUROSTAT	28 361	22 629	14 581	5 324	4 674	5 264
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	15 602	15 523	17 970	15 513	21 102	18 236
Energy sector - EUROSTAT	15 602	15 523	17 970	15 513	21 102	18 236
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	357 710	319 944	311 328	318 818	347 294	370 469
Final consumption - EUROSTAT	357 710	319 944	311 328	318 818	347 294	370 469
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	116 699	88 281	78 484	89 468	90 654	89 786
Final consumption - Industry - EUROSTAT	116 699	88 281	78 484	89 468	90 654	89 786
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	0	0	1	8
Final consumption - Transport - EUROSTAT	0	0	0	0	1	8
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	151 599	161 030	169 396	170 300	179 396	192 291
Final consumption - Other sectors - EUROSTAT	151 599	161 030	169 396	170 300	179 396	192 291
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	135 782	148 527	156 902	157 322	168 523	177 288
Final consumption - Residential - EUROSTAT	135 782	148 527	156 902	157 322	168 523	177 288
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	15 319	12 197	12 433	12 831	10 637	14 733
Final consumption - Commercial and public services - EUROSTAT	15 319	12 197	12 433	12 831	10 637	14 733
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	498	306	61	147	236	270
Final consumption - Agriculture/forestry - EUROSTAT	498	306	61	147	236	270
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 5. (cont.) Analysis of consistency between data from Eurostat and IEA databases for *Natural gas* consumption [TJ] (GCV)

	2000	2005	2010	2015	2016	2017
Production - IEA	154 138	180 700	171 797	171 329	165 272	163 373
Production - EUROSTAT	154 138	180 700	171 797	171 329	165 272	163 373
Production - difference	0	0	0	0	0	0
Imports - IEA	308 917	398 547	414 583	464 842	566 852	606 014
Imports - EUROSTAT	308 917	398 547	414 583	464 842	566 852	606 014
Imports - difference	0	0	0	0	0	0
Exports - IEA	1 562	1 667	1 752	2 112	33 294	47 232
Exports - EUROSTAT	1 562	1 667	1 752	2 112	33 294	47 232
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	1 832	-8 431	11 048	6 790	-18 084	-3 664
Stock changes - EUROSTAT	1 832	-8 431	11 048	6 790	-18 084	-3 664
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	0	-389	-7503	-6331	-2480	2289
Statistical differences - EUROSTAT	0	-389	-7 503	-6 331	-2 480	2 289
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	32 880	72 952	72 432	96 802	106 293	120 435
Transformation input - EUROSTAT	32 880	72 952	72 432	96 802	106 293	120 435
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	35 112	27 320	32 982	55 607	48 451	66 490
Energy sector - EUROSTAT	35 112	27 320	32 982	55 607	48 451	66 490
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	379 510	462 146	490 576	493 534	527 249	528 695
Final consumption - EUROSTAT	379 510	462 146	490 576	493 534	527 249	528 695
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	106 143	130 002	143 714	150 250	158 673	171 406
Final consumption - Industry - EUROSTAT	106 143	130 002	143 714	150 250	158 673	171 406
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	2 775	10 962	10 299	16 719	17 801	17 793
Final consumption - Transport - EUROSTAT	2 775	10 962	10 299	16 719	17 801	17 793
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	185 237	227 338	259 273	227 965	252 695	238 108
Final consumption - Other sectors - EUROSTAT	185 237	227 338	259 273	227 965	252 695	238 108
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	141 790	150 123	164 919	146 891	161 276	168 858
Final consumption - Residential - EUROSTAT	141 790	150 123	164 919	146 891	161 276	168 858
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	42 852	76 011	92 703	79 803	89 969	67 562
Final consumption - Commercial and public services - EUROSTAT	42 852	76 011	92 703	79 803	89 969	67 562
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	595	1 204	1 651	1 271	1 450	1 688
Final consumption - Agriculture/forestry - EUROSTAT	595	1 204	1 651	1 271	1 450	1 688
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 6. Analysis of consistency between data from Eurostat and IEA data for *Fuel oil* consumption [kt]

	1990	1991	1992	1993	1994	1995
Production - IEA	3 631	3 480	2 983	3 340	3 259	3 452
Production - EUROSTAT	3 631	3 480	2 983	3 340	3 259	3 452
Production - difference	0	0	0	0	0	0
Imports - IEA	101	12	1	0	11	18
Imports - EUROSTAT	101	12	1	0	11	18
Imports - difference	0	0	0	0	0	0
Exports - IEA	927	1043	839	1 005	894	899
Exports - EUROSTAT	927	1 043	839	1 005	894	899
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	0	-13	2	-4	1	0
Stock changes - EUROSTAT	0	-13	2	-4	1	0
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	-119	-11	-330	-303	-361	-186
Statistical differences - EUROSTAT	-119	-11	-330	-303	-361	-186
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	1 634	1 532	1 410	1 377	1 390	646
Transformation input - EUROSTAT	1 634	1 532	1 410	1 377	1 390	646
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	287	265	396	329	306	814
Energy sector - EUROSTAT	287	265	396	329	306	814
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	741	556	502	830	937	994
Final consumption - EUROSTAT	741	556	502	830	937	994
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	593	445	436	491	518	763
Final consumption - Industry - EUROSTAT	593	445	436	491	518	763
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	59	43	30	4	1	13
Final consumption - Transport - EUROSTAT	59	43	30	4	1	13
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	89	68	36	335	418	218
Final consumption - Other sectors - EUROSTAT	89	68	36	335	418	218
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	0	0	0	0	0	0
Final consumption - Residential - EUROSTAT	0	0	0	0	0	0
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	0	0	0	0	0	0
Final consumption - Commercial and public services - EUROSTAT	0	0	0	0	0	0
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	89	68	36	335	418	218
Final consumption - Agriculture/forestry - EUROSTAT	89	68	36	335	418	218
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 6. (cont.) Analysis of consistency between data from Eurostat and IEA databases for *Fuel oil* consumption [kt]

	2000	2005	2010	2015	2016	2017
Production - IEA	3 558	2 537	3 123	3 869	3 609	3 436
Production - EUROSTAT	3 558	2 537	3 123	3 869	3 609	3 436
Production - difference	0	0	0	0	0	0
Imports - IEA	113	13	86	2	47	38
Imports - EUROSTAT	113	13	86	2	47	38
Imports - difference	0	0	0	0	0	0
Exports - IEA	1 367	488	1 575	2 743	2 514	2 471
Exports - EUROSTAT	1 367	488	1 575	2 743	2 514	2 471
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	-12	0	18	-10	-2	-18
Stock changes - EUROSTAT	-12	0	18	-10	-2	-18
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	-10	-8	-93	18	35	9
Statistical differences - EUROSTAT	-10	-8	-93	18	35	9
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	544	596	542	399	416	379
Transformation input - EUROSTAT	544	596	542	399	416	379
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	708	678	808	563	537	449
Energy sector - EUROSTAT	708	678	808	563	537	449
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	802	584	198	91	93	95
Final consumption - EUROSTAT	802	584	198	91	93	95
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	662	401	173	81	79	80
Final consumption - Industry - EUROSTAT	662	401	173	81	79	80
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	0	0	0	0
Final consumption - Transport - EUROSTAT	0	0	0	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	140	183	25	10	14	15
Final consumption - Other sectors - EUROSTAT	140	183	25	10	14	15
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	0	0	0	0	0	0
Final consumption - Residential - EUROSTAT	0	0	0	0	0	0
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	0	0	2	0	0	0
Final consumption - Commercial and public services - EUROSTAT	0	0	2	0	0	0
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	140	180	23	10	14	15
Final consumption - Agriculture/forestry - EUROSTAT	140	180	23	10	14	15
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 7. Analysis of consistency between data from Eurostat and IEA databases for *Solid biomass* consumption [TJ]

	1990	1991	1992	1993	1994	1995
Production - IEA	60 643	51 434	56 983	158 944	154 590	156 943
Production - EUROSTAT	60 643	51 434	56 983	158 944	154 590	156 943
Production - difference	0	0	0	0	0	0
Imports - IEA	0	0	0	0	0	0
Imports - EUROSTAT	0	0	0	0	0	0
Imports - difference	0	0	0	0	0	0
Exports - IEA	0	0	0	0	0	0
Exports - EUROSTAT	0	0	0	0	0	0
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	0	0	0	0	-3	0
Stock changes - EUROSTAT	0	0	0	0	-3	0
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	0	0	0	0	594	49
Statistical differences - EUROSTAT	0	0	0	0	594	49
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	14 571	14 384	17 265	13 783	14 051	1 322
Transformation input - EUROSTAT	14 571	14 384	17 265	13 783	14 051	1 322
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	6	0	4	8	11	3
Energy sector - EUROSTAT	6	0	4	8	11	3
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	46 066	37 050	39 714	145 153	139 931	155 569
Final consumption - EUROSTAT	46 066	37 050	39 714	145 153	139 931	155 569
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	7 191	6 106	5 159	6 784	5 130	20 509
Final consumption - Industry - EUROSTAT	7 191	6 106	5 159	6 784	5 130	20 509
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	3	0	0	0
Final consumption - Transport - EUROSTAT	0	0	3	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	38 875	30 944	34 552	138 369	134 801	135 060
Final consumption - Other sectors - EUROSTAT	38 875	30 944	34 552	138 369	134 801	135 060
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	0	0	0	106 000	104 715	105 000
Final consumption - Residential - EUROSTAT	0	0	0	106 000	104 715	105 000
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	0	0	0	12 312	11 719	11 560
Final consumption - Commercial and public services - EUROSTAT	0	0	0	12 312	11 719	11 560
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	0	0	0	20 057	18 367	18 500
Final consumption - Agriculture/forestry - EUROSTAT	0	0	0	20 057	18 367	18 500
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0

Table 7. (cont.) Analysis of consistency between data from Eurostat and IEA databases for *Solid biomass* consumption [TJ]

	2000	2005	2010	2015	2016	2017
Production - IEA	150 485	174 431	245 606	276 199	268 577	257 952
Production - EUROSTAT	150 485	174 431	245 606	276 199	268 577	257 952
Production - difference	0	0	0	0	0	0
Imports - IEA	0	0	0	27 343	24 305	16 581
Imports - EUROSTAT	0	0	0	27 343	24 305	16 581
Imports - difference	0	0	0	0	0	0
Exports - IEA	0	0	0	15 338	15 709	11 151
Exports - EUROSTAT	0	0	0	15 338	15 709	11 151
Exports - difference	0	0	0	0	0	0
Stock changes - IEA	-292	0	0	0	0	0
Stock changes - EUROSTAT	-292	0	0	0	0	0
Stock changes - difference	0	0	0	0	0	0
Statistical differences - IEA	0	0	0	0	0	0
Statistical differences - EUROSTAT	0	0	0	0	0	0
Statistical differences - difference	0	0	0	0	0	0
Transformation input - IEA	3 461	17 228	65 114	95 657	74 057	56 414
Transformation input - EUROSTAT	3 461	17 228	65 114	95 657	74 057	56 414
Transformation input - difference	0	0	0	0	0	0
Energy sector - IEA	6	2	349	0	26	15
Energy sector - EUROSTAT	6	2	349	0	26	15
Energy sector - difference	0	0	0	0	0	0
Final consumption - IEA	146 726	157 201	180 143	192 547	203 090	206 954
Final consumption - EUROSTAT	146 726	157 201	180 143	192 547	203 090	206 954
Final consumption - difference	0	0	0	0	0	0
Final consumption - Industry - IEA	26 112	31 283	38 280	56 853	62 482	67 950
Final consumption - Industry - EUROSTAT	26 112	31 283	38 280	56 853	62 482	67 950
Final consumption - Industry - difference	0	0	0	0	0	0
Final consumption - Transport - IEA	0	0	0	0	0	0
Final consumption - Transport - EUROSTAT	0	0	0	0	0	0
Final consumption - Transport - difference	0	0	0	0	0	0
Final consumption - Other sectors - IEA	120 614	125 918	141 863	135 694	140 608	139 004
Final consumption - Other sectors - EUROSTAT	120 614	125 918	141 863	135 694	140 608	139 004
Final consumption - Other sectors - difference	0	0	0	0	0	0
Final consumption - Residential - IEA	95 000	100 700	112 746	108 395	111 435	109 725
Final consumption - Residential - EUROSTAT	95 000	100 700	112 746	108 395	111 435	109 725
Final consumption - Residential - difference	0	0	0	0	0	0
Final consumption - Commercial and public services - IEA	8 514	6 171	8 029	7 043	7 715	8 003
Final consumption - Commercial and public services - EUROSTAT	8 514	6 171	8 029	7 043	7 715	8 003
Final consumption - Commercial and public services - difference	0	0	0	0	0	0
Final consumption - Agriculture/forestry - IEA	17 100	19 047	21 088	20 256	21 458	21 276
Final consumption - Agriculture/forestry - EUROSTAT	17 100	19 047	21 088	20 256	21 458	21 276
Final consumption - Agriculture/forestry - difference	0	0	0	0	0	0