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Annual European Union greenhouse gas inventory 1990–2021 and inventory report 2023

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Annexes

ES-1 BACKGROUND INFORMATION ON GREENHOUSE GAS INVENTORIES AND CLIMATE CHANGE

The present report is the official inventory submission of the European Union (EU) for 2023 under the United Nations Framework Convention on Climate Change (UNFCCC).

Consistent with the latest Decision on the UNFCCC Reporting Guidelines adopted at COP27 in Sharm-El-Sheik, the EU has decided to apply the 100-year global warming potentials values to calculate the carbon dioxide equivalence of anthropogenic GHG emissions by sources and removals by sinks as set out in table 8.A.1 of the contribution of Working Group 1 to the Fifth Assessment Report of the IPCC from the current 2023 inventory submission.

The European Union (EU), as a party to the UNFCCC, reports annually on greenhouse gas (GHG) inventories for the years between 1990 and 2021 which is the current calendar year (t) minus two (t-2), for emissions and removals within the area covered by its Member States (i.e. emissions taking place within its territory).

The legal basis for the compilation of the EU inventory is the Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action (Governance Regulation)[1] and the 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].

These Regulations establish inter alia a mechanism for:

a) ensuring the timeliness, transparency, accuracy, consistency, comparability and completeness of reporting by the EU and its Member States to the UNFCCC Secretariat;
b) reporting and verifying information relating to commitments of the EU and its Member States pursuant to the UNFCCC and the Paris Agreement and evaluating progress towards meeting those commitments;
c) monitoring and reporting all anthropogenic emissions by sources, and removals by sinks, of GHGs not controlled by the Montreal Protocol on substances that deplete the ozone layer in Member States;
d) monitoring, reporting, reviewing and verifying GHG emissions and other information under the Effort Sharing Regulation[3].

The Governance Regulation replaces and expands the previous Monitoring Mechanism Regulation 525/2013.

The EU GHG inventory comprises the direct sum of emissions and removals from the national inventories compiled by the EU Member States. Energy data from Eurostat are used for the reference approach for CO_2 emissions from fossil fuels, developed by the Intergovernmental Panel on Climate Change (IPCC).

The main institutions involved in the compilation of the EU GHG inventory are the Member States, the European Commission Directorate-General for Climate Action (DG CLIMA), the European

[1] OJ L 328, 21.12.2018, p. 1–77 .

[2] OJ L 278, 26.8.2020, pp. 1–132

[3] 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 (OJ L 156, 19.6.2018, p. 26–42.

Environment Agency (EEA) and its European Topic Centre on Climate Change Mitigation (ETC/CM), and Eurostat.

The annual process of compiling the EU GHG inventory is described below:

1. Member States submit their annual GHG inventories by 15 January each year to the European Commission (DG CLIMA), with a copy to the EEA.
2. The EEA and its ETC/CM then perform ‘initial checks’ on the data submitted. Specific findings from the initial quality assurance/quality control (QA/QC) checks are communicated to Member States by 28 February. In addition, the draft EU GHG inventory and inventory report are circulated to Member States for review and comments by 28 February.
3. Member States check their national data and the information presented in the EU GHG inventory report, respond to specific findings from the initial QA/QC checks by the EU inventory team, that may lead to improved emissions and removals by Member States, send updates if necessary and review the EU inventory report by 15 March.
4. The EEA and its ETC/CM review final inventory submissions from Member States and their responses to the initial checks and prepare the final EU GHG inventory and inventory report by 15 April so that they can be submitted to the UNFCCC[4].

ES-2 SUMMARY OF GREENHOUSE GAS EMISSIONS TRENDS IN THE EU

Total GHG emissions - including Land Use, Land Use Change and Forestry (LULUCF), indirect CO_2 emissions and international aviation - in the EU amounted to 3 311 million tonnes CO_2 equivalent in 2021. All GHG emission totals provided in this report include indirect CO_2 emissions[5]. The EU’s national total emissions[6] also include LULUCF and international aviation to be consistent with the scope of the EU’s 2030 Nationally Determined Contribution (NDC)[7]

In 2021, total GHG emissions were 30 % (-1 401 million tonnes CO_2 equivalents) below 1990 levels. Emissions increased by 6.2 % or 193 million tonnes CO_2 equivalent) between 2020 and 2021. Still, emissions in 2021 remained below the 2019 pre-COVID-19 pandemic level (3 477 million tonnes CO_2 equivalent) and confirm an overall downward trend (Figure ES. 1).

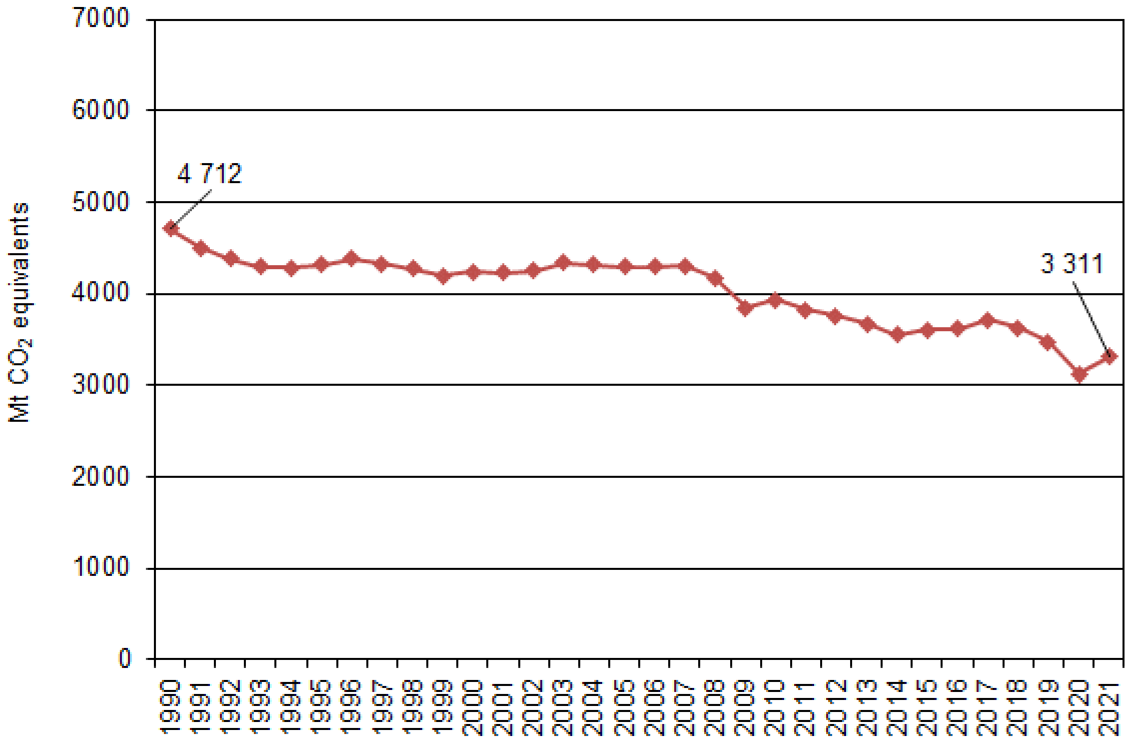
[4] The EU, as Party to the UNFCCC, reports its GHG inventory according to UNFCCC Decision 24/CP.19 (reporting guidelines on annual GHG inventories). The EU should not be held liable for any errors caused by the UNFCCC CRF Reporter software during the technical review of the information submitted.

[5] According to the UNFCCC reporting guidelines, Annex I Parties may report indirect CO_2 from the atmospheric oxidation of CH_4, CO and NMVOCs. For Parties that decide to report indirect CO_2, the national totals will be presented with and without indirect CO_2. The EU national total includes indirect CO_2 emissions if Member States have reported these emissions. The CRF tables include national totals, including and excluding indirect CO_2 emissions.

[6] Unless otherwise specified, the national GHG totals in this report always include LULUCF. They may also be referred to as ‘net’ total GHG emissions. The other UNFCCC sectors that are included in the national totals are energy, industrial processes and product use, agriculture, waste, international aviation, and indirect CO_2 emissions.

[7] https://unfccc.int/NDCREG

Figure ES. 1 EU GHG emissions (incl. LULUCF, indirect CO_2 emissions and international aviation)



Notes: The GHG emissions data shown in this figure include indirect CO_2 emissions, emissions and removals from LULUCF; and emissions from international aviation, but exclude emissions from international maritime transport. CO_2 emissions from biomass with energy recovery are reported as a Memorandum item according to UNFCCC guidelines and are not included in national totals. In addition, no adjustments for temperature variations or electricity trade are considered. The 100-year global warming potentials are those from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

1.1 Main trends by source category, 1990-2021

Total GHG emissions (including LULUCF and international aviation) decreased by 1401 Mt CO_2 eq. since 1990 (or 29.7 %) reaching 3 311 Mt CO_2 equivalent in 2021. There has been a progressive decoupling of gross domestic product (GDP) and GHG emission compared to 1990, with an increase in GDP of 61 % alongside a decrease in emissions of about 30 % over the period.

The trend in GHG emissions over the 31-year period was driven by a variety of factors, including the growing share in the use of renewables, the use of less carbon intensive fossil fuels and improvements in energy efficiency, as well as to structural changes in the economy, and more recently the economic recession from the COVID-19 pandemic in 2020 and the recovery of 2021.

The long-lasting changes have resulted in a lower energy intensity of the economy and in a lower carbon intensity of energy production and consumption in 2021 compared to 1990. Demand for energy to heat households has also been lower, as Europe on average has experienced milder winters since 1990, which has also helped reduce emissions.

GHG emissions decreased in the majority of sectors between 1990 and 2021, with the notable exception of transport, refrigeration and air conditioning, where emissions increased, and forest land, where net removals decreased. For the latter, the main reasons for the decrease in net removals include the aging of the forests from the late 2000s and a lower annual increment, as well as increased harvesting. At the aggregate level, emission reductions were largest for manufacturing industries and construction, electricity and heat production, iron and steel production (including energy-related emissions) and residential combustion.

A combination of factors explains lower emissions in industrial sectors, such as improved efficiency and lower carbon intensity as well as structural changes in the economy, with a higher share of services and a lower share of more-energy-intensive industry in total GDP.

Emissions from electricity and heat production have decreased strongly since 1990. In addition to improved energy efficiency there has been a move towards less carbon intense fuels. Between 1990 and 2021, the use of solid and liquid fuels in thermal power stations decreased strongly (by 53% and 85%, respectively) whereas natural gas consumption developed in the opposite direction (increasing by 76%). Coal consumption in 1990 was two times higher than in 2021. The use of renewable energy sources in electricity and heat generation has increased substantially in the EU since 1990 (by almost four times, including also non-combustible renewables). Improved energy efficiency and a less carbon intensive fuel mix have resulted in reduced CO_2 emissions per unit of fossil energy generated.

Emissions in the residential sector also represented one of the largest reductions. Energy efficiency improvements from better insulation standards in buildings, and a less carbon-intensive fuel mix, can partly explain lower demand for space heating in the EU over the past 31 years.

In terms of the main GHGs, CO_2 was responsible for the largest reduction in emissions since 1990. Reductions in emissions from N_2O and CH_4 have been substantial, reflecting lower levels of mining activities, lower agricultural livestock, as well as lower emissions from managed waste disposal on land and from reduced adipic and nitric acid production.

A number of policies (both EU and country-specific) have contributed to the overall GHG emission reduction, including key agricultural and environmental policies in the 1990s and climate and energy policies in the past 16 years since 2005. Despite quick progress reducing agricultural emissions during the 1990s and early 2000s, they have remained broadly stable since 2005.

Almost all EU Member States reduced emissions compared to 1990 and thus contributed to the overall positive EU performance. Germany, Romania, Italy and France accounted for two thirds of the total net reduction in EU emissions during the past 31 years.

Table ES. 1 shows those categories that made the largest contribution to the change in total GHG emissions and removals in the EU between 1990 and 2021.

Table ES. 1 Overview of EU categories whose emissions and/or removals increased or decreased by more than 20 million tonnes CO_2 equivalent in the period 1990–2021

Source category	**Million tonnes (CO_2 equivalents)**
Road Transportation (CO2 from 1.A.3.b)	131
Refrigeration and Air conditioning (HFCs from 2.F.1)	64
Forest Land (CO2 from 4.A.1)	52
Agricultural soils: Direct N2O emissions (N2O from 3.D.1)	-22
Cement Production (CO2 from 2.A.1)	-23
Cropland (CO2 from 4.B.1)	-23
Adipic Acid Production (N2O from 2.B.3)	-33
Nitric Acid Production (N2O from 2.B.2)	-38
Fuels used Commercial/Institutional Sector (CO2 from 1.A.4.a)	-41
Managed Waste Disposal Sites (CH4 from 5.A.1)	-42
Fugitive Emissions from Oil and Natural Gas (CH4 from 1.B.2)	-42
Enteric Fermentation: Cattle (CH4 from 3.A.1)	-45
Fugitive Emissions from Solid Fuels (CH4 from 1.B.1)	-60
Manufacture of Solid Fuels and Other Energy Industries (CO2 from 1.A.1.c)	-71
Iron and Steel Production (CO2 from 1.A.2.a + 2.C.1)	-108
Fuels used Residential Sector (CO2 from 1.A.4.b)	-120
Manufacturing industries (excl. Iron and steel) (Energy-related CO2 from 1.A.2 excl. 1.A.2.a)	-218
Public Electricity and Heat Production (CO2 from 1.A.1.a)	-518
Total	**-1401**

Notes: As the table only presents sectors whose emissions have increased or decreased by at least 20 million tonnes CO_2 equivalent, the sum of the EU key categories in this table does not match the total change in emissions listed at the bottom of the table, which includes all emission sources in the EU inventory. Note that LULUCF categories and the Memorandum item of international aviation are reflected in this table.

1.2 Main trends by source category, 2020–2021

Total GHG emissions (including LULUCF and international aviation) increased in 2021 by 193 million tonnes, or 6.2 % compared to 2020, to reach 3 311 Mt CO_2 equivalent in 2021. The increase in GHG emissions in 2021 was the largest in absolute and relative terms year-on-year in the EU since 1990. This can be attributed to the economic recovery, underpinned by higher coal use in the power sector and transport demand, that followed the strong contraction in economic activity during the COVID-19 pandemic in 2020.

At EU level, almost two thirds of the net increase in GHG emissions in 2021 took place in road transportation and public electricity and heat production. But almost all economic sectors saw significant emission increases in 2021, including manufacturing industries and construction, iron and steel, and international aviation, among others.

The largest increase in CO_2 emissions in 2021 came from electricity and heat production, with 64 Mt (or 10% increase compared to 2020). The increase was driven almost fully by higher coal use in power stations. Also, greenhouse gas emissions from stationary installations in the EU ETS increased by about 7% in 2021, which represents the largest increase in emissions since the ETS began operating in 2005.

Based on Eurostat energy statistics, total electricity production increased in the EU in 2021. Bioenergy and solar electricity increased, while wind and hydroelectricity declined. Nuclear electricity also increased in 2021.

The second largest increase occurred in road transport, with CO_2 emissions increasing by 60 Mt (or 9%) in 2021, after a drastic reduction in transport activity in 2020 due to the lockdown measures during the COVID-19 pandemic. Passenger cars accounted for the largest share of the increase in road transport emissions, but emissions from light duty and heavy-duty vehicles also increased significantly in 2021.

Finally, COVID-19 pandemic-related travelling restrictions in 2020 had led to a major decrease in GHG emissions in the aviation sector (both domestic and international) of 57% compared to 2019 levels. Although emissions from international aviation increased in 2021 compared to 2020, the increase did not offset the massive reduction of 2020, with 2021 emissions remaining at levels comparable to those of the mid-1990s.

Table ES. 2 shows the categories making the largest contribution to the change in GHG emissions and removals in the EU between 2020 and 2021.

Table ES. 2 Overview of EU categories whose emissions and/or removals increased or decreased by more than 3 million tonnes CO_2 equivalent in the period 2020–2021

Source category	Million tonnes (CO_2 equivalents)
Public Electricity and Heat Production (CO2 from 1.A.1.a)	64
Road Transportation (CO2 from 1.A.3.b)	60
Iron and Steel Production (CO2 from 1.A.2.a + 2.C.1)	20
Manufacturing industries (excl. Iron and steel) (Energy-related CO2 from 1.A.2 excl. 1.A.2.a)	17
International Aviation (CO2 from 1.D.1.a)	13
Forest Land (CO2 from 4.A.1)	9
Fuels used Commercial/Institutional Sector (CO2 from 1.A.4.a)	8
Grassland (CO2 from 4.C.1)	5
Fuels used Residential Sector (CO2 from 1.A.4.b)	4
Harvested Wood Products (CO2 from 4.G)	-6
Total	**193**

Notes: As the table only presents sectors whose emissions have increased or decreased by at least 3 million tonnes of CO_2 equivalent, the sum of the EU key categories in this table does not match the total change in emissions listed at the bottom of the table, which includes all emission sources in the EU inventory. Note that LULUCF categories and the Memorandum item international aviation are reflected in this table.

1.3 Overview of total GHG emissions by countries

Table ES.3 gives an overview of total GHG emissions by countries, illustrating where the main changes occurred.

Table ES. 3 GHG emissions in million tonnes CO_2 equivalent (incl. LULUCF and international aviation)

	1990 (million tonnes)	2021 (million tonnes)	2020 - 2021 (million tonnes)	Change 2020 - 2021 (%)	Change 1990-2021 (%)
Austria	67.7	68.4	-1.4	-2.0%	0.9%
Belgium	146.1	115.2	4.6	4.2%	-21.1%
Bulgaria	83.4	45.3	6.3	16.1%	-45.6%
Croatia	25.6	18.9	0.5	2.9%	-26.1%
Cyprus	6.2	9.1	0.5	5.3%	45.7%
Czechia	192.8	127.8	2.4	1.9%	-33.7%
Denmark	80.2	47.5	0.6	1.3%	-40.7%
Estonia	36.7	15.6	1.6	11.7%	-57.4%
Finland	46.5	49.2	9.6	24.2%	5.8%
France	531.0	406.2	27.1	7.2%	-23.5%
Germany	1299.4	782.7	33.7	4.5%	-39.8%
Greece	104.2	74.5	3.2	4.4%	-28.5%
Hungary	92.1	57.4	1.2	2.2%	-37.7%
Ireland	62.7	70.8	3.5	5.2%	12.8%
Italy	522.3	395.1	38.9	10.9%	-24.4%
Latvia	13.9	13.4	1.9	16.5%	-3.8%
Lithuania	43.2	14.4	0.7	4.8%	-66.7%
Luxembourg	13.1	10.7	0.4	4.3%	-18.8%
Malta	2.8	2.4	0.1	2.9%	-15.4%
Netherlands	233.6	179.3	3.7	2.1%	-23.2%
Poland	447.0	382.3	28.0	7.9%	-14.5%
Portugal	68.2	52.5	-2.5	-4.6%	-23.0%
Romania	229.3	66.4	4.6	7.5%	-71.0%
Slovakia	64.6	33.7	4.1	13.8%	-47.8%
Slovenia	14.5	13.0	0.2	1.3%	-9.9%
Spain	258.6	252.6	18.0	7.7%	-2.3%
Sweden	26.5	7.1	1.2	21.1%	-73.2%
EU-27	4712.3	3311.5	192.8	6.2%	-29.7%

ES-3 SUMMARY OF EMISSIONS AND REMOVALS BY MAIN GREENHOUSE GAS

Table ES. 4 gives an overview of the main trends in the EU GHG emissions and removals for the period 1990–2021. By far the most important GHG is CO_2, which accounted for 80 % of total EU emissions in 2021, including LULUCF. In 2020, EU CO_2 emissions including LULUCF and aviation were 2633 million tonnes, which was 29 % below 1990 levels. Compared to 2020, CO_2 emissions increased by 8 %. During that period CH_4 and N_2O emissions decreased slightly.

Table ES. 4 Overview of EU GHG emissions and removals from 1990 to 2021 in million tonnes CO_2 equivalent

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2005	2010	2015	2020	2021
Net CO_2 emissions/removals	3 646	3 306	3 285	3 382	3 070	2 761	2 378	2 564
CO_2 International aviation	*54*	*65*	*84*	*95*	*100*	*108*	*56*	*69*
CH_4	663	607	557	510	471	444	418	415
CH_4 International aviation	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
N_2O	300	275	244	232	192	189	185	185
N_2O International aviation	*0*	*1*	*1*	*1*	*1*	*1*	*0*	*1*
HFCs	13	21	41	62	86	87	73	70
PFCs	22	15	10	6	3	3	2	2
Unspecified mix of HFCs and PFCs	5	5	2	1	1	1	2	2
SF_6	10	14	9	7	6	6	5	5
NF_3	0	0	0	0	0	0	0	0
Total (including LULUCF and aviation)	**4 712**	**4 310**	**4 233**	**4 296**	**3 929**	**3 599**	**3 119**	**3 311**

Notes: CO_2 emissions include indirect CO_2. Please note that historical data may have changed compared to last year's Inventory Report due to recalculations

More detailed information can be found in Chapter 2.

ES-4 SUMMARY OF EMISSIONS AND REMOVALS BY MAIN SOURCE AND SINK CATEGORY

Table ES. 5 gives an overview of EU GHG emissions in the main categories for the period 1990–2021. The most important sector in terms of GHG emissions is energy (i.e. combustion and fugitive emissions), which accounted for 80 % of total EU emissions including LULUCF in 2021. The second largest sector is agriculture (11 %), followed by industrial processes (10 %). The LULUCF sector accounted for 6.5% of the EU's gross national total emissions (excluding LULUCF and including international aviation) in 2021. More detailed trend descriptions are included in the individual sector chapters (chapters 3-7).

Table ES. 5 Overview of EU GHG emissions (in million tonnes CO_2-equivalent) in the main source and sink categories for the period 1990 to 2021

GHG SOURCE AND SINK	1990	1995	2000	2005	2010	2015	2020	2021
1. Energy	3 747	3 521	3 454	3 569	3 305	2 967	2 500	2 663
2. Industrial Processes	445	427	409	425	358	340	307	318
3. Agriculture	485	419	409	389	376	384	382	378
4. Land-Use, Land-Use Change and Forestry	-209	-316	-304	-342	-353	-322	-241	-230
5. Waste	184	188	174	154	137	118	111	109
6. Other	0	0	0	0	0	0	0	0
Indirect CO_2 emissions	6	6	5	5	4	3	3	3
Memo item: International aviation	54	66	85	96	100	109	56	70
Total (including LULUCF and aviation)	**4 712**	**4 310**	**4 233**	**4 296**	**3 929**	**3 599**	**3 119**	**3 311**
Total (without LULUCF and aviation)	**4 867**	**4 560**	**4 452**	**4 542**	**4 181**	**3 812**	**3 304**	**3 472**

ES-5 SUMMARY OF EU MEMBER STATE EMISSION TRENDS

Table ES. 6 gives an overview of Member States' contributions to EU GHG emissions for the period 1990–2021. Countries show large variations in GHG emissions trends.

Table ES. 6 Overview of countries' contributions to total EU GHG emissions, including LULUCF, international aviation and including indirect CO_2, from 1990 to 2021 in million tonnes CO_2-equivalent

Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Austria	67.7	61.5	68.0	76.1	67.0	74.5	69.7	68.4
Belgium	146.1	154.2	151.9	147.2	137.5	122.6	110.6	115.2
Bulgaria	83.4	56.6	40.6	46.6	48.1	53.3	39.1	45.3
Croatia	25.6	14.4	19.2	22.2	21.6	19.3	18.4	18.9
Cyprus	6.2	7.7	9.1	9.9	10.1	8.9	8.6	9.1
Czechia	192.8	150.8	143.7	142.8	135.0	123.3	125.3	127.8
Denmark	80.2	86.9	79.5	75.6	69.6	53.1	46.9	47.5
Estonia	36.7	16.8	12.8	16.5	15.7	17.3	14.0	15.6
Finland	46.5	48.0	46.9	42.6	51.3	40.3	39.6	49.2
France	531.0	522.4	540.2	515.6	482.3	435.2	379.0	406.2
Germany	1299.4	1112.6	1059.7	1016.0	954.2	910.2	748.9	782.7
Greece	104.2	109.2	126.7	135.8	118.4	94.6	71.4	74.5
Hungary	92.1	71.8	75.0	71.8	62.4	57.1	56.2	57.4
Ireland	62.7	67.9	78.9	81.7	72.4	70.5	67.3	70.8
Italy	522.3	517.6	546.4	567.2	490.7	411.4	356.2	395.1
Latvia	13.9	-2.1	-1.6	5.3	10.2	11.3	11.5	13.4
Lithuania	43.2	18.0	10.1	18.5	10.6	12.5	13.7	14.4
Luxembourg	13.1	10.1	10.0	13.7	13.3	11.3	10.2	10.7
Malta	2.8	3.0	3.1	3.3	3.3	2.5	2.3	2.4
Netherlands	233.6	245.7	235.6	231.9	230.1	211.3	175.6	179.3
Poland	447.0	430.2	360.7	354.2	376.3	356.7	354.3	382.3
Portugal	68.2	60.9	82.6	92.5	65.8	67.7	55.0	52.5
Romania	229.3	158.2	109.7	118.2	89.9	67.5	61.8	66.4
Slovakia	64.6	43.8	39.7	46.1	40.7	35.3	29.6	33.7
Slovenia	14.5	13.8	12.6	13.5	12.7	17.8	12.9	13.0
Spain	258.6	297.3	349.5	406.0	323.2	303.7	234.6	252.6
Sweden	26.5	32.1	22.1	25.1	16.2	9.3	5.9	7.1
EU-27	**4 712**	**4 310**	**4 233**	**4 296**	**3 929**	**3 599**	**3 119**	**3 311**

The largest emitters in the EU inventory in 2021 were Germany (24 % of EU emissions), followed by France, Italy and Poland with 12 % each.

Germany, Romania, France and Italy accounted for 67% of EU emission reductions between 1990 and 2020.

The main reasons for the favourable trend in Germany were an increase in the efficiency of power and heating plants and the economic restructuring of the five new Länder after the German reunification, particularly in the iron and steel sector. Other important reasons include a reduction in the carbon intensity of fossil fuels (with the switch from coal to gas), a strong increase in renewable energy use and waste management measures that reduced the landfilling of organic waste.

Common drivers to lower GHG emissions in most EU countries over the past 30 years, excluding the short term impact of the economic recession in 2020, have been, the use of less carbon intensive fuels, with a switch from coal to gas and a strong increase in the use of renewable energy sources, as well as significant improvements in energy efficiency, both in transformation and end use.

More information on GHG emission trends by country can be found in the relevant national inventory reports to UNFCCC https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2023.

ES-6 OTHER INFORMATION

INTERNATIONAL AVIATION AND MARITIME TRANSPORTATION

After a sharp drop due to the COVID-19 pandemic, emissions from international aviation were almost at 1990 levels in 2020. However, in 2021 emissions increased by 24 % compared to 2020 and were 29 % above the 1990 level in 2021. GHG emissions from international shipping also increased in 2021 due to the economic recovery and were 26 % above 1990 levels in 2021. In 2021, international aviation accounted for 70 million tonnes CO_2 equivalent (compared to 56 million tonnes in 2020) and international shipping for 129 million tonnes CO_2 equivalent (compared to 121 million tonnes in 2020).

For detailed information on emissions from international bunkers, see Chapter 3.7 of this report.

INFORMATION ON RECALCULATIONS

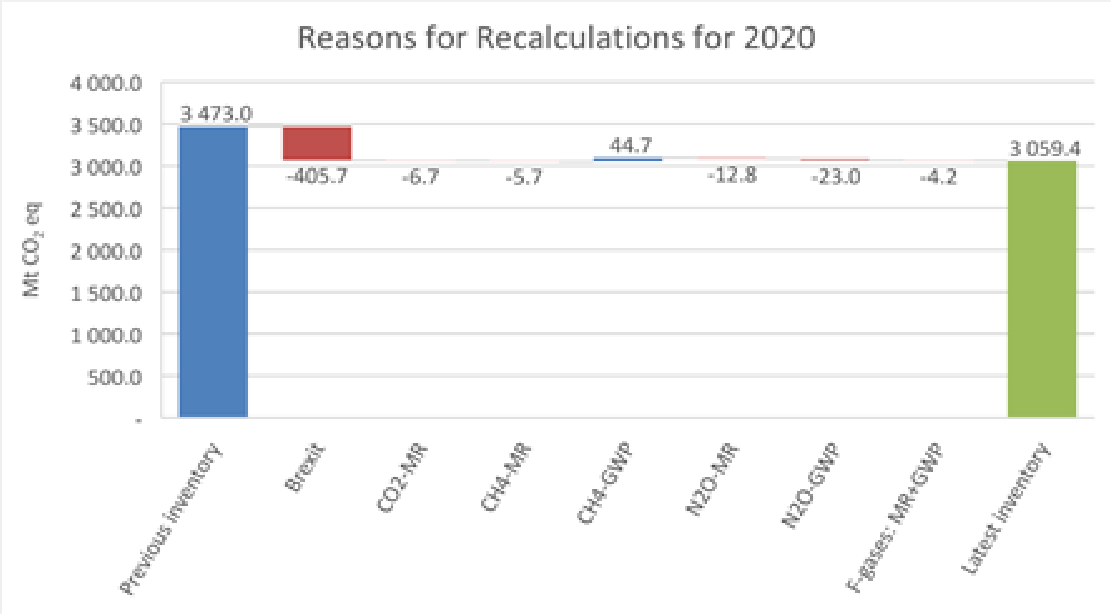
According to UNFCCC Reporting Guidelines, the inventory for the whole time series should be estimated using the same methodologies, and the underlying activity data and emissions factors should be used in a consistent manner, ensuring that changes in emissions trends are not introduced as a result of changes in estimation methods. Thus, recalculations of past emissions data occur every year based on GHG inventory improvements by countries and should ensure the consistency of the time series and be carried out to improve the accuracy and/or completeness of the inventory.

In addition, there are two more reasons for recalculations in the EU GHG inventory 2023:

- Due to the Brexit emissions and removals from the UK are no longer included in the EU inventory. The EU inventory is the sum of emissions and removals of its 27 Member States.
- Based on the latest Decision on the UNFCCC Reporting Guidelines adopted at COP27 in Sharm-El-Sheik, Parties shall apply the global warming potentials values set out in the IPCC Fifth Assessment Report by no later than 31 December 2024. The EU has decided to implement this Decision one year before the deadline; thus in its 2023 submission already.

Figure ES.2 illustrates that the Brexit is by far the most important reason for recalculations at EU level, whereas the new global warming potentials do not affect overall GHG emissions significantly.

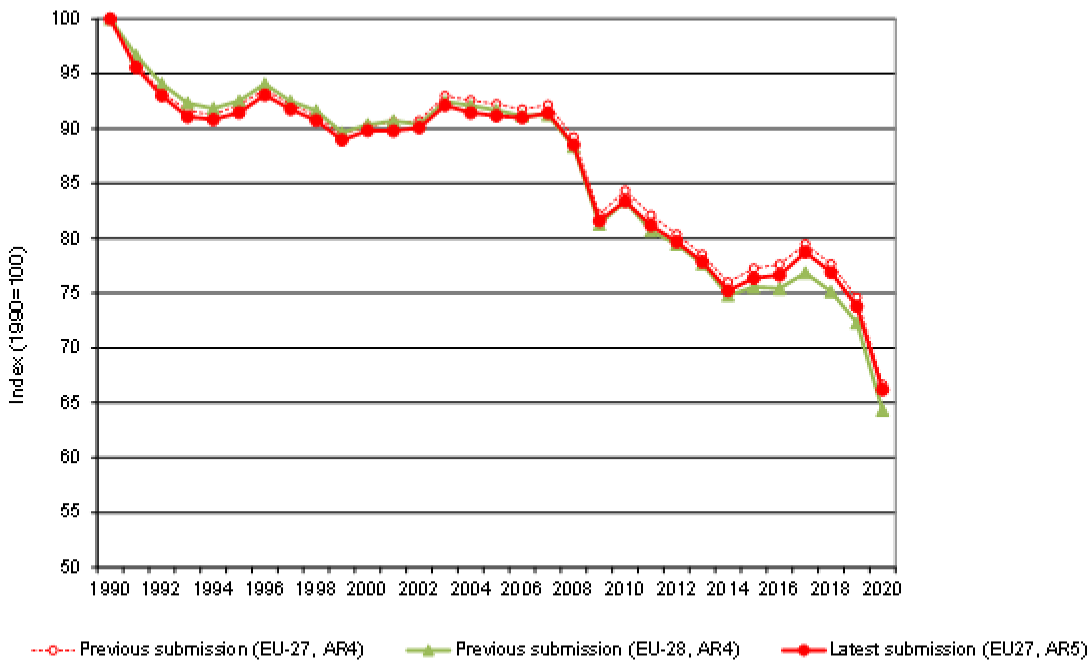
Figure ES. 2 EU GHG emissions (incl. LULUCF, indirect CO_2 emissions and international aviation)



Notes: Reasons for recalculations may relate to the Brexit, the use of new global warming potentials (GWP) and/or methodological revisions (MR) Including revisions of activity data.

Figure ES.3 shows that the long-term trend in GHG emissions since 1990 has also been very similar when comparing the EU's 2022 submission with the current 2023 submission.

Figure ES. 3 EU GHG emissions (incl. LULUCF, indirect CO_2 emissions and international aviation)



For more information on recalculations see Chapter 10.

1 INTRODUCTION TO THE EU GREENHOUSE GAS INVENTORY

The present report is the official inventory submission of the European Union for 2023 under the UNFCCC.

Consistent with the latest Decision on the UNFCCC Reporting Guidelines adopted at COP27 in Sharm-El-Sheik, the EU has decided to apply the 100-year global warming potentials values to calculate the carbon dioxide equivalence of anthropogenic GHG emissions by sources and removals by sinks as set out in table 8.A.1 of the contribution of Working Group 1 to the Fifth Assessment Report of the IPCC from the current 2023 inventory submission.

The European Union (EU), as a party to the United Nations Framework Convention on Climate Change (UNFCCC), reports annually on greenhouse gas (GHG) inventories for the years between 1990 and the current calendar year (t) minus two (t-2), for emissions and removals within the area covered by its 27 Member States (i.e. emissions taking place within its territory). The EU-27 Member States are: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden.

The UK left the EU on February 1, 2020. This report, therefore, refers to the totals of the EU-27.. Even though not all Member States were part of the European Union in 1990, GHG emissions in the EU are time-series consistent since 1990 and account for all sources and sinks of the current 27 EU MS. For reasons of clarity, please note that in some cases the terms 'Member States' and ''EU' and 'Union' may be used.

The EU should not be held liable for any remaining errors caused by the CRF Reporter in the review of the information submitted.

This report aims to present transparent information on the process and methods of compiling the EU GHG inventory. It addresses the relevant aspects at EU level, but does not describe detailed sectoral methodologies of the Member States' GHG inventories. As the data used in the EU inventory are the aggregation of the scope-relevant data of the Member States inventories, the detailed sectoral methodologies used in the EU inventory are fully consistent with the methodologies reported by the Member States to the UNFCCC. As such, the complete details on the methodologies used by the Member States are available in the national inventory reports of the Member States, which are submitted to the UNFCCC and published in the UNFCCC website. To facilitate the work of the expert review teams during the annual UNFCCC review process, and as follow up to previous review recommendations, the EU submission in 2023 includes an Annex (Annex III) with a summary description of the methodologies used by each Member State for the EU key categories. The more detailed descriptions can be found in Member State's own submissions. Note that all Member States' submissions (common reporting format (CRF) tables and inventory reports), are considered to be part of the EU inventory. Several chapters in this report refer to information provided by the Member States, where additional insights can be gained. In many cases this Member State information is presented in summary overview tables.

The EU greenhouse gas inventory has been compiled under Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action [8] (hereafter referred to as the Governance Regulation). The emissions compiled in the EU GHG inventory are the sum of the respective emissions in the respective national inventories, except for the Intergovernmental Panel on Climate Change (IPCC) reference approach for CO_2 emissions from the combustion of fossil fuels.

[8] OJ L 328, 21.12.2018, p. 1–77 .

1.1 Background information on greenhouse gas inventories and climate Change

The annual EU GHG inventory is required for two purposes.

Firstly, the EU, as the only regional economic integration organisation having joined the UNFCCC as a Party, has to report annually on GHG inventories within the area covered by its Member States.

Secondly, under the EU Governance Regulation, the European Commission has to assess annually whether the actual and projected progress of Member States is sufficient to ensure fulfilment of the EU's commitments under the UNFCCC, and with respect to EU legislation for reduction of GHG emissions (Effort Sharing Regulation)[9]. For this purpose, the Commission has to prepare a progress evaluation report (State of the Energy Union Report), which has to be forwarded to the European Parliament and the Council. The annual EU inventory is used for the evaluation of actual progress.

The legal basis of the compilation of the EU inventory is the Governance Regulation and 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[10]. The Governance Regulation and the implementing regulation establish a mechanism for inter alia: (1) ensuring the timeliness, transparency, accuracy, consistency, comparability and completeness of reporting by the Union and its Member States to the UNFCCC Secretariat; (2) reporting and verifying information relating to commitments of the Union and its Member States pursuant to the UNFCCC and the Paris Agreement and to decisions adopted thereunder and evaluating progress towards meeting those commitments; (3) monitoring and reporting all anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol on substances that deplete the ozone layer in the Member States; (4) evaluating progress by the Member States towards meeting their obligations under the Effort Sharing Regulation.

Under the provisions of Article 26(3) of the Governance Regulation and Articles 8-18 of the Commission Implementing Regulation 2020/1208, the Member States shall determine and report to the Commission by 15 January each year (year X) inter alia:

- their anthropogenic emissions of greenhouse gases listed in Annex I of the MMR (same as in Annex A to the Kyoto Protocol) for the year X-2, in accordance with UNFCCC reporting requirements
- data in accordance with UNFCCC reporting requirements on their anthropogenic emissions of carbon moNO$_X$ide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_X) and volatile organic compounds, for the year X-2
- their anthropogenic greenhouse gas emissions by sources and removals of CO_2 by sinks resulting from LULUCF, for the year X-2, in accordance with UNFCCC reporting requirements
- any changes to the information referred to in points above relating to the years between 1990 and the year three-years previous (year X – 3);
- the elements of the national inventory report necessary for the preparation of the EU greenhouse gas inventory report, such as information on the Member State's quality assurance/quality control plan, a general uncertainty evaluation, a general assessment of

[9] 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 (OJ L 156, 19.6.2018, p. 26–42.

[10] OJ L 278, 26.8.2020, pp. 1–132

completeness, information on methods and emission factors used, and information on recalculations performed.

Submissions of updated or additional inventory data and complete national inventory reports by Member States shall be reported by 15 March.

Specific requirements on structure, format, submission processes under the Governance Regulation are detailed in the Commission Implementing Regulation 2020/1208. According to the Governance Regulation and its implementing decision the reporting requirements are exactly the same as for the UNFCCC, regarding content and format. The EU and its Member States prepare the inventory according to the relevant provisions under the UNFCCC.

In relation to the UNFCCC review of the EU GHG inventory, it is relevant to highlight that the EU GHG inventory is based on the inventories of its MS. They are responsible for the methods, emission factors and emissions used, and for the implementation of the UNFCCC reporting guidelines and the 2006 IPCC Guidelines, taking into account inventory priorities and resource constraints.

The unique nature of the EU GHG inventory has been recognized by the GHG lead reviewers and is reflected in their conclusions (16^{th} and 19^{th} meetings, respectively).

Conclusions of the 16^{th} meeting of GHG lead reviewers:

Reviewing the GHG inventory of the European Union (EU): the LRs noted that the review of the EU submission is unique in that it is the direct sum of emissions and removals from the national inventories compiled by the EU member States as well as Iceland, and that individual member States as well as Iceland are also subject to an inventory review. The LRs further noted that the focus of the EU review should be on ensuring that the EU submission accurately reflects the summation of the emissions and removals of its member States as well as Iceland and that information is transparently reported in the EU NIR, particularly for key categories identified at the level of the EU. Recommendations directed at specific member States as well as Iceland are beyond the scope for inclusion in the ARR of the EU. The LRs encouraged the secretariat to conduct the review of the EU submission after the submissions from individual EU member States and Iceland have been reviewed;

Conclusions of the 19^{th} meeting of GHG lead reviewers, on the scope of and approach to the review of the EU GHG inventory:

The LRs concluded that the conclusions from the 16th meeting of LRs on the focus of the EU review, considering elements of the conclusions from the 3rd meeting of LRs, should be supplemented with the following recommendations for ERTs:

(i) At the start of the review, the LRs should request the ERT to focus the review on the transparency of the information reported in the EU national inventory report and provide guidance thereon, particularly for key categories identified at the EU level, followed by categories for which recalculations have been performed, and categories that are the subject of recommendations in the previous review report, as well as for findings in the initial assessment and progress in the implementation of planned improvements. The LRs recalled that the EU GHG inventory is compiled from the national GHG inventories of the EU member States, Iceland and the United Kingdom of Great Britain and Northern Ireland and that the ERT should assess whether the EU GHG inventory is compiled in accordance with the UNFCCC Annex I inventory reporting guidelines.

(ii) The LRs should ensure that recommendations in the review report are addressed to the EU, because the inventories of the member States, Iceland and the United Kingdom fall outside the scope of the EU review.

(iii) The LRs noted that the ERT may also consider information on the efforts undertaken at the EU level to address the main issues pertaining to the member States, Iceland and the United Kingdom, as reflected in previous EU review reports.

1.2 A description of the institutional arrangements

1.2.1 Institutional, legal and procedural arrangements

In accordance with the Governance Regulation Article 37(3), a Union Inventory system is established to ensure the timeliness, transparency, accuracy, consistency, comparability and completeness of national inventories with regard the Union greenhouse gas inventory. The Commission's Staff Working Document (SWD (2013) 308 final[11]) outlines the main elements of the Union inventory system. An overview is presented in Figure 1.1.

The Directorate General Climate Action of the European Commission has overall responsibility for the inventory of the European Union (EU) while each Member State is responsible for the preparation of its own inventory which is the basic input for the inventory of the European Union. DG Climate Action is supported in the establishment of the inventory by the following main institutions: the European Environment Agency (EEA) and its European Topic Centre on Climate Change Mitigation (ETC/CM) as well as the DG Eurostat[12].

[11] https://ec.europa.eu/clima/sites/clima/files/strategies/progress/monitoring/docs/swd_2013_308_en.pdf

[12] The Statistical Office of the European Communities (Eurostat) is a DG of the European Commission. For simplicity reasons, this institution is referred to as 'Eurostat'in this report.

Figure 1.1 Inventory system of the European Union

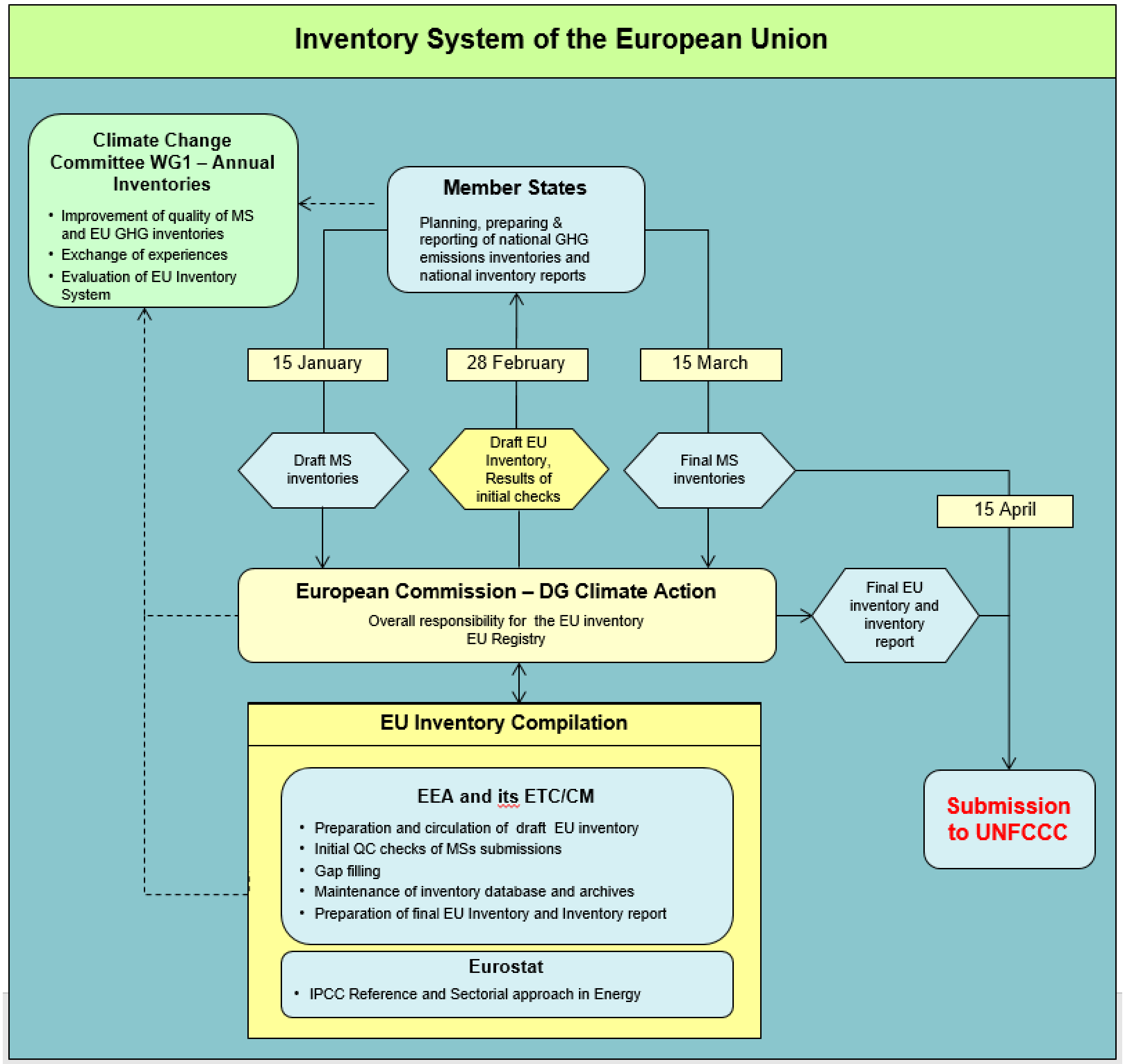


Table 1.1 shows the main institutions and persons involved in the compilation and submission of the EU inventory.

Table 1.1 List of institutions and experts responsible for the compilation of Member States' inventories and for the preparation of the EU inventory

Member State/EU institution	Contact address
Austria	Michael Anderl Umweltbundesamt michael.mailto:anderl@umweltbundesamt.at
Belgium	Peter Wittoeck Federal Department of the Environment
Bulgaria	Detelina Petrova Executive Environment Agency dpetrova@moew.government.bg
Croatia	Ms Vlatka Palčić and Ms Tatjana Obučina Ministry of Economy and Sustainable Development vlatka.palcic@mingor.hr; tatjana.obucina@mingor.hr Ms Iva Švedek

Member State/EU institution	Contact address
	Ekonerg - Energy and Environmental Protection Institute iva.svedek@ekonerg.hr
Cyprus	Theodoulos Mesimeris Department of Environment tmesimeris@environment.moa.gov.cy
Czech Republic	Ing. Eva Krtkova Czech Hydrometeorological Institute (CHMI) eva.krtkova@chmi.cz
Denmark	Ole-Kenneth Nielsen Aarhus University okn@envs.au.dk
Estonia	Kristiina Joon Ministry of the Environment Senior Officer, Climate Department kristiina.joon@envir.ee Cris-Tiina Pärn Adviser, Estonian Environmental Research Centre cris-tiina.parn @klab.ee
Finland	Riitta Pipatti Statistics Finland riitta.pipatti@stat.fi
France	Pascale Vizy Ministère de l'Environnement, de l'Energie et de la Mer (MEEM) Pascale.VIZY@developpement-durable.gouv.fr Jean-Pierre Chang Centre Interprofessionel Technique d'Etudes de la Pollution Atmosphérique (CITEPA) jean-pierre.chang@citepa.org
Germany	Dirk Günther Federal Environmental Agency Dirk.Guenther@uba.de
Greece	Mr. Kyriakos Psychas Ministry of Environment and Energy
Hungary	Mr. Gábor KIS-KOVÁCS Hungarian Meteorological Service kiskovacs.g@met.hu
Ireland	Paul Duffy Environmental Protection Agency p.duffy@epa.ie
Italy	M. Contaldi, R. de Lauretis, D. Romano National Environment Protection Agency (ANPA) riccardo.delauretis@isprambiente.it, daniela.romano@isprambiente.it
Latvia	Agita Gancone Ministry of Climate and Energy agita.gancone@kem.gov.lv
Lithuania	Ms. Jolanta Merkeliene Climate Change Policy Division of the Ministry of Environment Lithuanian Ministry of Environment j.merkeliene@am.lt
Luxembourg	Eric De Brabanter Département de l'Environnement Ministère du Développement durable et des Infrastructures eric.debrabanter@mev.etat.lu Dr. Marc Schuman

Member State/EU institution	Contact address
	Administration de l'Environnement marc.schuman@aev.etat.lu
Malta	Mr Saviour Vassallo Malta Resources Authority – Climate Change Unit Saviour.vassallo@mra.org.mt
Netherlands	Margreet van Zanten National Institute for Public Health and the Environment margreet.van.zanten@rivm.nlmailto:
Poland	Anna Olecka National Centre for Emissions Management Institute of Environmental Protection - National Research Institute anna.olecka@kobize.pl
Portugal	Ana Paula Rodrigues Agência Portuguesa do Ambiente, Departamento de Alterações Climáticas (DCLIMA) apaula.rodrigues@apambiente.pt
Romania	Sorin Deaconu National Environmental Protection Agency sorin.deaconu@anpm.ro
Slovakia	Janka Szemesova Department of Emissions and Biofuels, Slovak Hydrometeorological Institute janka.szemesova@shmu.sk
Slovenia	Tajda Mekinda Majaron Environmental Agency of the Republic of Slovenia tajda.mekinda-majaron@gov.si
Spain	Maj Britt Larka Abellán Dirección General de Calidad y Evaluación Ambiental y Medio Natural Ministerio de Agricultura, Alimentación y Medio Ambiente
Sweden	Anne Wisten The Ministry of the Environment anne.wisten@regeringskansliet.se Frida Löfström The Swedish Environmental Protection Agency frida.lofstrom@naturvardsverket.se
European Commission	Xavier Seront European Commission, DG Climate Action Xavier.SERONT@ec.europa.eu
European Environment Agency (EEA)	Ricardo Fernandez, Claire Qoul European Environment Agency Ricardo.Fernandez@eea.europa.eu, Claire.Qoul@eea.europa.eu
European Topic Centre on Climate Change Mitigation and Energy (ETC/CM)	Nicole Mandl, Michaela Gager, Elisabeth Rigler European Topic Centre on Climate Change Mitigation Umweltbundesamt nicole.mandl@umweltbundesamt.at, michaela.gager@umweltbundesamt.at, elisabeth.rigler@umweltbundesamt.at
Eurostat	Michael Goll Statistical Office of the European Communities (Eurostat) Michael.Goll@ec.europa.eu

1.2.1.1 The Member States

All EU Member States are Annex I parties to the UNFCCC Therefore, all Member States have committed themselves to prepare individual national GHG inventories in accordance with UNFCCC reporting guidelines and to submit those inventories to the UNFCCC secretariat by 15 April.

In this context, all Member States are required to establish, operate and seek to continuously improve national inventory systems in accordance to Article 37(1) of the Governance Regulation. Detailed information on institutional arrangements/national systems of each Member State is included in the respective national inventory reports.

The European Union's inventory is based on the inventories supplied by Member States. The total estimate of the EU greenhouse gas emissions should accurately reflect the sum of Member States' national greenhouse gas inventories. Member States are responsible for choosing activity data, emission factors and other parameters used for their national inventories as well as the correct application of methodologies provided in the 2006 IPCC Guidelines. Member States are also responsible for establishing quality assurance/quality control (QA/QC) programmes for their inventories. The QA/QC activities of each Member State are described in the respective national inventory reports.

For the EU to be able to provide the GHG inventory to the UNFCCC on time, all Member States are required to report individual GHG inventories prepared in accordance with UNFCCC reporting guidelines to the European Commission and to the European Environment Agency (EEA) by 15 January every year.

After the submission of national GHG inventories and inventory reports, QA/QC checks are performed by the EU team. The outcome of these 'initial checks', together with the draft EU inventory report is sent to Member States for checking, reviewing and providing of comments. The Member States take part in the review and comment phase of the draft EU inventory report. The purpose of circulating the draft EU inventory report is to improve the quality of the EU inventory. The Member States check their national data and information used in the EU inventory report, answer to the initial checks findings and send updates, as relevant by the 15th March. In addition, they can comment on the general aspects of the EU inventory report by the same deadline.

During the UNFCCC review of the Union inventory, Member States are also required to provide answers related to the issues under their responsibility as soon as possible. In these cases, the issues are forwarded directly as requested by the EU team.

The inventory authorities of the Member States take part in the Working Group 1 'Annual Inventories' (WG1) of the Climate Change Committee established under the Governance Regulation. The purpose of the Climate Change Committee is to assist the European Commission in its tasks under the Governance Regulation. Information on the WG1 tasks and responsibilities can be found in the next paragraph, but the main task of the WG1 members is to ensure the coordination of inventory activities between the Union system and the national inventory systems.

1.2.1.2 The European Commission, Directorate-General Climate Action

The European Commission's DG Climate Action in consultation with the Member States has the overall responsibility for the EU inventory. Member States are required to submit their national inventories and inventory reports under the Governance Regulation to the European Commission, DG Climate Action; and the European Commission, DG Climate Action itself submits the inventory and inventory report of the EU to the UNFCCC Secretariat, on behalf of the European Union. In the actual compilation of the EU inventory and inventory report, the European Commission, DG Climate Action, is assisted by the EEA including the EEA's ETC/CM and by Eurostat.

The consultation between the DG Climate Action and the Member States takes place in the Climate Change Committee established under Article 44(1)(a) of the Governance Regulation. The Committee is composed of the representatives of the Member States and chaired by the representative of the DG Climate Action. In order to facilitate decision-making in the Committee, working groups have been established, one of which is Working Group 1 on 'Annual inventories'. The objectives and tasks of Working Group 1 under the Climate Change Committee include:

- the promotion of the timely delivery of national annual GHG inventories as required under the Governance Regulation;
- the improvement of the quality of GHG inventories on all relevant aspects (transparency, consistency, comparability, completeness, accuracy and use of good practices);
- the exchange of practical experience on inventory preparation, on all quality aspects and on the use of national methodologies for GHG estimation;
- the evaluation of the current organisational aspects of the preparation process of the EU inventory and the preparation of proposals for improvements where needed.

1.2.1.3 The European Environment Agency

Under Article 42 of the Governance Regulation the role of the European Environment Agency (EEA) is defined as providing assistance to the Commission in its work. In relation to the inventories, this assistance includes the following:

(a) Compilation of the Union greenhouse gas inventory and preparation of the Union greenhouse gas inventory report;
(b) Performance of the quality assurance and quality control procedures for the preparation of the Union greenhouse gas inventory;
(c) Preparation of estimates for data not reported in the national greenhouse gas inventories;
(d) Conduction of the reviews of MS inventories.

The tasks of the EEA are facilitated by the European environmental information and observation network (Eionet), which consists of the EEA as central node (supported by European topic centres) and national institutions in the EEA member countries[13] (see http://eionet.eea.europa.eu). Member States report the information reported pursuant to Article 26(3) of the Governance Regulation to the Commission with a copy to the European Environment Agency, and for this reason they are making use of the EEA's ReportNet's Central Data Repository under the Eionet ('CDR', see http://cdr.eionet.europa.eu/).

Apart from the data capturing processes, and as part of its responsibility to compile the GHG inventory and prepare the Union GHG inventory report, the EEA is also responsible for the implementation of the QA/QC Programme of the EU, by performing inter alia a number of QA/QC checks focused on ensuring the completeness and consistency of the Union and Member States inventories. Since 2023 EEA is also responsible for initial checks and compilation of NIR chapters for the sectors agriculture and LULUCF (supported by ETC/CM – see below); in previous years these tasks were carried out by the Directorate General Joint Research Centre of the European Commission.

Finally, in the end of the process the EEA is publishing the GHG inventory dataset and the EU National Inventory Report on its website. To facilitate the access of the GHG information to the general public, the EEA data viewer is also provided.

The EEA is further assisted by its European Topic Centre on Climate Change Mitigation (ETC/CM), which is an international consortium working with the EEA under a framework partnership agreement. The activities of the EEA's ETC/CM are further deployed in the next paragraph.

1.2.1.4 The European Topic Centre on Climate Change Mitigation

The EEA's European Topic Centre on Climate Change Mitigation (ETC/CM) was established by a contract between the lead organisation Vito (vision on technology) in Belgium and EEA for the years 2022-2026, continuing on part of the work of the previous ETC/CME on Climate change Mitigation and Energy, which ended in 2021.

The EEA's ETC/CM involves 15 organisations and institutions in ten European countries. The technical annex of the work plan for the EEA's ETC/CM and a yearly action plan defines the specific

[13] EEA member countries include the EU Member States, Iceland, Liechtenstein, Norway, Switzerland and Turkey.

tasks of the EEA's ETC/CM partner organisations with regard to the preparation of the EU inventory and inventory report. Environment Agency Austria is the task leader for the compilation of the EU annual inventory and inventory report in the EEA's ETC/CM. The specific tasks undertaken by EEA's ETC/CM in this task include:

- Implementation of the quality assurance and quality control (QA/QC) procedures of the EU GHG inventory national system for the compilation and submission of the Union GHG inventory to the UNFCCC. Initial QA/QC checks of Member States' submissions are performed in cooperation with Eurostat and documented in the EEA review tool;
- Performing the first step of the annual Effort Sharing Regulation (ESR) review and identifying significant issues according to Art. 30 and Annex XXII of the Commission Implementing Regulation 2020/1208;
- Consultation with Member States in order to clarify data and other information provided;
- Preparation of the draft EU inventory and inventory report by 28 February based on Member States' submissions;
- Preparation of the final EU inventory and inventory report by 15 April (to be submitted by the Commission to the UNFCCC Secretariat).

The EEA's ETC/CM provides the CRF Aggregator developed to ensure the EU submission is fully consistent with member state's (MS) submissions. From the CRF aggregator the aggregated EU inventory is transferred into the CRF reporter software for preparing the official EU GHG inventory submission.

1.2.1.5 Eurostat

Eurostat collects national energy statistics reported under the EU Energy Statistics Regulation on an annual basis. These data are used for the estimation of the IPCC Reference Approach and the Sectoral Approach. The EEA compares the results of the two approaches with MS CRF submissions. These comparisons are sent to MS during the consultation on the Draft EU GHG inventory by 28 February. The Energy Statistics Regulation (Regulation EC/1099/2008) as amended by Commission Regulation (EU) No 147/2013 of 13 February 2013 is the basis for MS reporting of energy data to Eurostat. Article 6(2) of the Energy statistics regulation stipulates: 'Every reasonable effort shall be undertaken to ensure coherence between energy data declared in the energy statistics regulation, and data declared in accordance with Commission Decision No 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol'. The consistency of energy balances and CRF activity data is essential for good quality GHG estimates in the energy sector, and therefore it is at the core of the QA/QC activities at EU level.

1.2.2 Overview of inventory planning, preparation and management

1.2.2.1 A description of the process of inventory preparation

The annual process of compilation of the EU inventory is summarised in Table 1.2 . The Member States submit their annual GHG inventory by 15 January each year to the European Commission's DG Climate Action using the EEA's ReportNet Central Data Repository. Then, EEA's ETC/CM performs initial checks of the submitted data up to 28 February. The ETC/CM transfers the nationally submitted data from the xml-files into the CRF aggregator database which was developed for aggregating the EU submission from member state (MS) submissions. From the CRF aggregator the aggregated EU inventory is transferred into the CRF reporter software for preparing the official EU GHG inventory submission. Any information reported by MS in categories that do not have standardized UIDs or in categories for which several country settings are possible have to be included in the CRF Reporter manually.

Table 1.2 Annual process of submission and review of Member States inventories and compilation of the EU inventory

Element	Who	When	What
1. Submission of annual inventories (complete CRT and elements of the national inventory report) by Member States	Member States	15 January	Elements listed in Article 26(3) of the Governance Regulation
2. ‘Initial checks’ of Member States submissions	Commission (incl. Eurostat), assisted by the EEA	For the Member State submission from 15 January at the latest until 28 February	Checks to verify the transparency, accuracy, consistency, completeness and comparability of Member States’ inventories (by EEA). Comparison of energy data provided by Member States in the CRT with Eurostat energy data (sectoral and reference approach) by Eurostat and EEA. Check of Member States’ agriculture inventories by EEA (in consultation with Member States). Check of Member States’ land use, land-use change and forestry (LULUCF) inventories by EEA (in consultation with EEA and Member States).The findings of the initial checks will be documented.
3. Compilation of draft Union inventory and inventory report (elements of the Union inventory report)	Commission (incl. Eurostat), assisted by the EEA	up to 28 February	Draft Union inventory and inventory report (compilation of Member State information), based on Member State inventories and additional information where needed (as submitted on 15 January).
4. Circulation of ‘initial check’ findings including notification of potential gap-filling	Commission (DG Climate Action) assisted by the EEA	28 February	Circulation of ‘initial check’ findings including notification of potential gap-filling and making available the findings
5. Circulation of draft **Union** inventory and inventory report	Commission (DG Climate Action) assisted by the EEA	28 February	Circulation of the draft Union inventory on 28 February to Member States. Member States check data.
6. Submission of updated or additional inventory data and complete national inventory reports by Member States	Member States	15 March	Updated or additional inventory data submitted by Member States (to remove inconsistencies or fill gaps) and complete national inventory reports.
7. Member State commenting on the draft Union inventory	Member States	15 March	If necessary, provide corrected data and comments to the draft Union inventory
8. Member State responses to the ‘initial checks’	Member States	15 March	Member States respond to ‘initial checks’ if applicable.
9. Circulation of follow-up initial check findings	Commission assisted by EEA 31 March	Commission assisted by EEA 31 March	Circulation of follow-up initial check findings and making available the findings
10. Estimates for data missing from a national inventory	Commission (DG Climate Action) assisted by EEA	31 March	The Commission prepares estimates for missing data by 31 March of the reporting year, following consultation with the Member State concerned, and communicate these to the Member States.
11. Comments from Member States regarding the Commission estimates for missing data	Member States	7 April	Member States provide comments on the Commission estimates for missing data, for consideration by the Commission.
12. Member States responses to follow-up ‘initial checks’	Member States	7 April	Member States provide responses to follow up of ‘initial checks’.
13. Member States submissions to the UNFCCC	Member States	15 April	Submissions to the UNFCCC (with a copy to EEA)
14. Final annual Union inventory (incl. EU inventory report)	Commission (DG Climate Action) assisted by EEA	15 April	Submission to UNFCCC of the final annual Union inventory.
15. Submission of any other resubmission after the initial	Member States	When additional	Member States provide to the Commission any other resubmission

Element	Who	When	What
check phase		resubmissions occur	(CRT or national inventory report) which they provide to the UNFCCC secretariat after

By 28 February, the draft EU GHG inventory and inventory report are circulated to the Member States for review and comment. The Member States check their national data and information used in the EU inventory report and send updates, if necessary, and review the EU inventory report by 15 March. This procedure should assure the timely submission of the EU GHG inventory and inventory report to the UNFCCC Secretariat and it should guarantee that the EU submission to the UNFCCC Secretariat is consistent with Member States' UNFCCC submissions.

The final EU GHG inventory and inventory report is prepared by the EEA's ETC/CM by 15 April for submission to the UNFCCC Secretariat. After the submission to UNFCCC the inventory and the inventory report are published on the EEA website (http://www.eea.europa.eu) and the data are made available through the EEA data service (http://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-unfccc-and-to-the-eu-greenhouse-gas-monitoring-mechanism-9) and the EEA GHG data viewer

(http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer.)

Table 1.3 summarises timeliness and completeness of the EU Member States submissions in 2023 that were taken into account for the compilation EU GHG inventory.

Table 1.3 Date, mode and content of submission of EU Member States in 2023 that were taken into account for the compilation of EU GHG inventory

MS	Date	Submission mode	XML	CRF	NIR
AUT	15.03.2023	CDR	AUT_2023_2_14032023_1811168572142305488919927	1990-2021	x
BEL	15.03.2023	CDR	BEL_2023_1_14032023_1100161394471016717600873	1990-2021	x
BGR	15.03.2023	CDR	BGR_2023_1_07032023_2006066466280856462442663	1988-2021	x
CYP	07.03.2023	CDR	CYP_2023_5_07032023_1316054297440647173769100	1990-2021	
CYP	14.03.2023	CDR			x
CZE	13.03.2023	CDR	CZE_2023_2_06032023_1549511605512993480027754	1990-2021	x
DEU	15.03.2023	CDR	DEU_2023_2_13032023_1141366615856812153243971	1990-2021	x
DNM	15.03.2023	CDR	DNM_2023_1_13032023_1528353594768088021416329	1990-2021	x
ESP	15.03.2023	CDR	ESP_2023_2_13022023_0918328778019735951346079	1990-2021	x
EST	15.03.2023	CDR	EST_2023_1_14032023_1432446958541084519635465	1990-2021	x
FIN	15.03.2023	CDR	FIN_2023_2_08032023_0851561534978048188815755	1990-2021	x
FRK	15.03.2023	CDR	FRK_2023_1_14032023_1122322657851179311453982	1990-2021	x
GRC	15.03.2023	CDR	GRC_2023_1_18022023_1447337529686829563055080	1990-2021	x
HRV	15.03.2023	CDR	HRV_2023_1_14032023_1317573138050524460328637	1990-2021	x
HUN	17.03.2023	CDR	HUN_2023_2_17032023_1023298169124536052310591	1985-2021	
HUN	20.03.2023	CDR			x
IRL	15.03.2023	CDR	IRL_2023_2_08032023_13072862926718742285239	1990-2021	x
ITA	15.03.2023	CDR	ITA_2023_1_03032023_1840327136302360811658175	1990-2021	x
LTU	15.03.2023	CDR	LTU_2023_1_14032023_1706596491371771525735991	1990-2021	
LTU	17.03.2023	CDR			x
LUX	15.03.2023	CDR	LUX_2023_2_06032023_1257571599800436878973223	1990-2021	x
LVA	15.03.2023	CDR	LVA_2023_2_10032023_1518065064787951624836472	1990-2021	x

MS	Date	Submission mode	XML	CRF	NIR
MLT	13.03.2023	CDR			x
MLT	13.03.2023	CDR	MLT_2023_2_06032023_135251580922533557385001	1990-2021	
NLD	15.03.2023	CDR			x
NLD	16.03.2023	CDR	NLD_2023_1_06032023_0914213602593415506818424	1990-2021	
POL	15.03.2023	CDR	POL_2023_1_10032023_1159476066973457462964238	1988-2021	x
PRT	14.03.2023	CDR	PRT_2023_1_10032023_2229044927850958747790821	1990-2021	x
ROU	15.03.2023	CDR	ROU_2023_2_09032023_0903262505267739345725341	1989-2021	x
SVK	15.03.2023	CDR	SVK_2023_4_13-03-2023_simple	1990-2021	x
SVN	15.03.2023	CDR	SVN_2023_3_10032023_2138591896340231941417953	1986-2021	x
SWE	15.03.2023	CDR	SWE_2023_1_30012023_1504082880998344132668622	1990-2021	x

Table 1.4 gives an overview on people involved in the compilation of the EU GHG inventory submission in 2023 and their individual responsibilities in this process.

Table 1.4 Responsibility list for the compilation of the EU GHG inventory submission in 2023

	Name	**EU GHG inventory/inventory report compilation**				**Initial Checks**			
		Overall responsibility	Project manager	Sector experts	Quality expert	Overall responsibility	QA/QC coordinator	Sector experts/ expert	Quality expert
Commission	Xavier Seront (DG Clima) Xavier.SERONT@ec.europa.eu	X			Executive summary, chapter 1				
	Roxanne Lake (DG Clima) Roxanne.LAKE@ec.europa.eu	X			Executive summary, chapter 1				
	Francesca LANZA (DG Clima) Francesca.LANZA@ec.europa.eu			Annex - Kyoto units, Annex - Changes to registry, EU-SEF Tables / Annex					
	Bogdan Voinea (DG Clima) Bogdan.VOINEA@ext.ec.europa.eu			Annex - Changes to registry, EU-SEF Tables, Annex					
	Michael Goll (Eurostat) Michael.Goll@ec.europa.eu			1A Reference approach				1A Reference approach	
EEA and ETC-CM	Ricardo Fernandez (EEA) ricardo.fernandez@eea.europa.eu	X			Executive summary, chapter 1, trend chapter, chapter 10				
	Claire Qoul (EEA) claire.qoul@eea.europa.eu	X			Executive summary, chapter 1, trend chapter, chapter 10	X			
	Peter Iversen (EEA) peter.iversen@eea.europa.eu			sector 4	sector 4			sector 4	sector 4
	Herdis Gudbrandsdottir (EEA) herdis.gudbrandsdottir@eea.europa.eu			Data checks					
	Gorka Mendiguren Gorka.Mendiguren@eea.europa.eu			plots all sectors				plots sector 3, plots all sectors	
	Katarzyna Kowalczewska Katarzyna.Kowalczewska@eea.europa.eu				sector 3				sector 3
	Michaela Gager (ETC/CM; UBA-V) michaela.gager@umweltbundesamt.at		Data manager	support				support	
	Günther Schmidt (ETC/CM; UBA-V) guether.schmidt@umweltbundesamt.at		Data manager						

Name	EU GHG inventory/inventory report compilation				Initial Checks			
	Overall responsibility	Project manager	Sector experts	Quality expert	Overall responsibility	QA/QC coordinator	Sector experts/ expert	Quality expert
Bernd Gugele (ETC/CM, UBA-V) bernd.gugele@umweltbundesamt.at		X	Executive summary, chapter 1, trend chapter, 1A reference approach			X	cross-cutting issues, 1A reference approach	cross-cutting issues
Bradley Matthews (ETC/CM, UBA-V) bradley.matthews@umweltbundesamt.at			uncertainties				uncertainties	
Manuela Wieser (ETC/CM, UBA-V) manuela.wieser@umweltbundesamt.at				sector 2 - f-gases only				sector 2 - f-gases only
Marion Pinterits (ETC/CM; Klarfakt) m.pinterits@klarfakt.com		Support	1B, 1C	Reference approach			1B, 1C	Reference approach
Elisabeth Kampel (ETC/CM, Klarfakt) e.kampel@klarfakt.com		Support	chapter 10					
Zuzana Roskova (ETC/CM;CHMI) zuzana.roskova@chmi.cz			1A2				1A2	
Barbora Koci (ETC/CM; CHMI) barbora.koci@chmi.cz			1A4, 1A5				1A4, 1A5	
Jitka Slamova (ETC/CM; CHMI) jitka.slamova@chmi.cz				1A1				1A1
SAARIKIVI RISTO JUHANA (ETC/CM; CHMI) ristojuhana.saarikivi@chmi.cz				sector 5				sector 5
Céline GUEGUEN (ETC/CM; T4L) celine.gueguen2@gmail.com			sector 5				sector 5	
Coralie JEANNOT (ETC/CM; CITEPA) coralie.jeannot@citepa.org			EU ETS, 2C				EU ETS, 2C	
Julien Vincent (ETC/CM; CITEPA) julien.vincent@citepa.org			1A1, 2D, 2G3-2G4, 2H	1A2, 1A4, 1A5; 1B, 1C			1A1, 2D, 2G3-2G4, 2H	1A2, 1A4, 1A5; 1B, 1C
Etienne MATHIAS etienne.mathias@citepa.org				sector 3				sector 3
Anais Durand anais.durand@citepa.org			sector 3				sector 3	
Giorgos Mellios (ETC/CM; Emisia) giorgos.m@emisia.com				1A3 + bunkers				1A3 + bunkers
Giannis Papadimitriou (ETC/CM; Emisia) giannis.p@emisia.com			1A3 + bunkers, comparison with Eurocontrol				1A3 + bunkers	
Barbara Gschrey (ETC/CM; Oeko Recherche) b.gschrey@oekorecherche.de			F-gases, 2B9 2E, 2F, 2G1-2				F-gases, 2B9 2E, 2F, 2G1-2	
David Robin (ETC/CM; Oeko Recherche) david.robin@oekorecherche.de			F-gases, 2B9 2E, 2F, 2G1-2				F-gases, 2B9 2E, 2F, 2G1-2	

Name	EU GHG inventory/inventory report compilation				Initial Checks			
	Overall responsibility	Project manager	Sector experts	Quality expert	Overall responsibility	QA/QC coordinator	Sector experts/ expert	Quality expert
Lorenz Moosmann (ETC/CM; Oeko) l.moosmann@oeko.de			sectors 2A, 2B				2A, 2B	
Lukas Emele (ETC/CM; Oeko) l.emele@oeko.de			sectors 2A, 2B				2A, 2B	
Ils Moorkens (ETC/CM; VITO) ils.moorkens@vito.be				sector 2 (excluding F-gases)				sector 2 (excl. f-gases)
Raul Abad-Vinas abad.raul@hotmail.com			sector 4				sector 4	

1.2.3 Quality assurance, quality control of the European Union inventory

1.2.3.1 Quality assurance and quality control procedures in the EU

The European Commission (Directorate General Climate Action) is responsible for coordinating QA/QC procedures for the EU inventory and ensures that the objectives of the QA/QC programme are implemented in the design of the QA/QC manual defining general and specific QC procedures for the EU GHG inventory submission. The European Environment Agency (EEA) is responsible for the annual implementation of these QA/QC procedures for the EU inventory.

The EU QA/QC programme is established in Chapter II of the Commission's Staff Working Document (SWD(2013) 308). In the EU QA/QC programme the general responsibilities for the QA/QC are defined as follows:

- The Member States are responsible for the quality of activity data, emission factors and other parameters used for their inventories, for adherence to the IPCC methodologies and the establishment of the national QA/QC programmes. As EU Member States inventories form part of the EU inventory submission information on the individual Member States QA/QC procedures can be found in their national inventory reports.
- The European Commission (DG Climate Action) is responsible for setting up the QA/QC Programme, ensuring the establishment and fulfilment of its objectives and ensuring the development of a QA/QC plan.
- The EEA, together with its ETC/CM, are responsible for the practical implementation and coordination of QA/QC procedures for the Union inventory, as well as for the archiving and documentation.

The following part focuses on QA/QC procedure at EU level.

The overall objectives of the EU QA/QC programme are:

- To establish quality objectives for the EU GHG inventory taking into account its specific nature of the EU GHG inventory as a compilation of MS GHG inventories:
- To implement the quality objectives in the design of the QA/QC plan defining general and specific QC procedures for the EU GHG inventory submission taking into account the specific nature of the EU GHG inventory:
- to provide an EU inventory of greenhouse gas emissions and removals consistent with the sum of Member States' inventories of greenhouse gas emissions and removals submitted to the EU and covering the EU geographical area:
- to ensure the timeliness of MS GHG inventory submissions to the EU for the compilation of the EU's GHG inventory;
- to ensure the completeness of the EU GHG inventory, inter alia by implementing procedures to estimate any data missing from the national inventories, in consultation with the MS concerned;
- to contribute to the improvement of quality of Member States' inventories and
- to provide assistance for the implementation of national QA/QC programmes.

A number of specific objectives have been elaborated in order to ensure that the EU GHG inventory complies with the UNFCCC inventory principles of transparency, completeness, consistency, comparability, accuracy and timeliness. The quality objectives are implemented via the QA/QC plan that, among others, aims at ensuring the consistency of the Union inventory with the sum of Member States inventories so that the inventory is complete in terms of both geographical and sectoral coverage. The QA/QC plan describes the quality control procedures that take place before the EU inventory compilation, for checking the consistency, completeness and correctness of the Member States inventories, as well as during the compilation of the EU GHG inventory, for ensuring the correctness of the EU data prior to its submission. In addition, QA procedures, procedures for documentation and archiving, the time schedules for QA/QC procedures and the provisions related to the inventory improvement plan are also included.

Based on the EU QA/QC programme a quality management manual was developed which includes all specific details of the QA/QC procedures (in particular checklists and forms). The structure of the EU quality management manual has been developed on the basis of the Austrian quality management manual. The reason for using the Austrian manual as a template for the EU manual is that the EU GHG inventory is compiled by Environment Agency Austria and the implementation of the annual QA/QC procedures are coordinated by Environment Agency Austria. By using the Austrian quality manual as a template for the EU quality manual the EU can benefit from the experience made during the set-up of the Austrian quality management system which fulfils the requirements of EN ISO/IEC 17020 (Type A); procedures and documents from the Austrian system have been taken and adapted according to the need of the EU quality management system.

The EU quality management manual is structured along three main processes (management processes, inventory compilation processes and supporting processes) of the quality management system (Table 1.5).

Table 1.5 Structure of the EU quality management manual

Chapter		Chapter description
Management processes		
ETC 01	EU inventory system	Describes the organisation and responsibilities within the EU GHG inventory system
ETC 02	QA/QC programme	Describes the preparation and evaluation of the EU QA/QC programme by the European Commission
ETC 03	Quality management system	Describes the responsibilities and the structure of the quality management system and gives an overview of the forms and checklists used
ETC 04	Quality management evaluation	Describes the evaluation of the status and effectiveness of the quality management system
ETC 05	Correction and prevention	Describes the procedures for the correction and prevention of mistakes that occur in the EU inventory
ETC 06	Information technology systems	Describes the information technology systems used such as CIRCA, Reportnet and the systems set up at Environment Agency Austria
ETC 07	External communication	Describes the communication with Member States and other persons and institutions
Inventory compilation processes		
ETC 08	QC MS submissions	Describes the quality control activities performed on the GHG inventories submitted by the EU Member States
ETC 09	QC EU inventory compilation	Describes the quality control activities performed during the compilation of the EU GHG inventory including checks of database integrity
ETC 10	QC EU inventory report	Describes the checks carried out during and after the compilation of the EU GHG inventory report
Supporting processes		
ETC 11	Documents	Describes the production, change, proofreading, release and archiving of quality management documents
ETC 12	Documentation and archiving	Describes the procedure for preparing documentation and archiving

The quality checks performed during inventory compilation process are the central part of the quality manual. Quality checks are made at three levels:

QUALITY CONTROL MS SUBMISSIONS

The QC activities of MS submissions include:

Completeness checks

- Check if all gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3) are available for all years
- Check correct use of notation keys related to completeness
  - Check categories where a MS report the notation key "NE" and where the current guidelines include methods/emission factors
  - Check categories where MS report a notation key ("NE", "NO", "NA", "IE") and >= 20 MS report emissions
  - Check categories where MS report "NE" and in the previous years they reported emissions
- Check blank cells

Time series consistency checks

- Check time series of emissions
- Check time series of implied emission factors
- Check if identical values have been used for the last two reporting years.

Comparisons of implied emission factors across Member States

Recalculations

- Check categories where MSs provide recalculations and focus on those of more than +/- 0.05% of national total emissions for each main gas and assess if there are potential over- or underestimates (excluding the effect of GWPs).
- Explanations for recalculations also need to be checked
- Check recalculations at more detailed category level compared to submission of the same year (e.g. recalculations between 15 January submission and 15 March submission of the same year)

EU ETS

- Check of consistency/transparency of EU ETS data with the CRF

Eurostat energy data

- Check of consistency of Eurostat energy data with the CRF

Recommendations

- Check whether recommendations from earlier Union or UNFCCC reviews, have been implemented by the Member State

Potential over- and underestimations

- Assess whether there are potential overestimations or underestimations in a Member State's inventory

Checks of MS reporting concerning methods and emission factors used by MS

- Additional QA/QC checks have been included in the yearly procedure in order to address the inconsistencies between the Member States' CRF tables and annex III to the NIR, which is updated regularly by member States.

- From 2023 onward it became mandatory for Member States to provide the relevant information as part of the reporting requirements under the new Governance Regulation.
- During the initial checks the EU inventory team checked consistency of MS CRF reporting with information reported by MS for Annex III.

For the communication with Member States and the documentation of the observations made by sector experts during the 'initial checks' phase the EEA Emission Review Tool (EMRT; https://emrt.eea.europa.eu/) is used. For this reason Member States nominations have been made to DG Climate Action and the EEA. The workflow in the tool allows the implementation of the 'four-eye' principle since the questions of the 'sectoral experts' are approved by the 'quality experts' team. Issues related to 'completeness', especially the ones that might need to be followed up by 'gap filling procedures' are also highlighted. All the issues identified in the EMRT are archived and can be accessed by the future EU sectoral and quality experts in the annual QA/QC procedures, to avoid repetition of questions on known issues.

According to the timeline provided above, the checks are performed between 15th January and 28th February.

On 28 February MS receive the EIONET/WG1 consultation package. In particular, Member States are asked to check:

1. the QA/QC findings flagged in the EMRT;
2. if the correct data/information has been included in the draft CRF tables/draft inventory report, including the information on methodologies and EFs used for the EU key categories (Annex III).

Both responses to the findings included in the EMRT and comments to the draft EU GHG inventory and inventory report are provided by latest 15 March to the EU inventory team. By that date Member States can resubmit their inventories, also correcting issues that came up during the initial checks. In order to follow up on significant issues, as provided for in the Governance Regulation, all the tools supporting the checks are re-produced and the findings in the EMRT are followed up. Between 15th March and 7th April follow-up questions and questions on new material received from MS may be asked in the EMRT.

Observations by the EU inventory team that are not resolved at the end of the QA/QC process in one submission year will be followed-up in the consecutive year.

QUALITY CONTROL EU INVENTORY COMPILATION

After the initial checks of the emission data, the ETC/CM transfers the national data from the xml-files into the ETC/CM CRF aggregator database. The ETC/CM CRF aggregator database is maintained and managed by Environment Agency Austria. The new CRF Aggregator has been designed in a way that the EEA can also perform the aggregation to ensure that there is always a back-up option and minimizing the risk of not submitting to the UNFCCC.

As the EU GHG inventory is compiled on the basis of the inventories of the EU Member States, the focus of the quality control checks performed during the compilation of the EU GHG inventory lays on checking if the correct MS data are used, if the data can be summed-up (same units are used) and that the summing-up is correct. Finally, the consistency and the completeness of the EU GHG inventory is checked. These checking procedures are performed by the EEA and the results are shared with the ETC/CM and are archived. Comments to these results are then provided and used as relevant for approving the inventory prior to its submission. All the checks are carried out for the original submission by 15 April each year and for any resubmission. Two checklists from the QA/QC manual are used for this purpose: 'Inventory preparation/consistency' and 'Data file integrity'.

QUALITY CHECKS EU INVENTORY REPORT

The checks carried out during and after the compilation of the EU GHG inventory report, are specified in the checklist 'EU inventory report' as defined in the QA/QC manual. They cover e.g. checks of data consistency between the inventory and the inventory report, data consistency between the tables and the text, but also layout checks. Since 2014 the EU team has also been reinforced by 'quality control' experts who have the additional task of reviewing the content and the consistency between the CRF data and tables and the NIR.

The circulation of the draft EU inventory and inventory report on 28 February to the EU Member States for reviewing and commenting also aims to improve the quality of the EU inventory and inventory report. The Member States check their national data and information used in the EU inventory report and send updates, if necessary, and review the EU inventory report. This procedure should assure the timely submission of the EU GHG inventory and inventory report to the UNFCCC secretariat and it should guarantee that the EU submission to the UNFCCC secretariat is consistent with the Member States UNFCCC submissions.

EU peer review

A collaborative internal review mechanism was established within the European Union such that all participants (MS, EEA, Eurostat, and JRC) may contribute to the identification of shortcomings and propose amendments to existing procedures. The review activities with experts from Member States are coordinated by the ETC/CM through WG1 and normally take place during the period from April through September each year. The synthesised findings of collaborative reviews provide a basis for the planned progressive development of inventories both at Member State and at EU level.

In 2014, such activities included the identification of areas where inconsistent reporting between different Member States could have taken place, in cases where the 2006 IPCC Guidelines are not sufficiently clear, and discussions on how the ETS data are used in the inventories. These discussions were followed up in 2016 and 2017, after analysing the inventory reporting of the Member States and the conclusions from the UNFCCC reviews.

In 2017, a team of Member States' experts reviewed the EU GHG NIR and provided recommendations for improvements. Several of these recommendations have been implemented in the submissions thereafter.

EU internal reviews (Reviews under the 'Effort Sharing Decision')

Between 2012 and 2022, nine EU internal inventory reviews have been carried out in order to determine the emission allocations 2013-2020 for the EU internal GHG emission reduction targets for 2020 and in order to determine compliance with the ESD targets.

The Effort Sharing Decision (ESD)[14] sets out the 2020 emission limit of a Member State in relation to its 2005 emissions, and its emission limits from 2013 to 2020 form a linear trajectory. In accordance with Article 3.2 of the ESD, the starting point of the linear trajectory is defined as the average annual ESD emissions during 2008, 2009 and 2010 in 2009 (for Member States with positive limits under Annex II of the ESD) or in 2013 (for Member State with negative limits). The annual emission allocations shall be determined using reviewed and verified emission data. Thus, complete emission inventories for the reference years (2005, and 2008-2010) had to be available and reviewed prior to determining the annual emission allocations in 2012. In order to determine compliance with the ESD targets accurate, reliable and verified information on annual greenhouse gas emissions is needed from the inventory year 2013 onwards.

[14] Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020; OJ L 140, 5.6.2009, p. 136–148

The ESD reviews were coordinated by the EEA, and were carried out in two steps: Step 1 was implemented by the EU team and made use of the procedures available in the EU QA/QC system, taking into account both the existing quality assurance/quality control procedures for Member States' emission inventory submissions under EU legislation and the separate inventory review process occurring under the UNFCCC. Step 2 was implemented by independent review teams comprising of lead reviewers and sector experts. The ESD reviews were carried out either as comprehensive review or as annual review (see separate box).

The reviews under the ESD can be seen as a more robust and consistent QA of MS GHG inventories that have led to improvements in the quality of the EU and its Member States' GHG inventory submissions to UNFCCC in the years thereafter.

Specific activities for the LULUCF sector are described under Ch. 7.10 Quality Assurance and Quality control.

Annual and comprehensive ESD review

In 2012, the first comprehensive ESD review was carried out in order to determine the emission allocations 2013-2020 for the EU internal GHG emission reduction targets 2020 and respective trajectories. All 28 Member States have been reviewed by a team of 22 reviewers.

From 2015 onwards the GHG emission inventories were reviewed annually in the context of the "ESD review". The Monitoring Mechanism Regulation (MMR)[15] enhanced the reporting rules on GHG emissions to meet reporting requirements to the UNFCCC Secretariat and introduced requirements concerning the monitoring, reporting, reviewing and verifying of GHG emissions and other information pursuant to Article 6 of the Effort Sharing Decision.
The ESD and the MMR introduced an annual compliance cycle requiring a review of Member States' greenhouse gas inventories within a shorter time frame than the current UNFCCC inventory review to enable the use of flexibilities and the application of corrective action, where necessary, at the end of each relevant year.
Article 19 of the MMR established an EU-internal review process to ensure that compliance with annual GHG emission limits is assessed in a credible, consistent, transparent and timely manner. The reviewed inventory data is used to check Member States' compliance with their annual ESD targets. There were two types of reviews: annual and comprehensive. Comprehensive reviews have been carried out in 2016 and 2020 – for all other years an annual review was carried out. The annual review consisted of two steps. The first step verified the transparency, accuracy, consistency, comparability and completeness of the national inventory data. The checks of step 1 were made by the same team that carried out the initial checks before the compilation of the EU GHG inventory. If the first step of the annual review revealed a significant issue as defined by Article 19(4) of the MMR, such as overestimations or underestimations relating to a key category in a Member State's inventory, a review team performed the second step checks of the national inventory data of this Member State to identify cases where inventory data is prepared in a manner which is inconsistent with UNFCCC guidance documentation or Union rules. Where appropriate, the review team calculated the resulting technical corrections, in consultation with the concerned Member State, to correct originally submitted estimates.
In 2015, due to the problems with the CRF reporting software the annual review had to be postponed to 2016. However, the European Commission decided to organize a trial review in order to support Member States in improving their GHG inventories and to gain experience organizing reviews and reviewing under the new guidelines. In 2015, step 1 checks were made for all 28 Member States whereas step 2 was carried out only for 18 Member States which volunteered to participate in step 2.
In April-August 2016, the second comprehensive review was carried out. All 28 Member States have been reviewed by a team of 22 reviewers. As it was not possible to carry out the ESD review in 2015 due to the problems with CRF reporter software the ESD comprehensive review 2016 has been an extended review and covered the years 2005, 2008-2010 and 2013-2014. The review considered the six GHGs CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. It did not consider NF_3 because

[15] Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC; OJ L 165, 18.6.2013, p. 13–40

NF_3 is not covered by the ESD. All sectors were considered with the exception of LULUCF; domestic and international aviation was also reviewed but no technical corrections were made because aviation is covered under the EU ETS and excluded under the ESD.
In 2017, 2018 and 2019 annual reviews have been performed. The annual review is a two steps process where all 28 MS have to undergo step 1 and only those Member States are subject to step 2 for which significant issues are identified during step 1.

- In 2017 15 MS were subject to step 2; the final review reports include 70 recommendations, 16 revised estimates provided by the Member States and four technical corrections calculated by the review team.
- In 2018 eleven MS were subject to step 2; the final review reports include 34 recommendations, ten revised estimates provided by the Member States and one technical correction calculated by the review team.
- In 2019 13 MS were subject to step 2. In addition Norway and Iceland participated in step 2 on a voluntary basis. The final review reports include 56 recommendations, 16 revised estimates provided by the Member States and four technical correction calculated by the review team.

In April-August 2020, the third comprehensive review was carried out. All 27 EU Member States + UK, Iceland and Norway were reviewed by a team of 28 reviewers. On the basis of the GHG inventories reviewed in 2020, the European Commission fixed the base year and the greenhouse gas emissions targets for 2030, and the trajectory years for 2021-2029. The review covered the years 2005 and 2016-2018, all gases and all sectors apart from LULUCF. The review resulted in 133 recommendations, 79 revised estimates received from countries and eight technical corrections calculated by the review team.
In 2021, an annual review was organized in order to assess compliance of the MS with the ESD targets for the inventory year 2019. 18 MS were subject to step 2. The final review reports include 32 recommendations, 14 revised estimates provided by the Member States and three technical corrections calculated by the review team.
In 2022, an annual review was organized in order to assess compliance of the MS with the ESD targets for the inventory year 2020. Eight MS were subject to step 2. The final review reports include 21 recommendations, 14 revised estimates provided by the Member States and three technical corrections calculated by the review team.

Capacity building activities based on the ESD reviews

After the ESD review in autumn, each year capacity building workshops/webinars are organized in order to discuss cases where MS had problems with implementing the 2006 IPCC guidelines and/or where the guidelines are not clear enough or where there are gaps and/or errors in the guidelines.

In 2017, four webinars were organized for following the sectors Energy, IPPU, Agriculture, and Waste. Overall experts from 26 Member States + Iceland and Norway participated in the webinars. The webinar conclusions include 55 issues, 47 of which were considered to be resolved by 30 November 2017. Eight issues have been subject to follow-up activities.

In 2018, four webinars were organized following the sectors Energy, IPPU, Agriculture, and Waste on four days. The IPPU webinar was split into two sessions following the (group of) subcategories of the ESD review 2018: (1) IPPU excluding F-gases and (2) IPPU F-gases. Overall experts from 23 Member States plus Iceland and Norway registered for the webinars. In total 110 experts registered for one or more webinars. During the webinars in 2018 the status of all open issues from previous webinars was presented and discussed. Seven out of eight follow-up issues from 2017 have been resolved and closed during 2018.

In 2019, four webinars were organized following the sectors Energy, IPPU, Agriculture, and Waste on four days. Overall 109 experts from 21 Member States registered for one or more webinars.

In 2020, four webinars were carried for the sectors Energy, IPPU, Agriculture, and Waste. As the ESD review 2020 was a comprehensive review covering all Member States a larger number of Member

States' experts participated in the webinars. Overall, 176 experts from 23 Member States registered for one or more webinars.

In 2021, four webinars were carried for the sectors Energy, IPPU, Agriculture, and Waste. Overall, 193 experts from 26 Member States registered for one or more webinars. In addition, a webinar was also organized for LULUCF based on the findings from the LULUCF trial review 2021 that was carried out in parallel with the ESD review 2021. The purpose of the LULUCF trial review 2021 was to prepare the Member States for the new reporting needs regarding the EU LULUCF Regulation. 15 volunteering countries were subject to the LULUCF trial review 2021. At the LULUCF webinar, 64 experts from 22 countries participated.

In 2022, four webinars were carried for the sectors Energy, IPPU, Agriculture, and Waste. Overall, 217 experts from 26 Member States registered for one or more webinars.

As a result of the capacity building webinars guidance documents have been developed in order to support the Member States in improving their inventories. By April 2023 19 guidance documents are available: five for the Energy Sector; six for the IPPU Sector; four for the Agriculture Sector; four for the Waste Sector.

Apart from the capacity building webinars open to all Member States the ESD project team carried out additional capacity building targeted at specific countries in 2018, 2019 and 2020. In this context the experts:

- Provided support via e-mail or webinar for several MS related to the sectors energy, transport, F-gases, agriculture and waste;
- Organized five in-country visits in the sectors energy, transport, F-gases, agriculture and waste.

In the year 2023 further country-specific support is planned.

UNFCCC reviews

In addition, European Union QA procedures build on the issues identified during the independent UNFCCC inventory review of Member States' inventories. Quality assurance procedures based on outcomes of the UNFCCC inventory review consist of the:

- Annual compilation of issues identified during the UNFCCC inventory review related to sectors, key source categories and the major inventory principles transparency, consistency, completeness, comparability and accuracy for all Member States;
- Identification of major issues from the compilation and discussion of ways to resolve them in WG1, including identification and documentation of follow-up actions that are considered as necessary within WG1;
- Reviews of the extent to which issues identified through this procedure in previous years have been addressed by Member States;
- Ongoing investigations of ways to produce a more transparent inventory for the unique circumstances of the European Union.

In 2022 the European Union was last reviewed by the UNFCCC inventory review. The latest review report is not yet published but the review report from 2020 is publicly available on the UNFCCC web site[16].

[16] Inventory Review Reports 2020 | UNFCCC

Improvement plan

Based on the findings of the UNFCCC reviews, the EU peer review, and the EU ESD review, and other recommendations the improvement plan for the EU GHG inventory and inventory report is compiled before the annual compilation process starts. After the finalisation of the annual EU GHG inventory, it is evaluated if the improvements planned have been implemented.

1.2.3.2 Further improvement of the QA/QC procedures

One of the most important activities for improving the quality of national and EU GHG inventories is the organisation of workshops and expert meetings under EU legislation. A number of other workshops and expert meetings have been organised in recent years with a focus on sector-specific quality improvements. Table 1.6 lists the most recent workshops. The follow-up activities are subsequently addressed in meetings of WG 1 under the Climate Change Committee.

Table 1.6 Overview of recent GHG inventory related workshops and expert meetings organised by the EU

Workshop/expert meeting	Date and venue
JRC technical workshop: Towards 'fit for 55': updates in LULUCF reporting and accounting"	20-21 June 2022, Varese, Italy
JRC virtual technical workshop: LULUCF in transition: present and future challenges for reporting and accounting	7-8 June 2021
JRC technical LULUCF workshop under the UNFCCC, the Kyoto Protocol (KP) and the EU LULUCF Decision No 529/2013	28-29 May 2019, Varese, Italy
JRC technical workshop on LULUCF reporting under the Kyoto Protocol	16-17 May 2018, Arona, Italy
Joint Workshop of the Eurostat Working Group Agro-Environmental Statistics and DG CLIMA Working Group 1	30 November 2017, ESTAT Luxembourg
JRC technical LULUCF workshop under the UNFCCC, the Kyoto Protocol (KP) and the EU LULUCF Decision No 529/2013	26-27 April 2017, Stresa, Italy
Joint workshop of the Eurostat Working Group Agro-Environmental Statistics and DG CLIMA Working Group 1	30 November 2017, Luxembourg

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

The national inventory arrangements were changed in 2023 as from this year onwards, EEA (supported by ETC/CM) has taken over the responsibility for preparing initial checks and compiling the NIR chapters for the sectors agriculture and LULUCF; in previous years these tasks were carried out by the Directorate General Joint Research Centre of the European Commission.

1.3 Inventory preparation and data collection, processing and storage

1.3.1 The compilation of the EU GHG inventory

The EU inventory is compiled in accordance with the recommendations for inventories set out in the 'UNFCCC guidelines for the preparation of national communications by parties included in Annex 1 to the Convention, Part 1: UNFCCC reporting guidelines on annual inventories' (FCCC/CP/2013/10/Add.3), to the extent possible. In addition, the *2006 IPCC guidelines for national greenhouse gas inventories* have been applied where appropriate and feasible. Finally, for the compilation of the EU GHG inventory, the Governance Regulation and its implementing legislation is applicable.

The EU GHG inventory is compiled on the basis of the inventories of the 27 Member States. The emissions of each source category are the sum of the emissions of the respective source and sink categories of the Member States.

The reference approach is calculated for the EU on the basis of Eurostat energy data (see Section 3.6) and the key category analysis (Section 1.5) is separately performed at EU level[17].

Since Member States use different national methodologies, national activity data or country-specific emission factors in accordance with IPCC and UNFCCC guidelines, these methodologies are reflected in the EU GHG inventory data. The EU believes that it is consistent with the UNFCCC reporting guidelines to use different methodologies for one source category across the EU especially if this helps to reduce uncertainty of the emissions data provided that each methodology is consistent with the IPCC good practice guidance.

In general, no separate methodological information is provided at EU level except summaries of methodologies used by Member States. Annex III includes a summary description of the methodologies used by each Member State for the EU key categories. The more detailed descriptions can be found in Member State's own submissions, which are considered to be part of the EU inventory.

1.3.1.1 Internal consistency of the EU CRF tables

In principle every single EU value is aggregated from the respective value of the EU Member States. However, sometimes there are consistency problems when compiling the EU CRF tables (i.e. the sum of sub-categories is not equal to the category total) in those categories where Member States have difficulties to allocate emissions to the sub-categories. Member States use notation keys like IE or C if they cannot provide an emission estimate for a certain sub-category. At Member State level, the use of the notation keys makes transparent the reason for not providing emission estimates. However, at EU-level, the sub-category emission value is the sum of Member States emission values and the information of the notation keys used by some Member States is lost in the EU CRF submission. In order to make this more transparent, the CRF tables include the values or notation keys reported by the MS as comments. In order to address this problem, some source categories have been reallocated for the EU CRF tables.

A second problem is the reporting of Member States in "grey cells" or in categories that do not have standardized UIDs which then need to be included in the CRF reporter manually.

Table 1.7 lists the procedures applied for the EU.

[17] However, the choice of the emission calculation methodology is made at Member State level and is based on the key category analysis of each individual Member State.

Table 1.7 Manual changes in the CRF Reporter

Year	Sector	Source category	Parameter	Manual changes / inclusion in the CRF Reporter
1990-2021	Energy	1 AB, 1AC, 1AD	All	Enter Reference Approach data from Eurostat
2013-2021	Energy, IPPU	1.A.1, 1.A.2, 1.B.2, 2.C, 2D, 2G	CO_2, CH_4, N_2O, NO_X, NMVOC and CO	Shift differences due to SWE confidential data into 'Other fossil fuels' within the same sub-category, if the total emissions of the sub-category are available. Otherwise shift differences to 'Other' sub-category.
1990-2021	IPPU	2.B, 2.C, 2.E, 2.F, 2.G, 2.H	f gases	Enter country-specific f gases
1990-2021	IPPU	2.C.7, 2.G.4, 2.H	CO_2, CH_4, N_2O, NO_X, NMVOC, SO_2	Enter country-specific emissions and recovery data.
1990, 2021	IPPU	2.A.2, 2.B.1	AD	Replace aggregated activity ('AD') data with gap-filled AD provided by sector experts
1990-2021	IPPU	2.A, 2.B, 2.C, 2.D, 2.G, 2.H	AD	Replace aggregated AD with notation key 'NE' if an aggregation does not make sense due to inhomogeneous AD
1990-2021	Agriculture	3	CH_4, N_2O, NMVOC	Enter aggregated data from EEA
1990-2021	Agriculture	3	AD	Correct additional information with aggregated data from EEA
1990-2021	LULUCF	4.G	All	Enter aggregated data (approach B)

1.3.2 Documentation and archiving

The documentation consists of quality management documentation in forms, checklists, inventory reports and correspondence. Archiving includes archiving of inventory documents and QM documents; a systematic archiving procedure is a prerequisite for a transparent inventory system.

All the material used for the compilation of the EU GHG inventory including inventory documents and QM documents are posted in the following directory:

\\umweltbundesamt.at\Projekte\20000\20926_ETC_CM_2022_2026\Intern\ETC_CM_2023\2.2.1.2 GHG inventory

There are four sub-directories under this directory:

1. \Inventory
2. \Archive
3. \Quality manual
4. \General

The Member States submissions and all correspondence are stored in the sub-directory\Archive. The central tool for documenting all the material received from MS (including correspondence) is the MS archive database which includes references, short characterisations and links to e-mails for all MS submissions. The MS archive database can be searched for documents (CRF, XML, NIR, etc.) or for mails. Each submission is numbered consecutively.

1.4 Brief general description of methodologies and data sources used

For the key categories (see Chapter 1.5) the most accurate methods for the estimation of the greenhouse gas inventory should be used. Table 1.8 gives an overview on the share of emissions for which higher tiers are used in the EU for all key categories for which this estimation was possible.

As mentioned above, the EU GHG inventory is based on the inventories of its MS. They are responsible for the methods, emission factors and emissions used, and for the implementation of the UNFCCC reporting guidelines and the 2006 IPCC Guidelines, taking into account inventory priorities and resource constraints.

Table 1.8 Share of higher tier methodologies used on the total of each EU key categories (excluding LULUCF)

Source category gas	Share of higher Tier
1.A.1.a Public Electricity and Heat Production: Gaseous Fuels (CO_2)	99.0 %
1.A.1.a Public Electricity and Heat Production: Liquid Fuels (CO_2)	95.3 %
1.A.1.a Public Electricity and Heat Production: Other Fuels (CO_2)	95.8 %
1.A.1.a Public Electricity and Heat Production: Peat (CO_2)	99.1 %
1.A.1.a Public Electricity and Heat Production: Solid Fuels (CO_2)	96.2 %
1.A.1.b Petroleum Refining: Gaseous Fuels (CO_2)	98.3 %
1.A.1.b Petroleum Refining: Liquid Fuels (CO_2)	97.7 %
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Gaseous Fuels (CO_2)	95.6 %
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Solid Fuels (CO_2)	96.4 %
1.A.2.a Iron and Steel: Gaseous Fuels (CO_2)	99.79 %
1.A.2.a Iron and Steel: Liquid Fuels (CO_2)	99.00 %
1.A.2.a Iron and Steel: Solid Fuels (CO_2)	99.95 %
1.A.2.b Non-Ferrous Metals: Gaseous Fuels (CO_2)	95.78 %
1.A.2.c Chemicals: Gaseous Fuels (CO_2)	99.42 %
1.A.2.c Chemicals: Liquid Fuels (CO_2)	92.63 %
1.A.2.c Chemicals: Solid Fuels (CO_2)	99.97 %
1.A.2.d Pulp, Paper and Print: Gaseous Fuels (CO_2)	92.81 %
1.A.2.d Pulp, Paper and Print: Liquid Fuels (CO_2)	92.06 %
1.A.2.d Pulp, Paper and Print: Solid Fuels (CO_2)	96.13 %
1.A.2.e Food Processing, Beverages and Tobacco: Gaseous Fuels (CO_2)	97.49 %
1.A.2.e Food Processing, Beverages and Tobacco: Liquid Fuels (CO_2)	68.80 %
1.A.2.e Food Processing, Beverages and Tobacco: Solid Fuels (CO_2)	95.46 %
1.A.2.f Non-metallic minerals: Gaseous Fuels (CO_2)	99.05 %
1.A.2.f Non-metallic minerals: Liquid Fuels (CO_2)	96.29 %
1.A.2.f Non-metallic minerals: Other Fuels (CO_2)	69.43 %
1.A.2.f Non-metallic minerals: Solid Fuels (CO_2)	95.98 %
1.A.2.g Other Manufacturing Industries and Constructions: Gaseous Fuels (CO_2)	98.34 %
1.A.2.g Other Manufacturing Industries and Constructions: Liquid Fuels (CO_2)	98.34 %
1.A.2.g Other Manufacturing Industries and Constructions: Other Fuels (CO_2)	98.34 %
1.A.2.g Other Manufacturing Industries and Constructions: Solid Fuels (CO_2)	98.34 %
1.A.3.a Domestic Aviation: Jet Kerosene (CO_2)	94.1 %
1.A.3.b Road Transportation: Diesel Oil (CO_2)	83 %

Source category gas	Share of higher Tier
1.A.3.b Road Transportation: Diesel Oil (N_2O)	95.6 %
1.A.3.b Road Transportation: Gaseous Fuels (CO_2)	91.4 %
1.A.3.b Road Transportation: Gasoline (CH_4)	97.4 %
1.A.3.b Road Transportation: Gasoline (CO_2)	90 %
1.A.3.b Road Transportation: Liquefied Petroleum Gases (LPG) (CO_2)	99.8 %
1.A.3.b Road Transportation: Other Fuels (CO_2)	95 %
1.A.3.c Railways: Liquid Fuels (CO_2)	73.7 %
1.A.3.d Domestic Navigation: Gas/Diesel Oil (CO_2)	74.3 %
1.A.3.d Domestic Navigation: Residual Fuel Oil (CO_2)	65.7 %
1.A.4.a Commercial/Institutional: Gaseous Fuels (CO_2)	94 %
1.A.4.a Commercial/Institutional: Liquid Fuels (CO_2)	80 %
1.A.4.a Commercial/Institutional: Other Fuels (CO_2)	97 %
1.A.4.a Commercial/Institutional: Solid Fuels (CO_2)	98 %
1.A.4.b Residential: Biomass (CH_4)	50 %
1.A.4.b Residential: Gaseous Fuels (CO_2)	94 %
1.A.4.b Residential: Liquid Fuels (CO_2)	83 %
1.A.4.b Residential: Solid Fuels (CH_4)	8 %
1.A.4.b Residential: Solid Fuels (CO_2)	98 %
1.A.4.c Agriculture/Forestry/Fishing: Gaseous Fuels (CO_2)	87 %
1.A.4.c Agriculture/Forestry/Fishing: Liquid Fuels (CO_2)	77 %
1.A.4.c Agriculture/Forestry/Fishing: Solid Fuels (CO_2)	97 %
1.A.5.a Other Other Sectors: Solid Fuels (CO_2)	99.5 %
1.A.5.b Other Other Sectors: Liquid Fuels (CO_2)	83 %
1.B.1.a Coal Mining and Handling: Operation (CH_4)	71 %
1.B.2.a Oil: Operation (CH_4)	39 %
1.B.2.a Oil: Operation (CO_2)	74 %
1.B.2.b Natural Gas: Operation (CH_4)	72 %
2.A.1 Cement Production (CO_2)	100 %
2.A.2 Lime Production (CO_2)	99.98 %
2.A.4 Other Process Uses of Carbonates (CO_2)	90.92 %
2.B.1 Ammonia Production (CO_2)	100 %
2.B.2 Nitric Acid Production (N_2O)	100 %
2.B.3 Adipic Acid Production (N_2O)	100 %
2.B.8 Petrochemical and Carbon Black Production (CO_2)	92.6 %
2.B.9 Fluorochemical Production (HFCs)	100 %
2.B.9 Fluorochemical Production (Unspecified mix of HFCs and PFCs)	100 %
2.B.10 Other chemical industry (CO_2)	84.8 %
2.C.1 Iron and Steel Production (CO_2)	100 %
2.C.3 Aluminium Production (PFCs)	100 %
2.F.1 Refrigeration and Air conditioning (HFCs)	100 %
3.A.1 Enteric Fermentation: Cattle (CH_4)	99.9 %
3.A.2 Enteric Fermentation: Other Sheep (CH_4)	82.8 %
3.A.4 Enteric Fermentation: Other livestock (CH_4)	63.8 %
3.B.1 CH_4 Emissions: Farming (CH_4)	99.8 %

Source category gas	Share of higher Tier
3.B.2 N_2O and NMVOC Emissions: Farming (N_2O)	98.2 %
3.D.1 Agricultural Soils: Direct N_2O Emissions From Managed Soils (N_2O)	48.6 %
3.D.2 Agricultural Soils: Farming (N_2O)	43.2 %
3.G.1 Limestone CaCO3: Farming (CO_2)	0 %
5.A.1 Managed Waste Disposal Sites: Waste (CH_4)	94.2 %
5.A.2 Unmanaged Waste Disposal Sites: Waste (CH_4)	100 %
5.B.1 Waste Composting: Waste (CH_4)	54.0 %
5.D.1 Wastewater Treatment and Discharge: Domestic Wastewater (CH_4)	41.6 %
5.D.1 Wastewater Treatment and Discharge: Domestic Wastewater (N_2O)	47.7 %
5.D.2 Wastewater Treatment and Discharge: Industrial Wastewater (CH_4)	64.6 %

1.4.1 Use of data from EU ETS for the purposes of the national GHG inventories in EU Member States

1.4.1.1 Overview

In January 2005 the European Union Greenhouse Gas Emission Trading System (EU ETS) commenced operation as the largest multi-country, multi-sector Greenhouse Gas Emission Trading System world-wide, based on Directive 2003/87/EC (European Community 2003). The European emissions trading system (EU ETS) covers around 40% of the EU's GHG emissions, in 10,000 installations in 30 participating countries. Besides the 27 Member States of the European Union, Norway, Iceland and Liechtenstein joined the EU ETS in 2008.

Emissions trading under the EU ETS has taken place in three 'trading periods' so far (2005–2007, also referred to as Phase I; 2008–2012 or Phase II; 2013–2020 or Phase III). The EU ETS Directive was amended in 2009 to improve and extend the EU ETS. The main changes in the third trading period compared to previous trading periods are:

- A single, EU-wide cap on emissions applies in place of the previous system of national caps;
- Auctioning, not free allocation, is the default method for allocating allowances. For allowances allocated for free, harmonised allocation rules apply which are based on EU-wide benchmarks of emissions performance;
- Inclusion of additional activities and gases, such as N_2O from production of nitric, adipic, glyoxal and glyoxylic acid production, PFCs and CO_2 from primary and secondary aluminium production, CO_2 from production and processing of ferrous metals and non-ferrous metals, CO_2 from manufacture of mineral wool, CO_2 from drying and calcination of gypsum or plaster boards, CO_2 emissions from carbon back production, CO_2 from ammonia production, CO_2 from bulk organic chemicals production, CO_2 from hydrogen production, CO_2 from soda ash and sodium bicarbonate production and CO_2 from CO_2 capture, transport and storage in storage sites).
- The aviation sector has been included in the EU ETS since 1 January 2012. The aviation sector, in the EU ETS context covering flights internal to the European Economic Area, has a separate cap to power stations and other fixed installations which is reduced at a slower rate. Surrender of emission allowances and reporting for 2013 is not required until 2015, and the inclusion of flights to

and from countries outside the European Economic Area has been postponed until after 31st December 2016 (EU 2014);

- Regulations for accreditation and verification (EU 2018a, EU2020a) and for monitoring and reporting were adopted (EU 2018b, EU2020b).

Phase IV of the EU ETS begun on 1st January 2021. The scope remains the same as in Phase III. Some adjustments have been brought to the monitoring of emissions for some sectors. The main changes were on the adjustments of free allowances through time (EU regulation 2019/2042).

Articles 14 and 15 of the Emission Trading Directive require Member States to ensure that emissions are monitored, reported and verified in accordance with legal requirements in the monitoring and reporting regulation (MRR) (EU 2018b) and in the accreditation and verification regulation (AVR) (EU 2018a), starting from 1 January 2013 (Phase III). All installations covered by the EU ETS have been required to monitor and report their emissions annually. Data for the installations covered by the EU ETS are reported by operators to national competent authorities based on a monitoring plan, elaborated by the operator and approved by the national competent authority, in accordance with the methodologies established in the monitoring and reporting regulation. The reported emissions for each installation are included in an annual emission report that must be verified by accredited verifiers in accordance with the provisions of the regulation on the verification of GHG emission reports (EU 2018a).

Similar to the IPCC 2006 Inventory Guidelines, the EU ETS monitoring and reporting regulation is based on a tier system which defines a hierarchy of different ambition levels for methods, activity data, calculation factors (such as emission factors, oxidation or conversion factors). The operator must, in principle, apply the highest tier level established in the MRR for his installation category, unless he can demonstrate to the competent authority that this is technically not feasible or would lead to unreasonably high costs. The operator must periodically prepare and submit to the competent authorities an improvement report, aiming at improvement of the accuracy of the greenhouse gas emissions.

Thus, the EU ETS generates an EU-27 data set on verified installation-specific emissions for the sectors covered by the scheme. For 2021 the main activities, number of entities and verified emissions reported under the EU ETS are presented Table 1.9.

Table 1.9 Activities and emissions covered by the EU ETS in 2021 (Member States)

Main activity	**Activity code**	**Number of entities**	**Verified emissions (Mt CO_2-eq.)**
Combustion of fuels	20	5 362	799
Refining of mineral oil	21	111	106
Production of coke	22	15	6
Metal ore roasting or sintering	23	9	2
Production of pig iron or steel	24	193	113
Production or processing of ferrous metals	25	191	8
Production of primary aluminium	26	20	4
Production of secondary aluminium	27	25	1
Production or processing of non-ferrous metals	28	74	6
Production of cement clinker	29	209	110
Production of lime, or calcination of dolomite/magnesite	30	214	27
Manufacture of glass	31	296	17
Manufacture of ceramics	32	653	13
Manufacture of mineral wool	33	43	2
Production or processing of gypsum or plasterboard	34	33	1
Production of pulp	35	147	4
Production of paper or cardboard	36	459	20
Production of carbon black	37	17	2
Production of nitric acid	38	28	3
Production of adipic acid	39	3	0.1
Production of glyoxal and glyoxylic acid	40	1	0
Production of ammonia	41	19	18
Production of bulk chemicals	42	278	34
Production of hydrogen and synthesis gas	43	37	7
Production of soda ash and sodium bicarbonate	44	12	4
Capture of greenhouse gases under Directive 2009/31/EC	45	1	0,00005
Transport of greenhouse gases under Directive 2009/31/EC	46	0	0
Other activity opted-in under Art. 24	99	195	1
All stationary installations		8 644	1 308

Source: EEA, 2023 (EU ETS data viewer, EU 27)

1.4.1.2 Mapping table between EU ETS activities and CRF categories

The table below indicates the mapping between the EU ETS activities and the IPCC/CRF categories, with supporting comments. Such table is based on the scope of the EU ETS in the fourth phase and the CRF categories based on the revised UNFCCC reporting guidelines (decision 24/CP.19) that implemented the 2006 IPCC Guidelines.

The legal framework defining the scope and the methodologies for the reporting of greenhouse gas emissions under the EU ETS presents differences compared to the 2006 IPCC guidelines. These differences lead to a different way of reporting emissions under the EU ETS and in the GHG inventory. Some of these differences may also prevent inventory compilers from using verified emissions reported under the EU ETS directly for emission reporting in the national GHG inventory. In order to use greenhouse gas emissions reported under the EU ETS in the national inventories, the inventory compilers need to deal with these differences.

As in Annex V under the MMR, Annex XII under Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (GOV REG) requires Member States to report EU ETS emissions per CRF categories and to comment the share of EU ETS emissions in CRF categories.

Table 1.10 Mapping table outlining the correspondence of CRF categories related to the EU ETS activities

EU ETS activity	CRF category	Comment
20 Combustion of fuels	1.A.1.a Public electricity and heat production 1.A.1.b Petroleum refining 1.A.2.a Iron and steel 1.A.2.b Non-ferrous metals 1.A.2.c Chemicals 1.A.2.d Pulp, paper and print 1.A.2.e Food processing, beverages and tobacco 1.A.2.f Non-metallic minerals 1.A.2.g Other 1.A.3.e Other transportation (pipeline transport) 1.A.4.a Commercial/ Institutional 1.A.4.c Agriculture/ Forestry / Fisheries 1.B Fugitive emissions from fuels	• For standalone combustion installations, EU ETS covers combustion of fuels in installation with a total rated thermal input exceeding 20 MW. For GHG inventories no such threshold applies. • In the GHG inventory, emissions are classified based on the purpose of the combustion activity, while such a differentiation does not exist in the definition of EU ETS activities. • Installations for the incineration of hazardous or municipal waste are excluded in the definition of 'combustion activities' under the EU ETS but included in GHG inventories. Installations used for research, development and testing of new products and processes are also not covered by the ETS Directive according to Annex I paragraph 1. • In the EU ETS an installation with different types of activities is classified according to the activity with predominant emissions, while in the inventory such activities should be reported in separate categories if so defined. This difference mostly applies in cases of large integrated installations. • Usually, a very small share of EU ETS emission from fuel combustion falls in the category of 1.A.4.a Commercial/ Institutional and 1.a.4.c Agriculture/ Forestry/ Fisheries as installations in these sectors mostly are below the EU ETS threshold.
21 Refining of mineral oil	1.A.1.b Petroleum refining 1.A.1.c Manufacture of solid fuels and other energy industries 1.A.2.c Chemicals 1.B.2.c Venting and flaring 1.B.2.a.iv Fugitive emissions from oil refining/ storage 2.B.8 Petrochemical and carbon black production 2.B.10 Other	EU ETS activity covers CO_2 emissions from combustion and also fugitive and process emissions. Emission sources reported under these activities are allocated to different CRF categories in the inventory: • Combustion emissions →1.A.1.b Petroleum refining • Flaring emissions → 1.B.2.c Venting and flaring • Refining → 1.B.2.a.iv Oil Refining/ storage • Hydrogen production → may be reported in 1.B.2.a.iv refining/ storage or in 2.B.10 Other chemical industry • Coke production / calcination → 1.A.1.c.i Manufacture of solid fuels • Flue gas scrubbing → 1.A.1.b Petroleum refining • Gasification of heavy fuel oil, methanol production → 2.B.8 Petro-chemical and carbon black production • Production of terephtalic acid → 2.B.10 Other chemical industry • Claus plants → 1.A.1.b Petroleum refining

EU ETS activity	CRF category	Comment
22 Production of coke	1.A.1.c Manufacture of solid fuels and other energy industries 1.B Fugitive emissions 1.A.2 Manufacturing Industries 2.C.1 Iron and Steel	• Scopes of EU ETS and 2006 IPCC Guidelines are generally consistent, however EU ETS emissions may be allocated to several CRF categories in the inventory. • The use of mass balance approaches in integrated iron and steel installations may complicate allocation between iron and steel categories and coke production.
23 Metal ore roasting or sintering, including palletisation	1.A.2.a Iron and steel 2.C.1 Iron and steel production 2.C.5 Lead production 2.C.6 Zinc production 2.C.7 Other metal production	• No clear separate category for this EU ETS activity in the inventory, allocation depends on the metal type. • Combustion emissions should be allocated to 1.A.2.a Iron and steel. • Process emissions should be allocated to 2.C.1 Iron and steel production or other metal production categories under industrial processes.
24 Production of pig iron or steel including continuous casting	1.A.2.a Iron and steel 2.C.1 Iron and steel production 1.B Fugitive emissions 1.A.1.c Manufacture of solid fuels and other energy industries	• Emissions are included in EU ETS only for those pig iron or steel installations with a capacity exceeding a threshold of 2.5 tonnes per hour while in GHG inventories there is no threshold. • EU ETS activity includes combustion and process emissions. • Combustion emissions should be allocated to 1.A.2.a Iron and steel. • Process emissions should be allocated to 2.C.1 Iron and steel production. • Emissions from coke production should be allocated to 1.A.1.c Manufacture of solid fuels and other energy industries. • Clear separation of combustion and process emissions is not always possible when mass balance approaches are used. • Comparability of emissions is influenced by the allocation of the transfer of CO_2 in the process gases (coke oven gas, blast furnace gas, basic oxygen furnace gas) to EU ETS activities as well as to CRF categories. Article 48 of the EU ETS MRR specifies the allocation of inherent CO_2 which results from an EU ETS activity and is contained in a gas which transferred to other installations as a fuel. If transfers of inherent CO_2 take place between EU ETS installations, the CO_2 transferred should not be counted as emissions for the installation of origin, but for the installation where it is finally emitted. However, if the transfer occurs to an installation outside the EU ETS scope, the transferring installation has to account for the emissions.
25 Production or processing of ferrous metals	1.A.2.a Iron and steel 2.C.1. Iron and steel production 2.C.2 Ferroalloys production 1.A.1.c Manufacture of solid fuels and other energy industries	• Emissions are included in EU ETS only for those ferroalloy production installations exceeding rated thermal input of 20 MW while in GHG inventories there is no threshold. • EU ETS scope of activity 25 covers CO_2 emissions related to the production or processing of ferrous metals from: ○ conventional and alternative fuels, ○ reducing agents including coke, ○ graphite electrodes, ○ raw materials including limestone and dolomite, ○ carbon containing metal ores and concentrates, ○ secondary feed materials.

EU ETS activity	CRF category	Comment
		• Combustion related emissions from EU ETS activity code 25 are included in in CRF 1.A.2.a. Iron and Steel. • Process related emissions can be included in CRF 2.C.1 Iron and steel production or 2.C.2. Ferroalloys Production.
26 Production of primary aluminium	2.C.3 Aluminium production 1.A.2.b Non-ferrous metals	• In EU ETS operators shall report emissions from the production of electrodes for primary aluminium smelting, including stand-alone-installations for the production of such electrodes. The operator shall consider CO_2 emissions from: fuels for the production of heat or steam, electrode production, reduction of Al_2O_3 during electrolysis which is related to electrode consumption, use of soda ash or other carbonates for waste gas scrubbing. • For PFC emissions resulting from anode effects the scope of the EU ETS activity and CRF category 2.C.3 are consistent. PFC emissions are allocated to 2.C.3 Aluminium production. • CRF category 1.A.2.b Non-ferrous metals includes combustion emission and emission from waste gas scrubbing. • Emissions from electrode consumption in EU ETS activity code 26 are included in CRF 2.C.3 Aluminium Production.
27 Production of secondary aluminium	1.A.2.b Non-ferrous metals	• Emissions are included in EU ETS only for installations exceeding rated thermal input of 20 MW while in GHG inventories there is no threshold. • In secondary aluminium production no process emissions occur therefore all emissions in activity code 27 are from fuel combustion and are reported in CRF category 1.A.2.b Non-ferrous metals.
28 Production or processing of non-ferrous metals	1.A.2.b Non-ferrous metals 2.C.4 Magnesium production 2.C.5 Lead production 2.C.6 Zinc production 2.C.7 Other metal production	• Emissions are included in EU ETS only for non-ferrous metals production or processing installations exceeding rated thermal input of 20 MW (including reducing agents) while in GHG inventories there is no threshold. • EU ETS activity includes combustion and process emissions. • Process related emissions from EU ETS activity code 28 are included in CRF 2.C.4 Magnesium Production, 2.C.5 Lead production, 2.C.6 Zinc Production and 2.C.7 Other metal industry. • 2006 IPCC Guidelines do not provide methodologies for metals other than iron and steel, ferroalloys, aluminium, magnesium, lead and zinc while the EU ETS has a broader scope and covers, e.g. copper production.
29 Production of cement clinker in rotary kilns	2.A.1 Cement Production 1.A.2.f Non-metallic minerals	• Emissions are included in EU ETS only for installations with production capacity exceeding 500 tonnes per day or in other furnaces with capacity exceeding 50 tonnes per day. Inventory methodology has no threshold. • EU ETS activity includes combustion and process emissions. • Process related emissions from EU ETS activity code 29 are included in CRF 2.A.1 Cement Production • Combustion related emissions from ETS activity code 29 are included in CRF 1.A.2.f. Non-metallic minerals
30 Production of lime, or calcination	2.A.2 Lime production	• Emissions are included in EU ETS only for

EU ETS activity	CRF category	Comment
of dolomite/magnesite in rotary kilns or in other furnaces	1.A.2.f Non-metallic minerals	installations with production capacity exceeding 50 tonnes per day. Inventory methodology has no threshold. • EU ETS activity includes combustion and process emissions. • Process related emissions from EU ETS activity code 30 are included in CRF 2.A.2 Lime Production • Combustion related emissions from EU ETS activity code 30 are included in CRF 1.A.2.f. Non-metallic minerals. • Non-marketed lime production in some industries such as iron and steel or sugar refining are included in the inventory in category 2.A.2, but may be included in the EU ETS in the dominant activity, e.g. iron and steel industry or fuel combustion.
31 Manufacture of glass including glass fibre	2.A.3 Glass production 1.A.2.f Non-metallic minerals	• Emissions are included in EU ETS only for installations with a melting capacity exceeding 20 tonnes per day. Inventory methodology has no threshold. • EU ETS activity includes combustion and process emissions. • Process related emissions from EU ETS activity code 31 are included in CRF 2.A.3 Glass Production • Combustion related emissions from EU ETS activity code 31 are included in CRF 1.A.2.f. Non-metallic minerals
32 Manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain	2.A.4 Other process uses of carbonates 1.A.2.f Non-metallic minerals	• Emissions are included in EU ETS only for installations with a production capacity exceeding 75 tonnes per day. Inventory methodology has no threshold. • EU ETS activity includes combustion and process emissions. • Process related emissions from EU ETS activity code 32 are included in CRF 2.A.4 Other process uses of carbonates. • Combustion related emissions from EU ETS activity code 32 are included in CRF 1.A.2.f. Non-metallic minerals. • EU ETS method A is based on carbonate input and is equivalent to IPCC tier 1 to 3 methods. EU ETS method B based on the alkali oxide output in the product has no equivalent method in the 2006 IPCC Guidelines. IPCC Guidelines also do not provide methods to estimate emissions from additives.
33 Manufacture of mineral wool insulation material using glass, rock or slag	2.A.3 Glass production 2.A.4 Other process uses of carbonates 2.A.5 Other 1.A.2.f Non-metallic minerals	• Emissions are included in EU ETS only for installations with a melting capacity exceeding 20 tonnes per day. Inventory methodology has no threshold. • EU ETS activity includes combustion and process emissions. • 2.A.3 Glass Production includes emissions from the production of glass wool, a category of mineral wool, where the production process is similar to glass making. Where the production of rock wool is emissive these emissions should be reported under IPCC Subcategory 2.A.5.
34 Drying or calcination of gypsum or production of plaster boards and	1.A.2.f Non-metallic minerals	• EU ETS covers CO_2 emissions from this activity, where combustion units have a total rated thermal input exceeding 20 MW. For GHG inventories no such threshold applies. • EU ETS activity only includes combustion-related emissions.

EU ETS activity	CRF category	Comment
other gypsum products		
35 Production of pulp from timber or other fibrous materials	1.A.2.d Pulp, paper and print 2.A.4 Other process uses of carbonates (soda ash use)	• EU ETS activity includes combustion and process emissions. • Combustion related emissions from EU ETS activity code 35 are included in CRF 1.A.2.d. • Process related emissions are included in 2.A.4. Other process uses of carbonates.
36 Production of paper or cardboard	1.A.2.d Pulp, paper and print 2.A.4 Other process uses of carbonates (soda ash use)	• EU ETS activity includes combustion and process emissions. • Threshold in EU ETS: installations involved in the production of paper or cardboard a production capacity exceeding 20 tonnes per day. Inventory methodology has no threshold. • Combustion related emissions from EU ETS activity code 36 are included in CRF 1.A.2.d. • Process related emissions are included in 2.A.4 Other process uses of carbonates.
37 Production of carbon black involving the carbonisation of organic substances such as oils, tars, cracker and distillation residues	2.B.8 Petrochemical and carbon black production 1.A.2.c Chemicals	• EU ETS covers CO_2 emissions from this activity, where combustion units have a total rated thermal input exceeding 20 MW. For GHG inventories no such threshold applies. • EU ETS activity includes combustion and process emissions.
38 Production of nitric acid	2.B.2. Nitric acid production 1.A.2.c Chemicals	• Scopes of EU ETS and 2006 IPCC Guidelines for CO_2 emissions from nitric acid production are consistent. • EU ETS activity includes combustion and process emissions. • For EU ETS activity 38 all N_2O emissions are process-related and should be allocated to 2.B.2 Nitric acid production. • CO_2 emissions in activity code 38 are from fuel combustion and should be allocated to 1.A.2.c Chemicals.
39 Production of adipic acid	2.B.3. Adipic acid production (CO_2) 1.A.2.c Chemicals	• Scopes of EU ETS and 2006 IPCC Guidelines for CO_2 emissions from Adipic Acid production are consistent. • EU ETS activity includes combustion and process emissions. • For EU ETS activity 39 all N_2O emissions are process-related and should be allocated to CRF code 2.B.3 Adipic Acid Production. • CO_2 emissions in activity code 38 are from fuel combustion and should be allocated to 1.A.2.c Chemicals .
40 Production of glyoxal and glyoxylic acid	2.B.4. Caprolactam, glyoxal and glyoxylic acid production 1.A.2.c Chemicals	• Scopes of EU ETS and 2006 IPCC Guidelines for N_2O emissions from glyoxal production and glyoxylic acid production are consistent. • EU ETS activity includes combustion and process emissions. • N_2O emissions should be allocated to CRF code 2.B.4 Caprolactam, glyoxal and glyoxylic acid production. • CO_2 emissions in activity code 40 are from fuel combustion and should be allocated to 1.A.2.c Chemicals
41 Production of ammonia	2.B.1. Ammonia production	• EU ETS scope of activity code 41 ammonia production includes:

EU ETS activity	CRF category	Comment
	CO_2 captured for urea production: 3.H Urea Application 1.A.3.b Road transport 2.D.3 Other non-energy products from fuels and solvent use	• combustion of fuels supplying the heat for reforming or partial oxidation, • fuels used as process input in the ammonia production process (reforming or partial oxidation), • fuels used for other combustion processes including for the purpose of producing hot water or steam. • According to 2006 IPCC Guidelines to avoid double counting, fuel consumption in ammonia production should be reported under Ammonia production. In this regard EU ETS and IPCC scopes are consistent. • In the inventory CO_2 from ammonia production which is recovered and used for urea production is subtracted and reported by the users. Urea use can be reported in different CRF sectors, e.g. in 1.A.3.b Road transport, 3.H Urea application in agriculture, 2.D.3 Other (e.g. in industry catalysts). Under the EU ETS the CO_2 transfer via urea out of the EU ETS system cannot be deducted from ammonia production for EU ETS reporting.
42 Production of bulk organic chemicals by cracking, reforming, partial or full oxidation or by similar processes	2.B.8 Petrochemical and carbon black production 2.B.10 Other chemical industry 1.A.2.c Chemicals	• Emissions are included in EU ETS only for installations with a production capacity exceeding 100 tonnes per day. Inventory methodology has no threshold. • EU ETS activity includes combustion and process emissions. • The combustion related emissions are allocated to CRF code 1.A.2.c Chemicals. • Some of the emissions reported under this EU ETS activity could be allocated to CRF category 2.B.8 Petrochemical and carbon black production (e.g. CO_2 process emissions). • Some of the emissions reported under this EU ETS activity could be allocated to CRF category 2.B.10 Other chemical industry (e.g. CO_2 emissions from flaring in chemical industry).
43 Production of hydrogen and synthesis gas by reforming or partial oxidation	1.A.2.c Chemicals 2.B.1. Ammonia production 2.B.8 Petrochemical and carbon black production 2.B.10 Other chemical industry 1.B.2.a.iv Fugitive emissions from oil refining/ storage	• Emissions are included in EU ETS only for installations with a production capacity exceeding 25 tonnes per day. IPCC methodology has no threshold. • EU ETS activity includes combustion and process emissions. • In the CRF, there is no separate reporting category for emissions from hydrogen production. Hydrogen and synthesis gas production are recognised as part of integrated chemical production. Therefore, MS have chosen different approaches for the inclusion of emissions from hydrogen production (e.g. 2.B.8 or 2.B.10). • Some emissions may also be reported under CRF category 1.B.2.a.iv Fugitive emissions from oil subcategory refining/ storage.
44 Production of soda ash and sodium bicarbonate	1.A.2.c Chemicals 2.B.7 Soda ash production	• EU ETS activity includes combustion and process emissions. • Combustion related emissions from EU ETS activity code 44 for production are included in CRF 1.A.2.c Chemicals. • Process related emissions are included in 2.B.7. Soda Ash Production

EU ETS activity	CRF category	Comment
45 Capture of greenhouse gases under Directive 2009/31/EC	Capture of emissions would be reported under the respective inventory sector e.g. 1.A.1.a Public electricity and heat production.	• Consistent with scope and methodologies of inventory.
46 Transport of greenhouse gases by pipelines for geological storage in a storage site permitted under Directive 2009/31/EC	1.C.1 Transport of CO_2	• Consistent with scope and methodologies of inventory
47 Geological storage of greenhouse gases in a storage site permitted under Directive 2009/31/EC	1.C.2 Injection and storage	• Consistent with scope of inventory (currently no emissions reported under the EU ETS)
99 Other activity opted-in under Art. 24 of the ETS Directive	Depending on type of activity opted-in	Article 24 allows the unilateral inclusion of additional activities and gases under the EU ETS. These activities and gases are not allocated to a specific activity, but under a separate activity code.

In the GHG inventory, the emissions are reported per CRF categories (Annex V under the MMR (phase III of EU ETS); Annex XII under the GOV REG for phase IV). In the EU ETS a single installation can include several ETS activities as defined in Annex I of the EU ETS Directive. In the EU ETS emissions are attributed to a specific installation, independently from the Annex I activities covered. Nevertheless, the operator must report detailed information for each source stream of the installation, and include activities classification as per Annex I, in his annual report to the competent authorities. The different approaches can lead to differences in reported emissions if ETS activities and inventory categories are compared directly.

Scope of activities and installation boundaries

For several activities, the EU ETS includes installations only if they exceed certain capacity thresholds. Such capacity thresholds are not used for the inventory reporting. In addition, installation boundaries and the scope as to what constitutes an activity under the EU ETS may be different to a source category for the inventory reporting. Therefore, the scope of activities and the installation boundaries need careful consideration before EU ETS data are used for inventory purposes.

Determination of tiers

Both IPCC guidelines are based on methodological tiers that require higher tier levels of accuracy for emission sources contributing to a significant extent to the total emissions in a country. In the inventory reporting, the key category analysis determines which methodological tier should be used which is based on the contribution of a source category to the total emission level and the emission trend. If a source category is determined as key, all emissions from this source/sector have to be estimated based the same minimum tier methodology.

In the EU ETS the tiers are related to the admissible level of uncertainty for each parameter involved in the reporting. In the EU ETS tiers apply at installation level for each source stream activity data and calculation factors and are defined in legislation on the basis of the installation emissions (thresholds are < 50 kt, ≥ 50 kt and ≤ 500 kt and > 500 kt CO_2eq). EU ETS verified emissions, if aggregated at sectoral level, may include contributions from small, medium and large emitters and are therefore based on different EU ETS tiers. When ETS data are used for key categories in the GHG inventory, it therefore has to be checked carefully whether the EU ETS tiers used for the monitoring of emissions are in conformity with the IPCC guidance related to the IPCC tiers for a particular source category.

In GHG inventories time series consistency is a mandatory requirement which has also implications on the choice of methodology. While methodological consistency is also required under the EU ETS (Article 6 of Regulation No 2018/2066), the EU ETS only started in 2005 and plant-specific and measured data is often not available for the whole time series back to 1990 and it may be challenging to construct a consistent time series back to 1990.

The mapping table above shows that a direct comparison between verified emissions from EU ETS activities and emissions reported in CRF categories is not straightforward.

An analysis of data consistency between EU ETS and inventory data requires: (1) an assessment of the assignment of the detailed data reported by each individual EU ETS installation to national competent authorities with respect to the CRF categories; (2) a detailed comparison of the methodological parameters (methods, activity data, calculation parameters).

1.4.1.3 Use of EU ETS data reported in 2023

Under the GOV REG article 37 (EU 2018c), Member States are required to perform consistency checks between the emissions reported in the GHG inventories and the verified emissions reported under the EU ETS Directive. The installation-specific emissions data reported by operators under the EU ETS can be used in different ways for the purposes of the national GHG inventories:

1. Reported verified emissions can be directly used in the GHG inventory to report CO_2 emissions for a specific source category. This requires a number of careful checks, e.g. whether the coverage of the respective EU ETS emissions is complete for the respective source category and that EU ETS activities and CRF source categories follow the same definitions. If EU ETS emissions are not complete, the emissions for the remaining part of the source category not covered by the EU ETS have to be calculated separately and added to the EU ETS emissions.
2. Emission factors (or other parameters such as oxidation factors) reported under the EU ETS can be compared with emission factors used in the inventory and the latter can be harmonised if the EU ETS provides improved information.
3. Activity data reported under the EU ETS can be used directly for the GHG inventory, in particular for source categories where energy statistics face difficulties in disaggregating fuel consumption to specific subcategories, e.g. to specific industrial sectors or for specific non-marketed fuels.
4. Data from EU ETS can be used for more general verification activities as part of national quality assurance (QA) activities without the direct use of emissions, activity data or emission factors.
5. Data from EU ETS can improve completeness of the estimation of IPCC source categories when additional data for sub-categories become available from EU ETS.
6. EU ETS data can improve the allocation of industrial combustion emissions to sub-categories under 1.A.2 Manufacturing Industries and Construction.
7. The comparison of the data sets can be used to improve the uncertainty estimation for the GHG inventories based on the uncertainties of data reported by installations.

Based on the information submitted in the national inventory reports (NIRs) in 2023 to the European Commission, all Member States indicated that they used EU ETS data at least for QA/QC purposes (Table 1.11). 24 Member States indicated to directly use the verified emissions reported by installations under the EU ETS (depending on the sectors). All Member States used EU ETS data to improve country-specific emission factors. And all Member States reported that they used activity data (e.g. fuel use) provided under the EU ETS in the national inventory (depending of the sectors).

Table 1.11 Use of EU ETS data for the purposes of the national GHG inventory

Member State	Use of emissions	Use of Activity data	Use of emission factors	Use for quality assurance
Austria	✓	✓	✓	✓
Belgium	✓	✓	✓	✓
Bulgaria	✓	✓	✓	✓
Croatia	✓	✓	✓	✓
Cyprus	✓	✓	✓	✓
Czech Republic	✓	✓	✓	✓
Denmark	✓	✓	✓	✓
Estonia		✓	✓	✓
France	✓	✓	✓	✓
Finland	✓	✓	✓	✓
Germany	✓	✓	✓	✓
Greece	✓	✓	✓	✓
Hungary	✓	✓	✓	✓
Ireland	✓	✓	✓	✓
Italy	✓	✓	✓	✓
Latvia	✓	✓	✓	✓
Lithuania	✓	✓	✓	✓
Luxembourg	✓	✓	✓	✓
Malta	✓	✓	✓	✓
Netherlands	✓	✓	✓	✓
Poland	✓	✓	✓	✓
Portugal	✓	✓	✓	✓
Romania	✓	✓	✓	✓
Slovakia		✓	✓	✓
Slovenia		✓	✓	✓
Spain	✓	✓	✓	✓
Sweden	✓	✓	✓	✓

Source: NIR 2023 submissions of Member States

1.4.1.4 References

EC 2003: Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (OJ L275, 25.10.2003, p. 32) amended by Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004, Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 and Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009, Directive 2018/410 of the European Parliament and of the Council of 14 March 2018.

EEA (European Environment Agency) 2022: EU Emissions Trading System (ETS) data viewer https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1

EU 2012a: 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 Text with EEA relevance (OJ L 181, 12.7.2012, p. 1–29).

EU 2012b: 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 (OJ L 181, 12.7.2012, p. 1-28).

EU 2014: Regulation No 421/2014 of the European Parliament and of the Council of 16 April 2014 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in view of the implementation by 2020 of an international agreement applying a single global market-based measure to international aviation emission (OJ L 129, 30.4.2014, p. 1–4).

EU 2018a: 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 (OJ L 334, 31.12.2018, p. 94–134)

EU 2018b: Commission Implementing Regulation (EU) 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 and amending Commission Regulation (EU) No 601/2012 (OJ L 334, 31.12.2018, p. 1–93)

EU 2018c: Regulation (EU) No 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (OJ L328/1, 21.12.2018)

EU 2020a: Commission Implementing Regulation (EU) 2020/2084 of 14 December 2020 amending and correcting Implementing Regulation (EU) 2018/2067 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 (OJ L 423, 15.12.2020, p. 23–36)

EU 2020b: Commission Implementing Regulation (EU) 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 and amending Commission Regulation (EU) No 601/2012 (OJ L 334, 31.12.2018, p. 1–93)

1.4.2 Cooperation with EUROCONTROL

At the end of 2010 the European Commission signed a framework contract with EUROCONTROL, the European organization for the safety of air navigation, regarding ‘the support to the European Commission in relation to climate change policy and the implementation of the EU ETS’. This support project is organized in different Work Packages (WP) corresponding to the different areas identified in the framework contract and has been regularly continued.

One of these Work Packages pertains to the improvement of GHG and air pollutant emissions inventories submitted by the 27 Member States and the European Union to the UNFCCC and to the UNECE. The main objective of the WP is to assist EU Member States improve the reporting of annual greenhouse gas (and other air pollutant) emission inventories by e.g., estimating the fuel split domestic/international using real flight data from EUROCONTROL. The European Environment Agency and its ETC/CME assist DG CLIMA regarding the technical requirements.

To support the inventory process for the submission in 2023, in August/September 2022 Member States received fuel and emissions data for the years 2005 to 2021 as calculated by EUROCONTROL using a TIER 3b methodology applying the Advanced Emissions Model (AEM). This is a follow up of ERT recommendations made to perform QA exercises and to make data from EUROCONTROL available to Member States on a regular basis. In November 2021 one webinar took place to exchange information between EUROCONTROL and Member States on the data provided.

In the course of the 'initial checks' of MS inventories in the first months of 2022 the comparison between Tier 3b calculations from EUROCONTROL and time series of MS inventories has been conducted with most actual inventories from Member States. In case of considerable differences between Member State results and those from EUROCONTROL, the European Environment Agency and its ETC/CME asked Member States via the EMRT about possible reasons. In addition, the European Environment Agency provided MS with a comparison between EUROCONTROL data and MS data on fuel consumption of civil and international aviation for the years 2015 and 2021, related CO_2 emissions and implied emission factors of CH_4 and N_2O. For more information on the results of the collaboration with EUROCONTROL and the comparison, see chapter 3.4.

As explained in the NIR 2014, comparing emissions reported by Member States with independent modelling results such as performed by EUROCONTROL is a genuine quality assurance exercise and assists in identifying areas in need for improvement of aviation emission calculations. In this sense, the EUROCONTROL results are used for identifying ways of checking and improving the accuracy of emission estimates for the EU and its Member States in accordance with the ARR of 2014.

1.4.3 Use of global warming potentials

Consistent with the latest Decision on the UNFCCC Reporting Guidelines adopted at COP27 in Sharm-El-Sheik, the EU has decided to apply the 100-year global warming potentials values to calculate the carbon dioxide equivalence of anthropogenic GHG emissions by sources and removals by sinks as set out in table 8.A.1 of the contribution of Working Group 1 to the Fifth Assessment Report of the IPCC (AR5) from the current 2023 inventory submission. Table 1.12 provides a comparison of the global warming potentials used in previous EU submissions (IPCC Fourth Assessment Report – AR4) and those used in this submissions (AR5).

Table 1.12 Global Warming Potentials from AR4 and AR5

Acronym, common name or chemical name	GWP AR4	GWP AR5
Carbon dioxide (CO_2)	1	1
Methane (CH_4)	25	28
Nitrous oxide (N_2O)	298	265
Sulphur hexafluoride (SF_6)	22 800	23 500
Nitrogen trifluoride (NF_3)	17 200	16 100
Hydrofluorocarbons (HFCs):		
HFC-23 CHF_3	14 800	12 400
HFC-32 CH_2F_2	675	677
HFC-41 CH_3F	92	116
HFC-125 CHF_2CF_3	3 500	3 170
HFC-134 CHF_2CHF_2	1 100	1 120
HFC-134a CH_2FCF_3	1 430	1 300
HFC-143 CH_2FCHF_2	353	328
HFC-143a CH_3CF_3	4 470	4 800
HFC-152 CH_2FCH_2F	53	16

Acronym, common name or chemical name	GWP AR4	GWP AR5
HFC-152a CH_3CHF_2	124	138
HFC-161 CH_3CH_2F	12	4
HFC-227ea CF_3CHFCF_3	3 220	3 350
HFC-236cb $CF_3CF_2CH_2F$	1 340	1 210
HFC-236ea $CF_3CHFCHF_2$	1 370	1 330
HFC-236fa $CF_3CH_2CF_3$	9 810	8 060
HFC-245fa $CHF_2CH_2CF_3$	1 030	858
HFC-245ca $CH_2FCF_2CHF_2$	693	716
HFC-365mfc $CH_3CF_2CH_2CF_3$	794	804
HFC-43-10mee $CF_3CHFCHFCF_2CF_3$ or ($C_5H_2F_{10}$)	1 640	1 650
Perfluorocarbons (PFCs):		
PFC-14, Perfluoromethane, CF_4	7 390	6 630
PFC-116, Perfluoroethane, C_2F_6	12 200	11 100
PFC-218, Perfluoropropane, C_3F_8	8 830	8 900
PFC-318, Perfluorocyclobutane, c-C_4F_8	10 300	9 540
Perfluorocyclopropane c-C_3F_6	>17 340	9 200
PFC-3-1-10, Perfluorobutane, C_4F_{10}	8 860	9 200
PFC-4-1-12, Perfluoropentane, C_5F_{12}	9 160	8 550
PFC-5-1-14, Perfluorohexane, C_6F_{14}	9 300	7 910
PFC-9-1-18, $C_{10}F_{18}$	>7 500	7 190

1.5 Description of key categories

A key category analysis has been carried out according to the Tier 1 method (quantitative approach) described in the 2006 IPCC guidelines. A key category is defined as an emission source that has a significant influence on a country's GHG inventory in terms of the absolute level of emissions, the trend in emissions, or both.

In addition to the key category analysis at Union level, every Member State provides a national key category analysis which is independent from the assessment at Union level. The Union key category analysis is not intended to replace the key category analysis by Member States. The key category analysis at Union level is carried out to identify those categories for which overviews of Member States' methodologies, emission factors, quality estimates and emission trends are provided in this report. In addition, the Union key category analysis helps identifying those categories that should receive special attention with regard to QA/QC at EU level. The Member States use their key category analysis for improving the quality of emission estimates at Member State level.

To identify key categories of the EU the following procedure was applied:

- Starting point for the key category identification for this report was the EEA database. All categories where GHG emissions/removals occur were listed, at an aggregation level such as 2.B.1 and split by gas, while for the sector Energy a less aggregated level such as 1.A.1.a, split by fuel and per gas was chosen. It makes sense for the EU to rely on this less aggregated level for the KCA as also the initial checks of the MS submissions are performed at this level of detail and therefore guarantee a more profound quality checking for all EU key categories (at fuel level). Additionally the EU KCA (at detailed level) is used in order to select the categories for which more detailed information is provided in the EU NIR. Although the more detailed EU approach differs from the KCA generated in the CRF overall the results are very similar.
- The confidential data of Sweden were not included when the key category analysis was conducted owing to timing constraints. The list of (sub-) categories for which confidential data reported by member States are excluded when conducting the key category analysis is included in chapter 1.7.3. The exclusion of confidential Swedish does not significantly affect the EU key

category analysis as these emissions account for roughly 1000 kt CO_2 equ. Whereas the smallest EU key category is 4744 kt CO_2 equ,

- A level and a trend assessment was carried out for the years 1990 and 2021. The assessment was carried out for emissions excluding LULUCF and including LULUCF.
  The key category analysis excluding LULUCF identified 85 key categories for the EU covering 96.4 % of total EU GHG emissions in 2021 (see Annex I). The key category analysis including LULUCF resulted in 97 key categories (Table 1.13).

In Chapters 3 to 7 overview tables are presented for each EU key category showing the Member States' contributions to the EU key category in terms of level and trend.

Table 1.13 Key categories for the EU (Gg CO_2 equivalents)

Source category gas	kt CO_2 equ.		Trend	Level	
	1990	2021		1990	2021
1.A.1.a Public Electricity and Heat Production: Gaseous Fuels (CO_2)	107683	192682	T	L	L
1.A.1.a Public Electricity and Heat Production: Liquid Fuels (CO_2)	156335	23787	T	L	L
1.A.1.a Public Electricity and Heat Production: Other Fuels (CO_2)	10453	36428	T	L	L
1.A.1.a Public Electricity and Heat Production: Peat (CO_2)	9164	3829	T	L	0
1.A.1.a Public Electricity and Heat Production: Solid Fuels (CO_2)	943402	452135	T	L	L
1.A.1.b Petroleum Refining: Gaseous Fuels (CO_2)	5228	20529	T	0	L
1.A.1.b Petroleum Refining: Liquid Fuels (CO_2)	97072	71844	T	L	L
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Gaseous Fuels (CO_2)	8199	7334	0	L	L
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Solid Fuels (CO_2)	88816	21620	T	L	L
1.A.2.a Iron and Steel: Gaseous Fuels (CO_2)	29392	17973	T	L	L
1.A.2.a Iron and Steel: Liquid Fuels (CO_2)	8753	882	T	L	0
1.A.2.a Iron and Steel: Solid Fuels (CO_2)	112412	60381	T	L	L
1.A.2.b Non-Ferrous Metals: Gaseous Fuels (CO_2)	3013	7496	T	0	L
1.A.2.c Chemicals: Gaseous Fuels (CO_2)	50492	39145	T	L	L
1.A.2.c Chemicals: Liquid Fuels (CO_2)	36118	21347	T	L	L
1.A.2.c Chemicals: Solid Fuels (CO_2)	11972	9021	0	L	L
1.A.2.d Pulp, Paper and Print: Gaseous Fuels (CO_2)	11115	18452	T	L	L
1.A.2.d Pulp, Paper and Print: Liquid Fuels (CO_2)	10783	1710	T	L	0
1.A.2.d Pulp, Paper and Print: Solid Fuels (CO_2)	6770	1882	T	0	0
1.A.2.e Food Processing, Beverages and Tobacco: Gaseous Fuels (CO_2)	15813	29679	T	L	L
1.A.2.e Food Processing, Beverages and Tobacco: Liquid Fuels (CO_2)	17725	2593	T	L	0
1.A.2.e Food Processing, Beverages and Tobacco: Solid Fuels (CO_2)	11536	3785	T	L	0
1.A.2.f Non-metallic minerals: Gaseous Fuels (CO_2)	27662	34005	T	L	L
1.A.2.f Non-metallic minerals: Liquid Fuels (CO_2)	45759	20068	T	L	L
1.A.2.f Non-metallic minerals: Other Fuels (CO_2)	1438	14429	T	0	L
1.A.2.f Non-metallic minerals: Solid Fuels (CO_2)	52433	13887	T	L	L
1.A.2.g Other Manufacturing Industries and Constructions: Gaseous Fuels (CO_2)	79637	79482	T	L	L
1.A.2.g Other Manufacturing Industries and Constructions: Liquid Fuels (CO_2)	82994	35833	T	L	L
1.A.2.g Other Manufacturing Industries and Constructions: Other Fuels (CO_2)	2451	4481	T	0	0
1.A.2.g Other Manufacturing Industries and Constructions: Solid Fuels (CO_2)	90752	11653	T	L	L
1.A.3.a Domestic Aviation: Jet Kerosene (CO_2)	11290	9587	0	L	L
1.A.3.b Road Transportation: Diesel Oil (CO_2)	270377	527871	T	L	L
1.A.3.b Road Transportation: Diesel Oil (N_2O)	1330	5856	T	0	L
1.A.3.b Road Transportation: Gaseous Fuels (CO_2)	508	5064	T	0	L
1.A.3.b Road Transportation: Gasoline (CH_4)	5562	787	T	0	0
1.A.3.b Road Transportation: Gasoline (CO_2)	330546	189637	T	L	L
1.A.3.b Road Transportation: Liquefied Petroleum Gases (LPG) (CO_2)	7266	14057	T	L	L
1.A.3.b Road Transportation: Other Fuels (CO_2)	1	3069	T	0	0
1.A.3.c Railways: Liquid Fuels (CO_2)	11535	3532	T	L	0

Source category gas	kt CO_2 equ.		Trend	Level	
	1990	2021		1990	2021
1.A.3.d Domestic Navigation: Gas/Diesel Oil (CO_2)	12831	9411	0	L	L
1.A.3.d Domestic Navigation: Residual Fuel Oil (CO_2)	7004	4671	0	L	0
1.A.4.a Commercial/Institutional: Gaseous Fuels (CO_2)	50214	88309	T	L	L
1.A.4.a Commercial/Institutional: Liquid Fuels (CO_2)	73404	30656	T	L	L
1.A.4.a Commercial/Institutional: Other Fuels (CO_2)	748	6004	T	0	L
1.A.4.a Commercial/Institutional: Solid Fuels (CO_2)	44985	3497	T	L	0
1.A.4.b Residential: Biomass (CH_4)	10438	12446	T	L	L
1.A.4.b Residential: Gaseous Fuels (CO_2)	130249	204136	T	L	L
1.A.4.b Residential: Liquid Fuels (CO_2)	173398	74950	T	L	L
1.A.4.b Residential: Solid Fuels (CH_4)	8908	2284	T	L	0
1.A.4.b Residential: Solid Fuels (CO_2)	118866	25937	T	L	L
1.A.4.c Agriculture/Forestry/Fishing: Gaseous Fuels (CO_2)	12291	12634	T	L	L
1.A.4.c Agriculture/Forestry/Fishing: Liquid Fuels (CO_2)	64579	56783	T	L	L
1.A.4.c Agriculture/Forestry/Fishing: Solid Fuels (CO_2)	9686	2671	T	L	0
1.A.5.a Other Other Sectors: Solid Fuels (CO_2)	5955	8	T	0	0
1.A.5.b Other Other Sectors: Liquid Fuels (CO_2)	8086	2284	T	L	0
1.B.1.a Coal Mining and Handling: Operation (CH_4)	84944	25414	T	L	L
1.B.2.a Oil: Operation (CH_4)	6901	777	T	L	0
1.B.2.a Oil: Operation (CO_2)	8593	9126	T	L	L
1.B.2.b Natural Gas: Operation (CH_4)	46325	13321	T	L	L
2.A.1 Cement Production: no classification (CO_2)	95237	72420	T	L	L
2.A.2 Lime Production: no classification (CO_2)	23918	17728	0	L	L
2.A.4 Other Process Uses of Carbonates: no classification (CO_2)	11061	9873	0	L	L
2.B.1 Ammonia Production: no classification (CO_2)	30591	19299	0	L	L
2.B.10 Other chemical industry: no classification (CO_2)	6849	12096	T	0	L
2.B.2 Nitric Acid Production: no classification (N_2O)	40718	2398	T	L	0
2.B.3 Adipic Acid Production: no classification (N_2O)	33454	120	T	L	0
2.B.8 Petrochemical and Carbon Black Production: no classification (CO_2)	10029	11945	T	L	L
2.B.9 Fluorochemical Production: no classification (HFCs)	12809	392	T	L	0
2.B.9 Fluorochemical Production: no classification (Unspecified mix of HFCs and PFCs)	4670	46	T	0	0
2.C.1 Iron and Steel Production: no classification (CO_2)	103475	67285	T	L	L
2.C.3 Aluminium Production: no classification (PFCs)	17303	283	T	L	0
2.F.1 Refrigeration and Air conditioning: no classification (HFCs)	5	63612	T	0	L
3.A.1 Enteric Fermentation: Cattle (CH_4)	200979	155937	T	L	L
3.A.2 Enteric Fermentation: Other Sheep (CH_4)	23561	16111	0	L	L
3.A.4 Enteric Fermentation: Other livestock (CH_4)	6545	6070	0	0	L
3.B.1 CH_4 Emissions: Farming (CH_4)	54426	44772	T	L	L
3.B.2 N_2O and NMVOC Emissions: Farming (N_2O)	25555	18131	0	L	L
3.D.1 Agricultural Soils: Direct N_2O Emissions From Managed Soils (N_2O)	116774	94410	T	L	L
3.D.2 Agricultural Soils: Farming (N_2O)	31590	23584	0	L	L
3.G.1 Limestone CaCO3: Farming (CO_2)	6701	4744	0	0	L
4.A.1 Forest Land: Land Use (CO_2)	-299886	-247793	T	L	L
4.A.2 Forest Land: Land Use (CO_2)	-47685	-41715	T	L	L
4.B.1 Cropland: Land Use (CO_2)	28487	5018	T	L	L
4.B.2 Cropland: Land Use (CO_2)	33463	14450	T	L	L
4.C.1 Grassland: Land Use (CO_2)	50918	34688	0	L	L
4.C.2 Grassland: Land Use (CO_2)	-8560	-13438	0	L	L
4.D Wetlands: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CH_4)	5481	5962	0	0	L
4.D.1 Wetlands: Land Use (CO_2)	8320	10217	T	L	L
4.D.2 Wetlands: Land Use (CO_2)	1004	3437	T	0	0
4.E.2 Settlements: Land Use (CO_2)	21635	23007	T	L	L

Source category gas	kt CO_2 equ.		Trend	Level	
	1990	2021		1990	2021
4.G Harvested Wood Products: Wood product (CO_2)	-28666	-47390	T	L	L
5.A.1 Managed Waste Disposal Sites: Waste (CH_4)	107939	65617	T	L	L
5.A.2 Unmanaged Waste Disposal Sites: Waste (CH_4)	27744	9592	T	L	L
5.B.1 Waste Composting: Waste (CH_4)	516	2861	T	0	0
5.D.1 Wastewater Treatment and Discharge: Domestic Wastewater (CH_4)	24354	11093	T	L	L
5.D.1 Wastewater Treatment and Discharge: Domestic Wastewater (N_2O)	6833	6028	0	0	L
5.D.2 Wastewater Treatment and Discharge: Industrial Wastewater (CH_4)	9569	5978	0	L	L

Note: EU totals for 2021 in sector Energy do not include data for Sweden due to confidential reporting. For more details on confidential reporting from Sweden refer to section 1.7.2.

1.6 General uncertainty evaluation

The uncertainty analysis was made on the basis of the Tier 1 uncertainty estimates, which were submitted by EU Member States as part of their EU GHG inventory reporting requirements under Article 26(3) and Annex V(Part 1)(m) of the Governance Regulation (EU) 2018/1999.

As documented in previous NIR submissions, some of the MS Tier 1 uncertainty estimates that are reported for the purpose of compiling the Union inventory are incomplete e.g. uncertainties not estimated for LULUCF and indirect CO_2 emissions, certain subsector emissions are confidential. Further complexity is also introduced by the fact that the sector and gas resolution at which uncertainties are provided varies between the countries. For the previous NIR submission in 2022, the methodology for compiling the EU inventory uncertainties was updated to harmonise and gap-fill the MS uncertainty estimates so that the tables containing the EU uncertainties are consistent with the final aggregate-, sector- and subsector emission values reported in the EU CRF tables and elsewhere in the NIR document.

A processing routine, implemented in R, reads the individual country uncertainty files that are pre-formatted manually to assign consistent sector and gas labels to the respective estimates of emissions/removals and uncertainties. The uncertainty values are then aggregated to a common sector resolution, at which the emissions and removals reported in the Tier 1 uncertainty tables of the countries are then replaced with the respective values from the final CRF tables of the countries. These final CRF data of the March submission are accessed via an SQL query of the EEA database containing the CRF submissions.

Due to the issue of incompleteness mentioned above, the country-level data are then screened to identify residual emissions and removals for which no uncertainty estimates have been provided. Where sectors are partially complete, the residual net emission is quantified in CO_2 equivalents and incorporated. An uncertainty is then estimated, by calculating the overall sector uncertainty of the sources and sinks that were included in that country's reported Tier 1 uncertainty estimates and assigning this percentage average to the residual net emission. In cases where for certain sectors no uncertainties have been provided at all (e.g. indirect CO_2 emissions, LULUCF), an average sector uncertainty in percent is calculated from all the countries for which complete sectoral emissions and uncertainties were reported, and this average uncertainty is assigned to the country's sector GHG total reported in its final CRF tables.

With complete data on uncertainties as well as emissions and removals for all 27 EU Member States, the routine then aggregates emissions and uncertainties in units of kt CO_2e (uncertainties summed in quadrature) for a specified gas and subsector resolution at the EU level. Despite working with Tier 1 data from the countries, a hybrid approach is applied to estimate level uncertainties that allows consideration of error correlations. The gas and subsector resolution applied was chosen to allow the routine to access respective data from CRF Table Summary 3 on emission factors and apply correlation coefficients (r) when aggregating the uncertainties. For a given gas and subsector, it is assumed that the errors of countries using default factors are completely correlated (r = 1), while errors of countries using country-specific factors are assumed uncorrelated (r = 0). For countries using a mix of default and country-specific factors, it is assumed that these errors are partially correlated (r = 0.5) with one another and with the errors of countries using the default factors only.

Based on these correlation assumptions, the routine then aggregates emissions and uncertainties for the specified gas and subsector resolution at the EU level. Uncertainties at the GHG and sector total level (Table 1.16) are then aggregated from the subsector and gas estimates assuming no correlation between subsectors and gases. However, for countries reporting very coarse resolution estimates (e.g. total sector GHG emissions/removals) or where the sector has been partially or completely gap-filled, it is assumed that these uncertainties are partially correlated (r = 0.5) with one another and with the other reported subsector- and gas level estimates. Level uncertainties on the total emissions and removals (with and without LULUCF) are then aggregated from the sector estimates assuming no correlation between sectors.

Trend uncertainties are also calculated with a hybrid method with varying assumptions with respect to error correlations in time. At the individual gas and subsector resolution of each country, a trend and trend uncertainty are calculated assuming full error correlation between the base year and latest year estimates (r = 1). In the IPCC GPG 2000, it is suggested to assume that emission factors between years are fully correlated, and activity data are independent. However, in the EU uncertainty estimate, it is assumed that activity data uncertainties also correlate to some extent between years, because typically the same data collection methods are used each year. Therefore, for the EU uncertainty estimate it was decided to assume that emissions (at the gas and subsector level) between years are fully correlated, even though this may underestimate trend uncertainty to some extent. For countries reporting very coarse resolution estimates (e.g. total sector GHG emissions/removals) or where the sector has been partially or completely gap-filled, it is assumed in the trend uncertainty that the base year and latest year uncertainties at country level are only partially correlated with one another (r = 0.5). These trends and trend uncertainties at country level are then aggregated at EU level (Table 1.16) assuming no correlation in the trend uncertainties between the countries. Correlation in trend uncertainties between countries is more difficult to quantify, where correlation between different countries in different years should also be quantified. Furthermore, the effect of correlation on uncertainty (increasing or decreasing) depends on the direction and magnitude of trend for each country and each source category. Therefore, a simple conservative assumption cannot be made, and for simplicity, it was assumed that the trend uncertainty estimates between the countries is independent. Note that the trend and trend uncertainties are calculated by aggregating in units of kt CO_2e (uncertainties summed in quadrature) and then expressed as percentages relative to the respective base year emissions/removals. The trend and level uncertainties reported throughout the NIR represent 95 % confidence intervals in the respective values.

Given the Tier 1 format of the reported country level uncertainties (95 % confidence intervals assuming normal distributions) the above method for the EU applies a first order, Gaussian error propagation approach. However, given the application of the pragmatic yet defensible assumptions of error correlations described above, it nonetheless constitutes a more sophisticated, hybrid approach than required minimum Tier 1 approach under the IPCC guidelines. For instance, assuming no correlation between level uncertainties between countries would almost certainly lead to underestimates of the EU total level uncertainties. The EU inventory team therefore considers the outlined pragmatic approach a workable and defensible methodology to estimate level uncertainties. Likewise, the assumptions applied to the trend uncertainty analysis is also considered justified, given that it is most important to consider the strong uncertainty correlation in time.

Effects of correlations were tested in previous submissions both with the previous analytical method developed, and by using Monte Carlo (MC) simulation, where normal distributions were used in all the cases to ensure comparability with analytical estimates. Table 1.14 gives an example of such a comparison made in 2006. The source category chosen for the example is 4D, N_2O emissions from agricultural soils, as this category has a major effect on inventory uncertainty in most MS. Both the effects of correlations between years and between Member States were tested.

Table 1.14 Trend uncertainty for EU emissions 2006 of N_2O from agricultural soils by using different assumptions of correlation estimated using Monte Carlo simulation

Years correlate	MS correlate	Trend uncertainty
YES	YES	-27 to +26
YES	NO	±13
NO	YES	-294 to +292
NO	NO	-116 to +115

Note: "YES" denotes full correlation between years or Member States. Trend uncertainty is presented as percentage points.

It should furthermore be mentioned that applying a MC approach in the EU case would not improve the uncertainty estimate. Given that the input data are provided by the countries in a Tier 1 format assuming normal error distributions, applying a MC procedure without any further detailed assumptions on distributions would simply lead to comparable estimates as the first order approximation (Table 1.15).

Table 1.15 .Comparison of trend uncertainty estimates 2005 for EU Waste Sector using the modified Tier 1 method and Monte Carlo simulation (Tier 2).

Sector	GHG	Tier 1	Tier 2
6A. Landfills	CH_4	±12	±12
6B. Wastewater	CH_4	±27	-28 to +27
6B. Wastewater	N_2O	±9	±9
6C. Waste incineration	CO_2	±7	±7
6C. Waste incineration	CH_4	±23	-23 to +24
6C. Waste incineration	N_2O	±18	±18
Waste Other	CH_4	±990	-976 to +993
Total Waste Sector		±11	±11

Note: Trend uncertainty is presented as percentage points.

Table 1.16 shows the main results of the Tier 1 uncertainty analysis for the EU. The lowest level uncertainty estimates are for Fuel combustion activities (2.6 %) and the highest estimates are for Waste (40.6 %). Overall level uncertainty estimates on total GHG emissions and removals including LULUCF is calculated at 4.9 %. If LULUCF is excluded, the total level uncertainty is lower at 3.7 %. With regard to trend uncertainty estimates (expressed as a percentage of base year emissions), the lowest uncertainty estimates are for Fuel combustion activities (+/-2.3 percentage points) and the highest estimates are for LULUCF (17.7 percentage points). Overall trend uncertainty (including LULUCF) of total emissions and removals is estimated to be 2.1 percentage points. Excluding LULUCF, the trend uncertainty is slightly lower at 1.9 percentage points. More detailed uncertainty estimates for the source categories are provided in Chapters 3-7.

These trend and level uncertainties differ (to varying extents) from the uncertainties previously reported in 2022 due to the following reasons:

- An error was identified in the processing routine that led to underestimated LULUCF level and trend uncertainties. The error has since been corrected with updated uncertainty estimates of the LULUCF sector and total GHG emissions and removals already provided to the ERT later in 2022.

- Change in countries included in the EU GHG inventory. The EU inventory and uncertainty estimates previously included the United Kingdom and Iceland in the Union totals reported under the Kyoto Protocol of the UNFCCC. With this 2023 submission marking the first year of post-Kyoto reporting under UNFCCC, the EU GHG inventory now includes only the 27 Member States. Analysis of the uncertainty data from 2022 (with and without UK and Iceland), revealed that this would have varying effects on level and trend uncertainties across sectors (e.g. increase in level uncertainties in sectors 1B, 3 and 5; decrease in level uncertainties in sector 4).
- Change from AR4 to AR5 global warming potentials (GWP). Even if emissions in absolute mass units are unchanged, the change in GWPs leads to a relative change in the contribution of CH_4 and N_2O sources to the total and sector GHG balances in CO_2eq. Due to the now higher GWP, CH_4 emissions contribute more to total and sector GHG balances, while N_2O emissions contribute less. Given that uncertainty estimates of CH_4 emissions are generally lower than those of N_2O emissions, the change in GWPs has alone reduced the uncertainties in total GHG emissions from the sector Agriculture.
- Methodological recalculations of emissions and uncertainties. Given the factors mentioned above, it is difficult to identify where methodological changes and recalculations in emissions by the MS have impacted the EU uncertainty estimates. It is nonetheless important to mention, that in contrast to previous years, Ireland and Cyprus have provided uncertainty estimates for the sector LULUCF, which together with recalculations by other MS, appears to have contributed to a reduction in the level and trend uncertainty of the LULUCF sector.

Due to the above factors, which can have diverging impacts on sector and total uncertainties, it was considered inappropriate to explicitly quantify and explain the changes in uncertainty estimates between this and the previous NIR submission. This will however be done in future submissions from 2024 onwards, where changes in uncertainties will not be confounded by changes in the structure of the Union and/or changes in global warming potentials.

Table 1.16 Tier 1 uncertainty estimates of EU GHG emissions and removals (in CO_2 equivalents) for the main sectors

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
1.A Fuel combustion activities	all	3 578 377	2 601 568	-27,3%	2,6%	2,3%
1.B Fugitive emissions	all	168 709	61 178	-63,7%	35,7%	8,6%
2. Industrial processes	all	444 676	317 934	-28,5%	8,0%	2,8%
3. Agriculture	all	484 607	378 430	-21,9%	24,7%	2,6%
4. LULUCF	all	-208 795	-229 985	10,1%	39,9%	17,7%
5. Waste	all	184 184	109 284	-40,7%	40,6%	15,5%
Indirect CO2 emissions	all	6 444	3 306	-48,7%	27,5%	8,1%
Total (excl LULUCF)	**all**	**4 866 998**	**3 471 700**	**-28,7%**	**3,7%**	**1,9%**
Total (incl LULUCF)	**all**	**4 658 202**	**3 241 716**	**-30,4%**	**4,9%**	**2,1%**

Table 1.17 gives an overview of information provided by EU Member States on uncertainty estimates in their 2023 national inventory reports and presents summarised results of these estimates.

Table 1.17 Overview of uncertainty estimates available from EU Member States

Member State	Austria		Belgium	Bulgaria		Croatia		Cyprus		Czechia		Denmark	
Citation	NIR March 2023, pp.61-72		NIR March 2023, pp.42-43	NIR March 2023, pp.51-52		NIR March 2023, pp.52-53		NIR March 2023, pp.49		NIR March 2023, pp.42-43		NIR March 2023, pp.56-62	
Method used	Tier 1		Tier 1	Tier 1		Tier 2		Tier 1		Tier 1		Tier 1	
Documentation in NIR (according to IPCC 2006 GL)	Yes (Annex 2)		Yes (Annex 2)	Yes (Annex 2)		Yes (Annex 2)		Yes (Annex 2)		Yes (Annex 2)		Yes (Annex 2)	
Years and sectors included	emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF	emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; excluding LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF	
Uncertainty (%)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 2 (e .L.)	Tier 2 (i .L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)
CO_2												5.7%	2.5%
CH_4												13.2%	
N_2O												102,0%	
F-gases												46.5%	
Total	7.88%	4.37%	3.46%		13.65%	-24.7 & +27.2%	-3.44 & +3.79%	1.91%	10.09%	4.36%	2.97%	12.5%	12.6%
Uncertainty in trend (%)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 2 (e .L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)
CO_2												-47.2%	-44.6%
CH_4												-6.9%	
N_2O												-34.2%	
F-gases												-15.9%	
Total	2.5%	2.06%	2,00%	5.95%	2.25%	-13.3 & +27.6%	-4.31 & +6.19%	1.63%	2.52%	4.01%	1.59%	-41.0	-38.7%

*Base year for F-gases is 1995

Member State	Estonia		Finland				France		Germany				Greece		Hungary	Ireland	
Citation	NIR March 2023, p.40		NIR March 2023, p.42				NIR March 2023, pp.83-86		NIR March 2023, pp 121-.124				NIR March 2023, pp.63-67		NIR March 2023, pp.26	NIR March 2023, pp.19-21	
Method used	Tier 1		Tier 1 + Tier 2				Tier 1		Tier 1 + Tier 2				Tier 1		Tier 1	Tier 1	
Documentation in NIR (according to IPCC 2006 GL)	Yes (Annex 1)		Yes (Annex 2)				Yes (Annex 6)		Yes (Annex 7)				Yes (Annex 4)		Yes (Annex 2)	Yes (Tab. 1.11 - 1.12)	
Years and sectors included	emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF				emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF				emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; excluding LULUCF	emissions: 2021; trends: 1990-2021; including LULUCF	
Uncertainty (%)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 2 (i .L.)	Tier 2 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 2 (i .L.)	Tier 2 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)
CO_2													4,0%	2.5%	2.6%		
CH_4													23.5%	23.8%	48,0%		
N_2O													109,0%	109.7%	143.9%		
F-gases													260.1%	260.1%	13,0%		
Total	13.03%	7.52%	±33%	±4%	-28% +46%	-4% +6%	6.7%	6.2%	3.22%	3.11%	-2.93% +3.26%	-1.93% +2.39%	13.1%	12,0%	12.3%	11.52%	3.67%
Uncertainty in trend (%)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 2 (i .L.)	Tier 2 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 2 (i .L.)	Tier 2 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)
CO_2																	
CH_4																	
N_2O																	
F-gases																	
Total	6.54%	1.91%	±50%	±4%	-34% +59%	-4% +4%	1.9%	1.7%	3.63%	2.98%	-10.2% +10.89 %	-6.96% +7.44%	9.3%	9.1%	3.6%	10.57%	2.29%

Member State	Italy		Latvia		Lithuania		Luxembourg		Malta	Netherlands			Poland	
Citation	NIR March 2023, pp.44		NIR March 2023, pp.59		NIR March 2023, pp.38-39		NIR March 2023, pp.66-71		NIR March 2023, p.48-49	NIR March 2023, pp.43-47			NIR March 2023, pp.457-467	
Method used	Tier 1		Tier 1		Tier 1		Tier 1		Tier 1	Tier 1 + Tier 2			Tier 1	
Documentation in NIR (according to IPCC 2006 GL)	Yes (Annex 1)		Yes (Annex 2)		Yes (Annex 2)		Yes (pp.55-71)		Yes (Annex 2)	Yes (Annex 2)			Yes (Annex 8)	
Years and sectors included	emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF	emissions: 2021; trends: 1990-2021*; including LULUCF			emissions: 2021; trends: 1990-2021; including LULUCF	
Uncertainty (%)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 2 (i.L.)	Tier 1 (i .L.)	Tier 1 (e. L.)
CO_2										3%		3%	3.1%	1.8%
CH_4										8%		9%	20.8%	20.8%
N_2O										31%		34%	42.7%	45.7%
F-gases										24%		24%		
Total	3.8%	2.9%	19%	5%	26.6%	22.2%	5.01%	2.11%	6.96%	3%		3%	4.3%	3.6%
Uncertainty in trend (%)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 2 (e.L.)	Tier 1 (i .L.)	Tier 1 (e. L.)
CO_2										1.4%			1.25%	1.19%
CH_4										4.7%			1.22%	1.22%
N_2O										6.3%			2.3%	2.27%
F-gases										5.5%				
Total	2.8%	2.2%	17%	2%	5.4%	4.3%	5.55%	2.33%	7.28%	1.6%				

* Base year for F-gases is 1995

Member State	Portugal	Romania		Slovakia		Slovenia		Spain		Sweden	
Citation	NIR March 2023, pp."1-23"-"1-24"	NIR March 2023 pp.94-95		NIR March 2023 pp.37		NIR March 2023 pp.29		NIR March 2023 pp.76		NIR March 2023 pp.NIR 56-58	
Method used	Tier 1	Tier 1		Tier 1		Tier 1		Tier 1		Tier 1	
Documentation in NIR (according to IPCC 2006 GL)	Yes (Annex F)	Yes (Annex 2)		Yes (Annex 3)		Yes (Annex 2)		Yes (Annex 6)		Yes (Annex 7)	
Years and sectors included	emissions: 2021; trends: 1990-2021; including LULUCF **	emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021; including LULUCF		emissions: 2021; trends: 1990-2021*; including LULUCF	
Uncertainty (%)	Tier 1	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)
CO_2											
CH_4											
N_2O											
F-gases											
Total	7.8%	41.1%	20.6%	11.67%	2.56%	9.9%	5.67%	12.7%	8.1%	110%	4.7%
Uncertainty in trend (%)	Tier 1	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)	Tier 1 (i .L.)	Tier 1 (e. L.)
CO_2											
CH_4											
N_2O											
F-gases											
Total	7.1%	2.6%	1.9%	4.9%	1.53%	29.51%	2.06%	9.8%	7.6%	19.58%	2,00%

* Base year for F-gases is 1995

** The uncertainty analysis was performed only for the direct GHG: CO2, CH4, N2O

1.7 General assessment of the completeness

1.7.1 Completeness checks of Member States' submissions

The EU GHG inventory is compiled on the basis of the inventories of the EU Member States. Therefore, the completeness of the EU inventory depends on the completeness of the Member States' submissions.

In response to the Saturday paper 2010 the EU implemented an action plan in 2011 aiming at improving the completeness regarding NEs of the EU greenhouse gas inventory.

1. Given the fairly wide interpretations and applications of notation keys, the identification of a "real" gap needs expert assessment which is provided by the UNFCCC review and which cannot be automated by existing EU internal procedures. Thus any action plan implemented by the EU needs to continue to be based primarily on the UNFCCC review reports. This was in particular evident with regards to the KP LULUCF, where a carbon pool could be not reported ('NR' should be used) provided that transparent and verifiable information was provided indicating that the pool was not a source, while notation keys such as NO and NA may also sometimes be linked to incomplete estimates. In this respect it needs to be stressed that the late availability of the review reports complicates the follow-up with Member States related to potential missing GHG estimates before the next EU inventory submission.
2. The notation key 'NE' is not in all cases an indication of a problem and neither the IPCC guidelines nor the UNFCCC review guidelines foresee an automatic procedure of gap filling when NEs are reported. For example, the notation "NE" can be used if there are no methods available in the 2006 IPCC Guidelines. Overall, a fair and complete analysis of the use of "NE" including the situations highlighted in point 1 above was considered to be indispensable (see chapter 1.7.1).

Given the above considerations the specific steps of the action plan followed since 2011 are as follows:

1. Member States are required by the Governance Regulation to submit their national GHG inventories electronically to the European Commission by 15 January of each year. A software program was created by the EEA so that upon submission of the relevant XML/CRF files a report is generated containing a list of all non-estimated source categories per Member State, specifying which of these source categories have been flagged in the Saturday Papers and for which ones IPCC methods are available. This report is then immediately notified to each Member State. During February the experts of the EU inventory team consult and discuss with Member States' experts inter alia:

    a. how MS have addressed and documented (or plan to address) the potential issues flagged in their Saturday Papers regarding missing estimates;

    b. the need for applying gap-filling procedures and the selection of the most appropriate methods;

    c. the need to use different notation keys.

2. Any finding with regard to the use of the notation key "NE" or relevant blank cells is communicated to the Member States' via the EMRT by 28 February latest. According to the procedures and time scales described in Annex XXI of the Implementing Regulation, the Draft EU inventory is sent to MS also by 28 February. Updated or additional inventory data submitted by MS (to remove inconsistencies or fill gaps) and complete final national inventory reports are submitted to the European Commission by 15 March.

3. In cases where, even after the two preceding steps a Member State's GHG inventory as submitted to the European Commission by 15 March still contained NEs for categories where IPCC methods exist, and/or if such reporting has been identified as a problem in previous reviews, then the EU inventory experts, in close cooperation with Member States, prepare the missing GHG source estimates in accordance with the gap-filling provisions in Article 5 of the Commission Delegated Regulation (EU) 2020/1044[18]. Article 5(3) requires Member States to use the gap-filled estimates in their national submissions to the UNFCCC to ensure consistency between the EU inventory and Member States' inventories.
4. A general assessment of completeness is included in the EU Greenhouse Gas Inventory Report. For transparency reasons, since 2011 the EU's inventory submission contains an improved description of this section to reflect the additional improvements discussed above.
5. In addition to the steps detailed above, the regular QA/QC procedures established to ensure the transparency, accuracy, comparability, consistency, and completeness of the EU inventory continue to be applied. The WG1 on annual inventories continues to address issues of completeness giving them priority and the EU peer reviews and the ESD reviews focus on identifying issues that may lead to an under- or overestimation of emissions.

Since 2012 the completeness checks have been extended to the use of the notation key NO and NA. All cases where less than seven Member States reported NO or NA and all other MS reported emission estimates were checked by the sector experts and clarified with Member States, if needed. With the implementation of the new 2006 IPCC Guidelines, there is an additional check regarding 'insignificance' as described in paragraph 37 of the UNFCCC Reporting Guidelines, which was also relevant for the ESD reviews.

Member States may only report NEs if:

1. There are no 2006 IPCC methods/EFs available.
2. Emissions are considered insignificant: below 0.05% of the NT & do not exceed 500 kt CO_2 eq. The sum of insignificant NEs shall remain below 0.1% of the NT.
   a. MS shall indicate in both the NIR and the CRF completeness table why such emissions/removals have not been estimated.
   b. MS should provide justifications for exclusion in terms of the likely level of emissions in the NIR, using approximated AD and default IPCC EFs.
3. Emissions have not been reported in a previous submission, otherwise they shall be reported in subsequent submissions.

➢ If MS report unjustified NEs (according to 1. 2. and 3. above) gap-filling rules will apply

For the sectors energy, industrial processes and product use, agriculture, LULUCF and waste sector-specific checks are performed by the EU sector experts using outlier tools similar to those of the UNFCCC and other QA/QC tools. The results of the consistency and completeness checks as well as the main findings of the sector specific checks are documented in the web-based EEA Emission Review Tool (EMRT). This tool is accessible for MS inventory coordinators and inventory experts. The Member States are asked to respond to findings in this tool and if needed provide revised emission estimates or additional information.

[18] Commission Delegated Regulation (EU) 2020/1044 of 8 May 2020 supplementing Regulation (EU) 2018/1999 of the European Parliament and of the Council with regard to values for global warming potentials and the inventory guidelines and with regard to the Union inventory system and repealing Commission Delegated Regulation (EU) No 666/2014; OJ L 230, 17.7.2020, p. 1–6

For every updated inventory submission provided by the MS by 15 March follow-up checks are performed by the sector experts and additional findings are documented in the EEA Emission Review Tool (EMRT). In addition it is checked if issues identified in the QA/QC communication tool (initial checks), which are relevant for the EU inventory (report) have been clarified by the MS. If this is not the case MS are contacted for clarification.

Since 2015 also cases where neither numeric values nor notation keys have been reported (blank cells) have been included in the checking procedure. EU experts have checked with Member States if blank cells have been caused by the new CRF reporter software or if in fact the blank cells should be replaced by notation keys or a numeric values.

1.7.2 Reporting of notation key "NE"

As the EU GHG inventory is the sum of MS inventories all categories reported as "NE" by Member States are also reflected in the EU GHG inventories. However, the EU CRF tables include only a small number of categories where "NE" is actually visible because the "NE" of a Member State is only visible in the EU CRF in a category where all EU MS report notation keys. Table 1.18 shows that 13 mandatory categories have "NE" visible in the CRF tables for 2021.

Table 1.18 Overview of the number of NE visible in the EU CRF tables for 2021

Sector	Number of NE visible in the EU CRF for the year 2020 for mandatory categories (MS reporting NE)
Energy	3 (CZE, POL)
IPPU	9 (CYP, DEU, FRK, SWE)
Agriculture	0
Waste	1 (CZE,)

1.7.3 Reporting of confidential data

According to the UNFCCC reporting guidelines Parties may report specific categories with the notation key C in case of confidentiality. In 2023 only two MS made use of this option; for the year 2021 Croatia reported CO_2, CH_4 and N_2O emission from 1D2 as confidential (Multilateral operations), while Sweden reported correct sector totals for all sectors but in the sectors Energy and IPPU on a less aggregated level the country reported 26 sub-categories as confidential. Manual changes have been performed in order to reflect this in the most appropriate way in the EU CRF tables. For further details refer to Table 1.7. Please note that the EU GHG inventory team – on request - obtains access to confidential MS data for quality checking purposes which has been the case for Sweden in 2023.

Therefore, in the relevant sector chapters, EU trends at fuel level do not always include Sweden for confidentiality reasons and also to preserve time series consistency for the EU. Consequently, the EU CRF tables at sub-category level and data shown on the same level in the NIR are not always consistent. Note that at sector level and at national totals level the EU NIR and the EU CRF tables are fully consistent.

Table 1.19 Confidential data reported by MS in key categories for the EU

Source category gas	Confidential data	
	1990	2020
1.A.2.c Chemicals: Gaseous Fuels (CO_2)		SWE
1.A.2.c Chemicals: Solid Fuels (CO_2)		SWE
1.A.2.f Non-metallic minerals: Gaseous Fuels (CO_2)		SWE

Source category gas	Confidential data	
	1990	2020
1.A.2.f Non-metallic minerals: Other Fuels (CO_2)		SWE
1.A.2.f Non-metallic minerals: Solid Fuels (CO_2)		SWE

As the EU GHG inventory is the sum of MS inventories all categories reported as confidential by Member States are also reflected in the EU GHG inventories. If Member States report confidential data the notation key "C" will be shown in the comments of the relevant cell in the CRF tables only.

1.7.4 Data gaps and gap-filling

1.7.4.1 Gap filling of emissions

The EU GHG inventory is compiled by using the inventory submissions of the EU Member States. If a Member State does not submit all data required for the compilation of the EU inventory by 15 March of a reporting year, the Commission prepares estimates for data missing in collaboration with the relevant Member State based on the following methodologies and data:

- where a Member State has submitted in the previous reporting year a consistent time series of estimates for the relevant source category and:
  - that Member State has submitted an approximated greenhouse gas inventory for the year X – 1 pursuant to Article 26(2) of Regulation (EU) 2018/1999 that includes the missing estimate, on the data from that approximated greenhouse gas inventory;
  - that Member State has not submitted an approximated greenhouse gas inventory for the year X – 1 under Article 26(2) of Regulation (EU) 2018/1999, but the Union has estimated approximated greenhouse gas emissions for the year X – 1 for that Member State in accordance with Article 26(2) of Regulation (EU) 2018/1999[19], on the data from that Union approximated greenhouse gas inventory;
  - the use of the data from the approximated greenhouse gas inventory of the Member State is not possible or may lead to a highly inaccurate estimation, for missing estimates in the energy sector, on the energy statistics data obtained in accordance with Regulation (EC) No 1099/2008 of the European Parliament and of the Council;
  - the use of the data from the approximated greenhouse gas inventory is not possible or may lead to a highly inaccurate estimation, for missing estimates in non-energy sectors, on estimation methodologies consistent with the technical advice on gap filling in Section 2.2.3 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 1) using, where appropriate, European statistics;
- where an estimate of an emission by source or removal by sink for the relevant category was subject to technical corrections in accordance with Article 38(2)(d) of Regulation (EU) 2018/1999 in the latest review prior to the submission and the Member State concerned has not submitted a revised estimate, on the method used by the technical expert review team to calculate the technical correction;
- where a consistent time series of reported estimates for the relevant source category is not available, on estimation methodologies consistent with the technical advice on gap filling in Section 2.2.3 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 1).

[19] Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics; OJ L 304, 14.11.2008, p. 1

The Commission prepares the estimates by 31 March of the reporting year, following consultation with the Member State concerned, and communicates the estimates to the other Member States. The Member State concerned shall use the estimates referred to for its national submission to the UNFCCC to ensure consistency between the EU inventory and Member States' inventories.

The methods used for gap filling include interpolation, extrapolation and clustering. These methods are consistent with the 2006 IPCC guidelines[20].

1.7.4.2 Gap filling of emissions in GHG inventory submissions 2021

Since 2011 GHG inventory estimates have been complete for all EU Member States, and therefore no gap filling has been needed.

1.7.4.3 Gap filling of activity data

In response to recommendations of the UNFCCC review team the EU elaborated and implemented a gap filling procedure for gaps in activity data (for further details on the methodology also see 4.3). Due to the large resource needs for gap filling the following rules apply:

- Only activity data for key categories will be gap-filled.
- If more than 75 % of the emissions are calculated on basis of consistent activity data.
- If the IEF has a reasonable degree of consistency (i.e. standard deviation divided by mean < 50 %).
- Only for the latest reporting year.

1.7.4.4 Gap filling of activity data in GHG inventory submissions 2023

Applying the rules mentioned above activity data of the following categories have been gap-filled in this inventory submission for the year 2021:

- Lime Production 2A2
- Ammonia Production 2B1

1.7.5 Geographical coverage of the European Union inventory

Table 1.20 shows the geographical coverage of the EU Member States' national inventories. Note that the EU territory of a Member State is not always equivalent to the territory of the Party to the UNFCCC. For two Member States there are differences in geographical coverage as UNFCCC Party and/or EU Member State (Denmark and France). If there are differences in geographical coverage the respective country needs to prepare more than one inventory.

As the EU inventory is the sum of the Member States' inventories, the EU inventory covers the same geographical area as the inventories of the 27 Member States for their respective EU territory. Note that Denmark and France submit GHG inventories to the UNFCCC that may differ from the GHG inventories used for the EU inventory because these countries submit an inventory to the UNFCCC, which is consistent with the Party coverage of these countries. However, the EU's submission under the Convention is fully consistent with MS GHG emissions by sources and sinks according to the EU territory. (see Table 1.2019).

[20] ETC ACC technical note on gap filling procedures, December 2006.

Table 1.20 Geographical coverage of the Union's GHG inventory

Member State	Geographical coverage	EU-territory coverage	Party coverage (UNFCCC)	Country code
Austria	Austria	✓	✓	AUT
Belgium	Belgium consisting of Flemish Region, Walloon Region and Brussels Region	✓	✓	BEL
Bulgaria	Bulgaria	✓	✓	BGR
Croatia	Croatia	✓	✓	HRV
Cyprus	Area under the effective control of the Republic of Cyprus	✓	✓	CYP
Czechia	Czech Republic	✓	✓	CZE
Denmark	Denmark (excluding Greenland and the Faeroe Islands)	✓		DNM
	Denmark (including Greenland and the Faeroe Islands)		✓	DNK
Estonia	Estonia	✓	✓	EST
Finland	Finland including Åland Islands	✓	✓	FIN
France	Metropolitan France, the overseas departments (Guadeloupe, Martinique, French Guiana, Réunion and Mayotte) and the overseas community Saint-Martin; excluding the overseas communities French Polynesia, Wallis and Futuna, Saint-Pierre and Miquelon, and Saint-Barthélemy; and excluding the overseas territories (the French Southern and Antarctic Lands) and New Caledonia.	✓		FRK
	Metropolitan France, the overseas departments, the overseas communities, overseas territories and New Caledonia.		✓	FRA
Germany	Germany	✓	✓	DEU
Greece	Greece	✓	✓	GRC
Hungary	Hungary	✓	✓	HUN
Ireland	Ireland	✓	✓	IRE
Italy	Italy	✓	✓	ITA
Latvia	Latvia	✓	✓	LVA
Lithuania	Lithuania	✓	✓	LTU
Luxembourg	Luxembourg	✓	✓	LUX
Malta	Malta	✓	✓	MLT
Netherlands	The reported emissions are those that derive from the legal territory of the Netherlands. This includes a 12-mile zone out from the coastline and inland water bodies. It excludes the Dutch Caribbean territories Aruba, Curaçao and Sint Maarten, which are constituent countries of the Kingdom of the Netherlands. It also excludes Bonaire, Saba and Sint Eustatius, which since 10 October 2010 have been public bodies (openbare lichamen) with their own legislation that is not applicable to the European part of the Netherlands. Emissions from offshore oil and gas production on the Dutch part of the continental shelf are included.	✓	✓	NLD
Poland	Poland	✓	✓	POL

Member State	Geographical coverage	EU-territory coverage	Party coverage (UNFCCC)	Country code
Portugal	Mainland Portugal and the two Autonomous regions of Madeira and Azores Islands. Includes also emissions from air traffic and navigation bunkers realised between these areas.	✓	✓	PRT
Romania	Romania	✓	✓	ROU
Slovakia	Slovakia	✓	✓	SVK
Slovenia	Slovenia	✓	✓	SVN
Spain	Spanish part of Iberian mainland, Canary Islands, Balearic Islands, Ceuta and Melilla	✓	✓	ESP
Sweden	Sweden	✓	✓	SWE
European Union	EU-27	✓	✓	EUA

1.7.6 Completeness of the European Union submission

1.7.6.1 National inventory report

The EU NIR follows – as far as possible - the annotated outline of the UNFCCC secretariat with the exception of the annexes. The main reason for this is the nature of the EU inventory being the sum of Member States' inventories. Therefore the main purpose of the annexes is to make transparent the EU emission estimates by providing the basic Member States tables for every CRF table. Table 1.21 provides information on what is included in the Annexes to the EU GHG inventory report and provides explanations where the EU does not follow the UNFCCC reporting guidelines.

Table 1.21 Annexes as outlined in the UNFCCC reporting guidelines and annexes included in the EU submission

Annex required in the UNFCCC reporting guidelines	Annex included in the EU submission
Annex I: Key categories	Included: Key category analyses Tier 1 including and excluding LULUCF
Annex II: Assessment of uncertainty	The uncertainty assessment is included in the NIR, section 1.6
Annex III: Detailed methodological descriptions for individual source or sink categories	Included: A summary description of the methodologies used by each Member State for the EU key categories
Annex IV: National energy balance of the most recent year	Not included: Due to the nature of the EU inventory being the sum of Member States' inventories there is no national energy balance which could be included in this annex.
Annex V: Additional information	Included: Summary Table 2 for all MS in order to make transparent the data basis of the EU inventory

1.7.6.2 Activity data in the EU CRF

The European Union cannot provide all data in the sectoral background tables. The main reasons for not completing all sectoral background data tables are: (1) limited data availability partly due to confidentiality issues; and (2) the use of different type of activity data by Member States. The latter is due to the fact that the Member States are responsible for calculating emissions. If they use country-specific methods they may also use different types of activity data. At EU-level these different types of activity data cannot be simply added up. It should be noted that at EU-level no emissions are calculated directly on the basis of activity data reported by MS. However, all the details for the calculation of MS emissions are documented in the Member States' CRF tables, as part of their national GHG inventories.

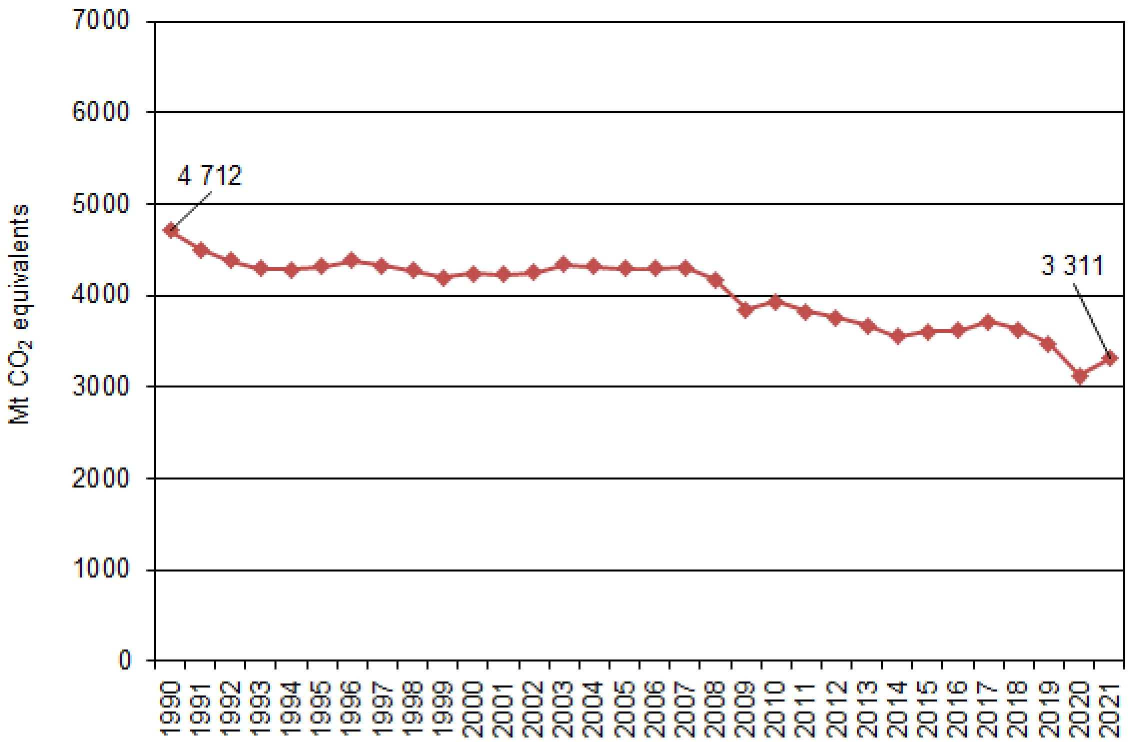
2 EU GREENHOUSE GAS EMISSION TRENDS

This chapter presents the main GHG emission trends in the EU. Aggregated results are described as regards total GHG and emission trends are briefly analysed mainly at gas level. A short overview of countries contributions to total EU GHG trends is given. Finally, the trends of indirect GHGs and SO_2 emissions are presented.

2.1 Aggregated greenhouse gas emissions

In 2021, total GHG emissions in the EU, including LULUCF, indirect CO_2 and international aviation, were 30 % (-1 401 million tonnes CO_2 equivalents) below 1990 levels. Emissions increased by 6.2 % (193 million tonnes CO_2 equivalents) between 2020 and 2021. Still, emissions in 2021 remained below the 2019 pre-COVID-19 pandemic level (3 477 million tonnes CO_2 equivalent) and confirm an overall downward trend (Figure 2.1). The EU's national total emissions[21] also include LULUCF and international aviation to be consistent with the scope of the EU's 2030 Nationally Determined Contribution (NDC)[22].

Figure 2.1 EU-27 GHG emissions 1990–2021 (incl. LULUCF, incl. International aviation)



Notes: The GHG emissions data shown in this figure include indirect CO_2 emissions, emissions and removals from LULUCF; and emissions from international aviation, but exclude emissions from international maritime transport. CO_2 emissions from biomass with energy recovery are reported as a Memorandum item according to UNFCCC guidelines and are not included in national totals. In addition, no adjustments for temperature variations or electricity trade are considered. The 100-year global warming potentials are those from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

[21] Unless otherwise specified, the national GHG totals in this report always include LULUCF. They may also be referred to as 'net' total GHG emissions. The other UNFCCC sectors that are included in the national totals are energy, industrial processes and product use, agriculture, waste, international aviation, and indirect CO_2 emissions.

[22] https://unfccc.int/NDCREG

2.1.1 Main trends by source category, 1990-2021

Total GHG emissions (including LULUCF and international aviation) decreased by 1401 Mt CO_2 eq. since 1990 (or 29.7 %) reaching 3 311 Mt CO_2 equivalent in 2021. There has been a progressive decoupling of gross domestic product (GDP) and GHG emission compared to 1990, with an increase in GDP of 61 % alongside a decrease in emissions of about 30 % over the period.

The trend in GHG emissions over the 31-year period was driven by a variety of factors, including the growing share in the use of renewables, the use of less carbon intensive fossil fuels and improvements in energy efficiency, as well as to structural changes in the economy, and more recently the economic recession from the COVID-19 pandemic in 2020 and the recovery of 2021.

The long-lasting changes have resulted in a lower energy intensity of the economy and in a lower carbon intensity of energy production and consumption in 2021 compared to 1990. Demand for energy to heat households has also been lower, as Europe on average has experienced milder winters since 1990, which has also helped reduce emissions.

GHG emissions decreased in the majority of sectors between 1990 and 2021, with the notable exception of transport, refrigeration and air conditioning, where emissions increased, and forest land, where net removals decreased. For the latter, the main reasons for the decrease in net removals include the aging of the forests from the late 2000s and a lower annual increment, as well as increased harvesting. At the aggregate level, emission reductions were largest for manufacturing industries and construction, electricity and heat production, iron and steel production (including energy-related emissions) and residential combustion.

A combination of factors explains lower emissions in industrial sectors, such as improved efficiency and lower carbon intensity as well as structural changes in the economy, with a higher share of services and a lower share of more-energy-intensive industry in total GDP.

Emissions from electricity and heat production have decreased strongly since 1990. In addition to improved energy efficiency there has been a move towards less carbon intense fuels. Between 1990 and 2021, the use of solid and liquid fuels in thermal power stations decreased strongly (by 53% and 85%, respectively) whereas natural gas consumption developed in the opposite direction (increasing by 76%). Coal consumption in 1990 was two times higher than in 2021. The use of renewable energy sources in electricity and heat generation has increased substantially in the EU since 1990 (by almost four times, including also non-combustible renewables). Improved energy efficiency and a less carbon intensive fuel mix have resulted in reduced CO_2 emissions per unit of fossil energy generated.

Emissions in the residential sector also represented one of the largest reductions. Energy efficiency improvements from better insulation standards in buildings, and a less carbon-intensive fuel mix, can partly explain lower demand for space heating in the EU over the past 31 years.

In terms of the main GHGs, CO_2 was responsible for the largest reduction in emissions since 1990. Reductions in emissions from N_2O and CH_4 have been substantial, reflecting lower levels of mining activities, lower agricultural livestock, as well as lower emissions from managed waste disposal on land and from reduced adipic and nitric acid production.

A number of policies (both EU and country-specific) have contributed to the overall GHG emission reduction, including key agricultural and environmental policies in the 1990s and climate and energy policies in the past 16 years since 2005. Despite quick progress reducing agricultural emissions during the 1990s and early 2000s, they have remained broadly stable since 2005.

Almost all EU Member States reduced emissions compared to 1990 and thus contributed to the overall positive EU performance. Germany, Romania, Italy and France accounted for two thirds of the total net reduction in EU emissions during the past 31 years.

Table 2.1 shows those sources that made the largest contribution to the change in total GHG emissions in the EU between 1990 and 2021.

Table 2.1 Overview of EU categories whose emissions and/or removals increased or decreased by more than 20 Million tonnes CO_2 equivalent in the period 1990-2021; including LULUCF categories

Source category	Million tonnes (CO_2 equivalents)
Road Transportation (CO2 from 1.A.3.b)	131
Refrigeration and Air conditioning (HFCs from 2.F.1)	64
Forest Land (CO2 from 4.A.1)	52
Agricultural soils: Direct N2O emissions (N2O from 3.D.1)	-22
Cement Production (CO2 from 2.A.1)	-23
Cropland (CO2 from 4.B.1)	-23
Adipic Acid Production (N2O from 2.B.3)	-33
Nitric Acid Production (N2O from 2.B.2)	-38
Fuels used Commercial/Institutional Sector (CO2 from 1.A.4.a)	-41
Managed Waste Disposal Sites (CH4 from 5.A.1)	-42
Fugitive Emissions from Oil and Natural Gas (CH4 from 1.B.2)	-42
Enteric Fermentation: Cattle (CH4 from 3.A.1)	-45
Fugitive Emissions from Solid Fuels (CH4 from 1.B.1)	-60
Manufacture of Solid Fuels and Other Energy Industries (CO2 from 1.A.1.c)	-71
Iron and Steel Production (CO2 from 1.A.2.a + 2.C.1)	-108
Fuels used Residential Sector (CO2 from 1.A.4.b)	-120
Manufacturing industries (excl. Iron and steel) (Energy-related CO2 from 1.A.2 excl. 1.A.2.a)	-218
Public Electricity and Heat Production (CO2 from 1.A.1.a)	-518
Total	**-1401**

Notes: As the table only presents sectors whose emissions have increased or decreased by at least 20 million tonnes CO_2 equivalent, the sum of the EU key categories in this table does not match the total change in emissions listed at the bottom of the table, which includes all emission sources in the EU inventory. Note that LULUCF categories and the Memorandum item international aviation are reflected in this table.

2.1.2 Main trends by source category, 2020-2021

Total GHG emissions (including LULUCF and international aviation) increased in 2021 by 193 million tonnes, or 6.2 % compared to 2020, to reach 3 311 Mt CO_2 equivalent in 2021. The increase in GHG emissions in 2021 was the largest in absolute and relative terms year-on-year in the EU since 1990. This can be attributed to the economic recovery, underpinned by higher coal use in the power sector and transport demand, that followed the strong contraction in economic activity during the COVID-19 pandemic in 2020.

At EU level, almost two thirds of the net increase in GHG emissions in 2021 took place in road transportation and public electricity and heat production. But almost all economic sectors saw significant emission increases in 2021, including manufacturing industries and construction, iron and steel, and international aviation, among others.

The largest increase in CO_2 emissions in 2021 came from electricity and heat production, with 64 Mt (or 10% increase compared to 2020). The increase was driven almost fully by higher coal use in power stations. Also, greenhouse gas emissions from stationary installations in the EU ETS increased by about 7% in 2021, which represents the largest increase in emissions since the ETS began operating in 2005.

Based on Eurostat energy statistics, total electricity production increased in the EU in 2021. Bioenergy and solar electricity increased, while wind and hydroelectricity declined. Nuclear electricity also increased in 2021.

The second largest increase occurred in road transport, with CO_2 emissions increasing by 60 Mt (or 9%) in 2021, after a drastic reduction in transport activity in 2020 due to the lockdown measures during the COVID-19 pandemic. Passenger cars accounted for the largest share of the increase in road transport emissions, but emissions from light duty and heavy-duty vehicles also increased significantly in 2021.

Finally, COVID-19 pandemic-related travelling restrictions in 2020 had led to a major decrease in GHG emissions in the aviation sector (both domestic and international) of 57% compared to 2019 levels. Although emissions from international aviation increased in 2021 compared to 2020, the increase did not offset the massive reduction of 2020, with 2021 emissions remaining at levels comparable to those of the mid-1990s.

Table 2.2 shows the categories making the largest contribution to the change in GHG emissions and removals in the EU between 2020 and 2021.

Table 2.2 Overview of EU categories whose emissions and/or removals increased or decreased by more than 3 million tonnes CO_2 equivalent in the period 2020–2021

Source category	Million tonnes (CO_2 equivalents)
Public Electricity and Heat Production (CO2 from 1.A.1.a)	64
Road Transportation (CO2 from 1.A.3.b)	60
Iron and Steel Production (CO2 from 1.A.2.a + 2.C.1)	20
Manufacturing industries (excl. Iron and steel) (Energy-related CO2 from 1.A.2 excl. 1.A.2.a)	17
International Aviation (CO2 from 1.D.1.a)	13
Forest Land (CO2 from 4.A.1)	9
Fuels used Commercial/Institutional Sector (CO2 from 1.A.4.a)	8
Grassland (CO2 from 4.C.1)	5
Fuels used Residential Sector (CO2 from 1.A.4.b)	4
Harvested Wood Products (CO2 from 4.G)	-6
Total	**193**

Notes: As the table only presents sectors whose emissions have increased or decreased by at least 20 million tonnes CO_2 equivalent, the sum of the EU key categories in this table does not match the total change in emissions listed at the bottom of the table, which includes all emission sources in the EU inventory. Note that LULUCF categories and the Memorandum item international aviation are reflected in this table.

Table 2.3 gives an overview on total GHG emissions by Member States, illustrating where main changes occurred.

Table 2.3 Greenhouse gas emissions in CO_2 equivalent (incl. LULUCF, including aviation)

	1990 (million tonnes)	2021 (million tonnes)	2020 - 2021 (million tonnes)	Change 2020 - 2021 (%)	Change 1990-2021 (%)
Austria	67.7	68.4	-1.4	-2.0%	0.9%
Belgium	146.1	115.2	4.6	4.2%	-21.1%
Bulgaria	83.4	45.3	6.3	16.1%	-45.6%
Croatia	25.6	18.9	0.5	2.9%	-26.1%
Cyprus	6.2	9.1	0.5	5.3%	45.7%
Czechia	192.8	127.8	2.4	1.9%	-33.7%
Denmark	80.2	47.5	0.6	1.3%	-40.7%
Estonia	36.7	15.6	1.6	11.7%	-57.4%
Finland	46.5	49.2	9.6	24.2%	5.8%
France	531.0	406.2	27.1	7.2%	-23.5%
Germany	1299.4	782.7	33.7	4.5%	-39.8%
Greece	104.2	74.5	3.2	4.4%	-28.5%
Hungary	92.1	57.4	1.2	2.2%	-37.7%
Ireland	62.7	70.8	3.5	5.2%	12.8%
Italy	522.3	395.1	38.9	10.9%	-24.4%
Latvia	13.9	13.4	1.9	16.5%	-3.8%
Lithuania	43.2	14.4	0.7	4.8%	-66.7%
Luxembourg	13.1	10.7	0.4	4.3%	-18.8%
Malta	2.8	2.4	0.1	2.9%	-15.4%
Netherlands	233.6	179.3	3.7	2.1%	-23.2%
Poland	447.0	382.3	28.0	7.9%	-14.5%
Portugal	68.2	52.5	-2.5	-4.6%	-23.0%
Romania	229.3	66.4	4.6	7.5%	-71.0%
Slovakia	64.6	33.7	4.1	13.8%	-47.8%
Slovenia	14.5	13.0	0.2	1.3%	-9.9%
Spain	258.6	252.6	18.0	7.7%	-2.3%
Sweden	26.5	7.1	1.2	21.1%	-73.2%
EU-27	4712.3	3311.5	192.8	6.2%	-29.7%

2.2 Emission trends by gas

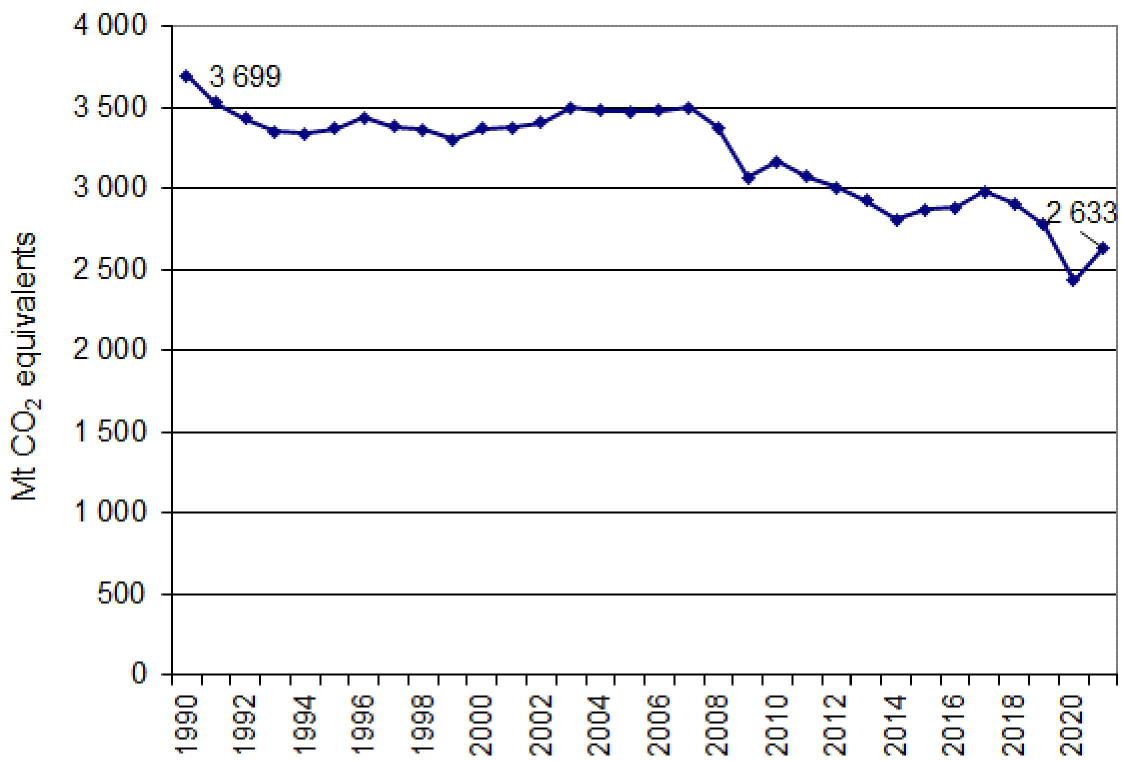
Table 2.4, Figure 2.2 and Figure 2.3 give an overview of the main trends in EU GHG emissions and removals for 1990–2021. In the EU the most important GHG is CO_2, accounting for 80 % of total EU emissions in 2021 including LULUCF and international aviation. In 2021, CO_2 emissions including LULUCF and international aviation were 2 633 Mt, which was 29 % below 1990 levels. Compared to 2020, CO_2 emissions increased by 8 %. During that period CH_4 and N_2O emissions decreased slightly.

Table 2.4 Overview of EU GHG emissions and removals from 1990 to 2021 in CO_2 equivalent

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2005	2010	2015	2020	2021
Net CO_2 emissions/removals	3 646	3 306	3 285	3 382	3 070	2 761	2 378	2 564
CO_2 International aviation	*54*	*65*	*84*	*95*	*100*	*108*	*56*	*69*
CH_4	663	607	557	510	471	444	418	415
CH_4 International aviation	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
N_2O	300	275	244	232	192	189	185	185
N_2O International aviation	*0*	*1*	*1*	*1*	*1*	*1*	*0*	*1*
HFCs	13	21	41	62	86	87	73	70
PFCs	22	15	10	6	3	3	2	2
Unspecified mix of HFCs and PFCs	5	5	2	1	1	1	2	2
SF_6	10	14	9	7	6	6	5	5
NF_3	0	0	0	0	0	0	0	0
Total (including LULUCF and aviation)	**4 712**	**4 310**	**4 233**	**4 296**	**3 929**	**3 599**	**3 119**	**3 311**

Notes: CO_2 emissions include indirect CO_2

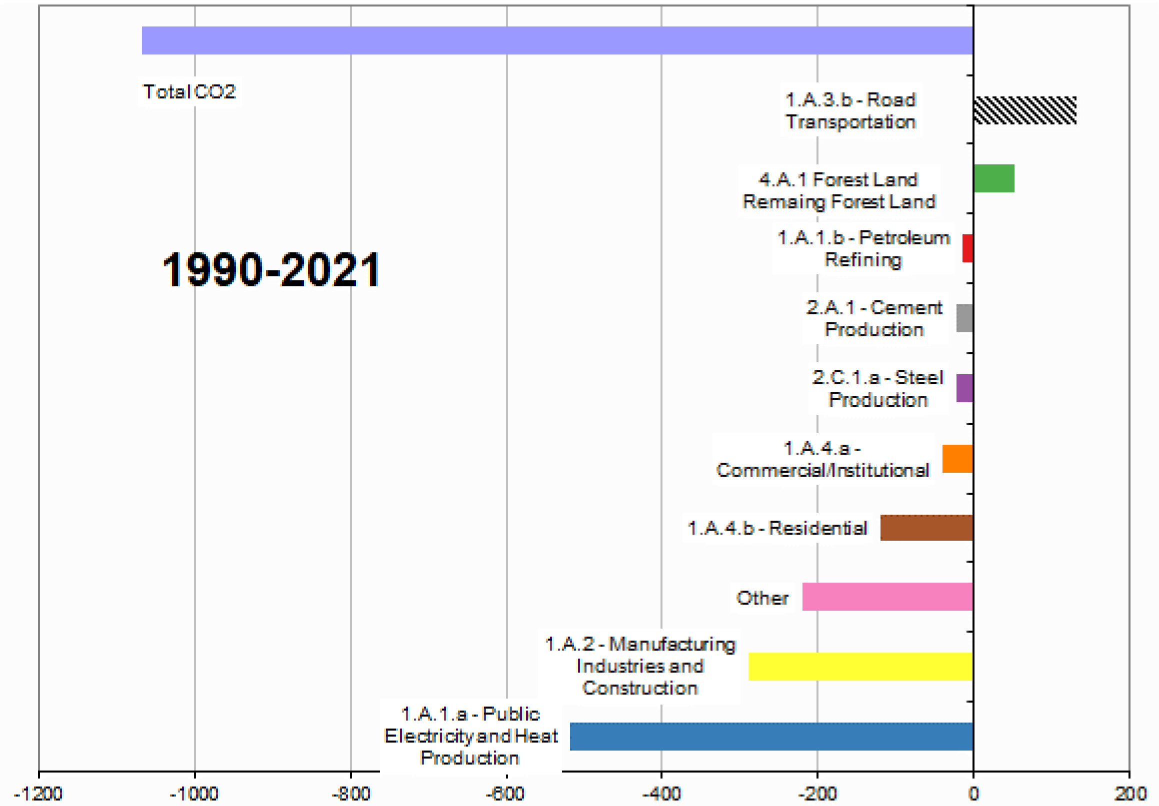
Figure 2.2 CO_2 emissions 1990 to 2021 (Mt) (including LULUCF and international aviation)



Notes: CO_2 emissions include indirect CO_2

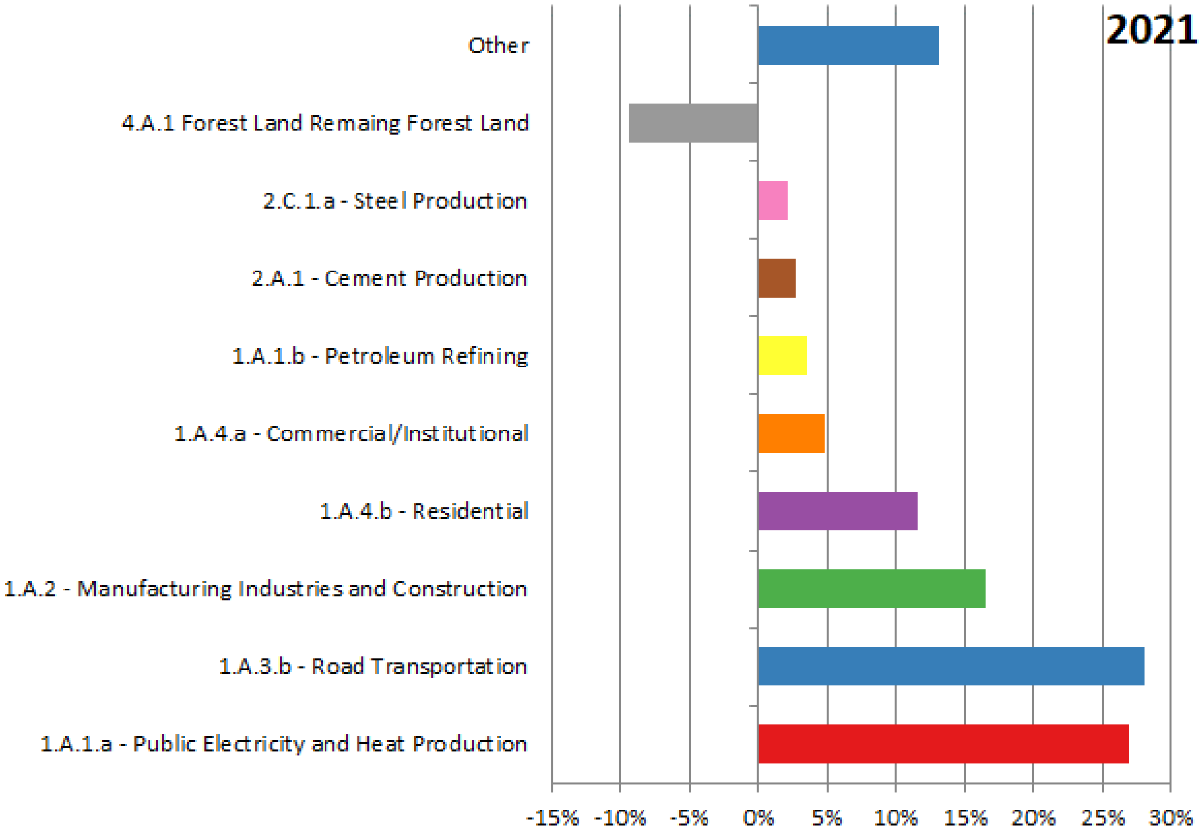
The largest key categories for CO_2 emissions and removals (Figure 2.3) have been reduced between 1990 and 2021 with the exception of 1.A.3.b Road transportation and 4.A.1 Forest Land Remaining Forest Land.

Figure 2.3 Absolute change of CO_2 emissions by large key categories 1990 to 2021 in CO_2 equivalents (Mt) for EU (including LULUCF and aviation)



Note: Other is calculated by subtracting the presented categories from the sector total including LULUCF and international aviation

Figure 2.4 CO_2 emissions: Share of key categories and all remaining categories in 2021 for EU



Note: Other is calculated by subtracting the presented categories from the sector total including LULUCF and international aviation
Percentages are rounded and may lead to a sum higher or lower than 100%

CH_4 emissions account for 13 % of total EU GHG emissions in 2021 and decreased by 37 % since 1990 to 415 Mt CO_2 equivalents in 2021 (Figure 2.5). The two largest key categories are enteric fermentation from cattle and anaerobic waste (Figure 2.7). They account for 53 % of CH_4 emissions in 2021.

Figure 2.5 CH_4 emissions 1990 to 2021 in CO_2 equivalents (Mt) (incl. LULUCF and incl. international aviation)

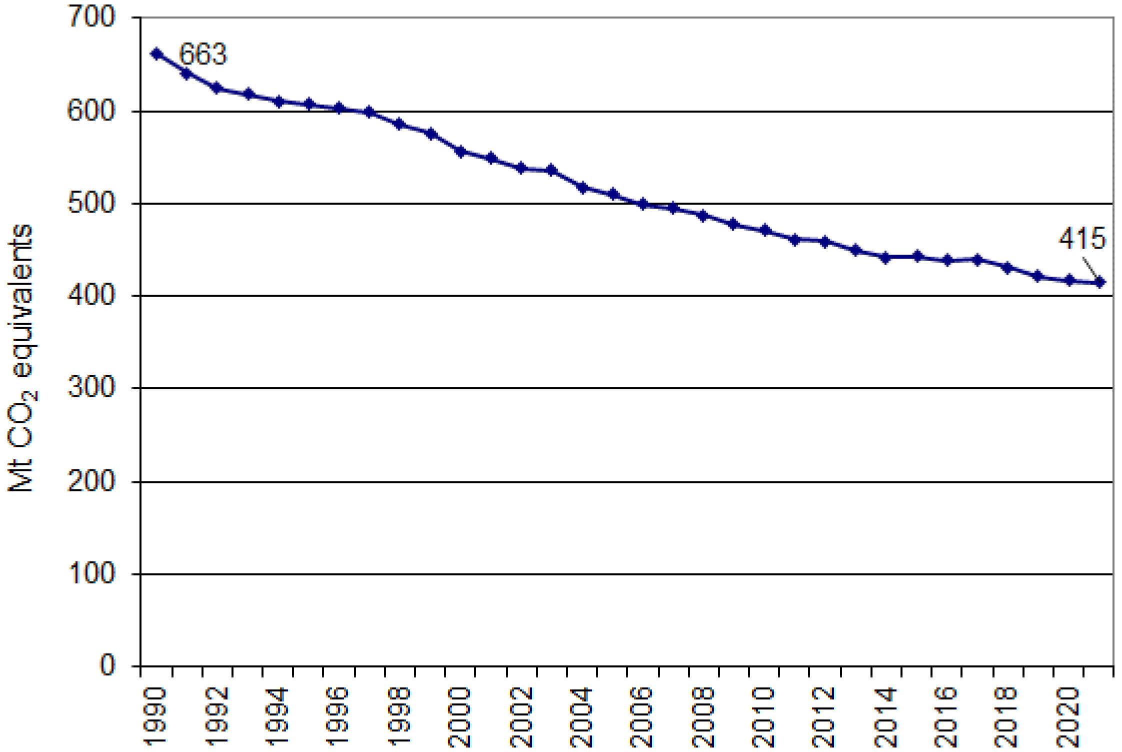
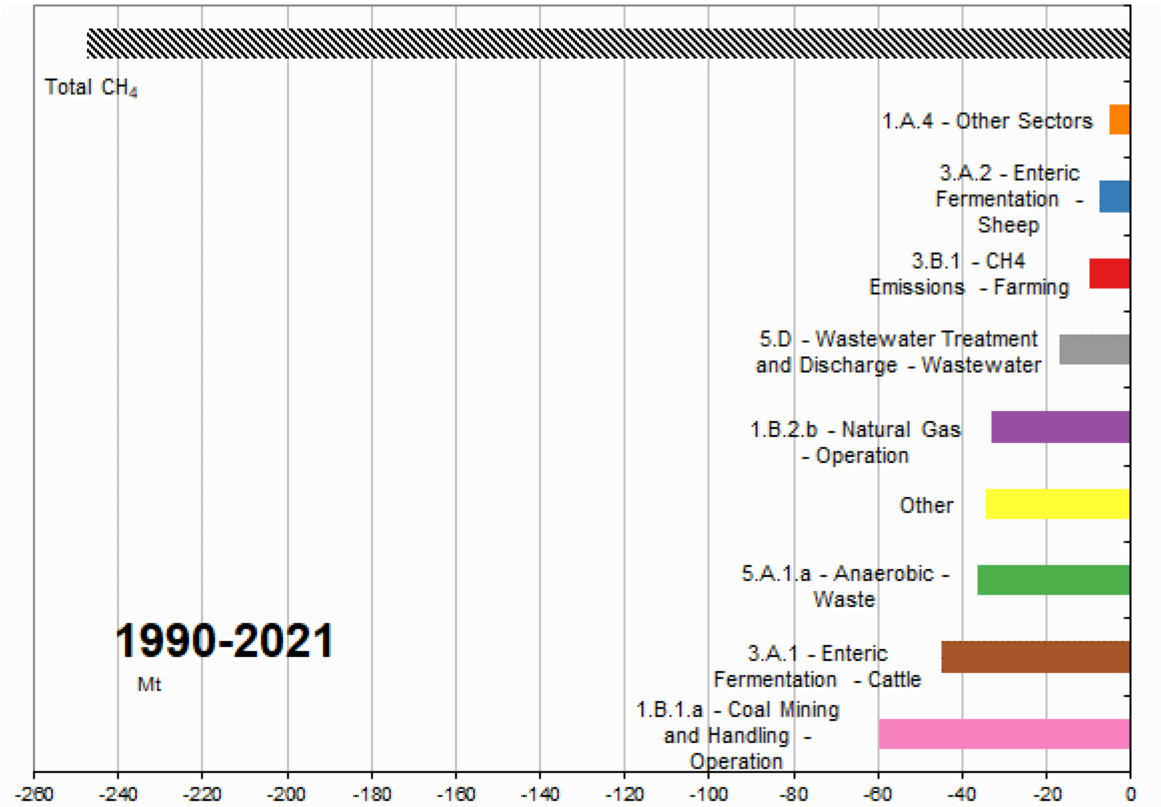


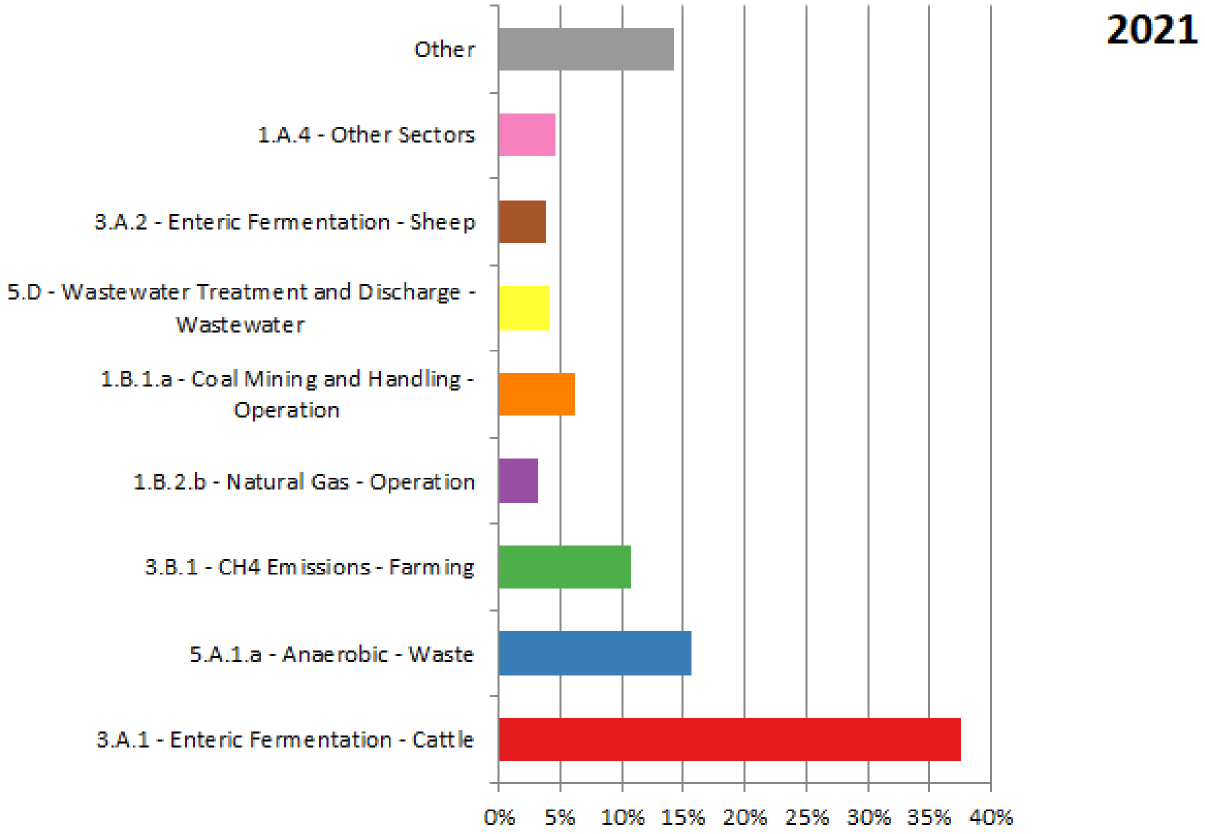
Figure 2.6 shows that the main reasons for declining CH_4 emissions were reductions in coal mining, cattle population and anaerobic waste.

Figure 2.6 Absolute change of CH_4 emissions by large key categories 1990 to 2021 in CO_2 equivalents (Mt) for EU



Note: Other is calculated by subtracting the presented categories from the sector total including LULUCF and international aviation

Figure 2.7 CH_4 emissions: Share of key categories and all remaining categories in 2021 for EU



Note: Other is calculated by subtracting the presented categories from the sector total including LULUCF and international aviation
Percentages are rounded and may lead to a sum higher or lower than 100%

N_2O emissions are responsible for 6 % of total EU GHG emissions and decreased by 38 % to 186 Mt CO_2 equivalents in 2021 (Figure 2.8). N_2O emissions derive mainly from the agriculture sector. The two largest key categories account for about 64 % of N_2O emissions in 2021 (Figure 2.10). Figure 2.9 shows that the main reason for large N_2O emission cuts were reductions in chemical industry and agricultural soils.

Figure 2.8 N_2O emissions 1990 to 2021 in CO_2 equivalents (Mt)

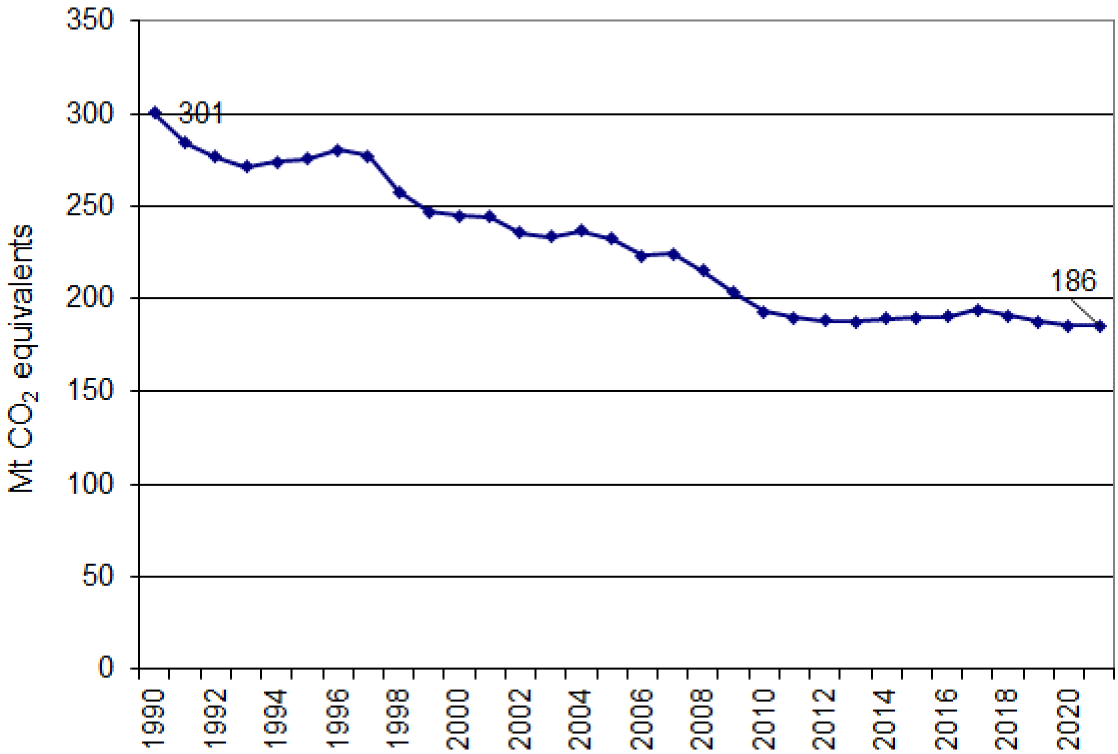
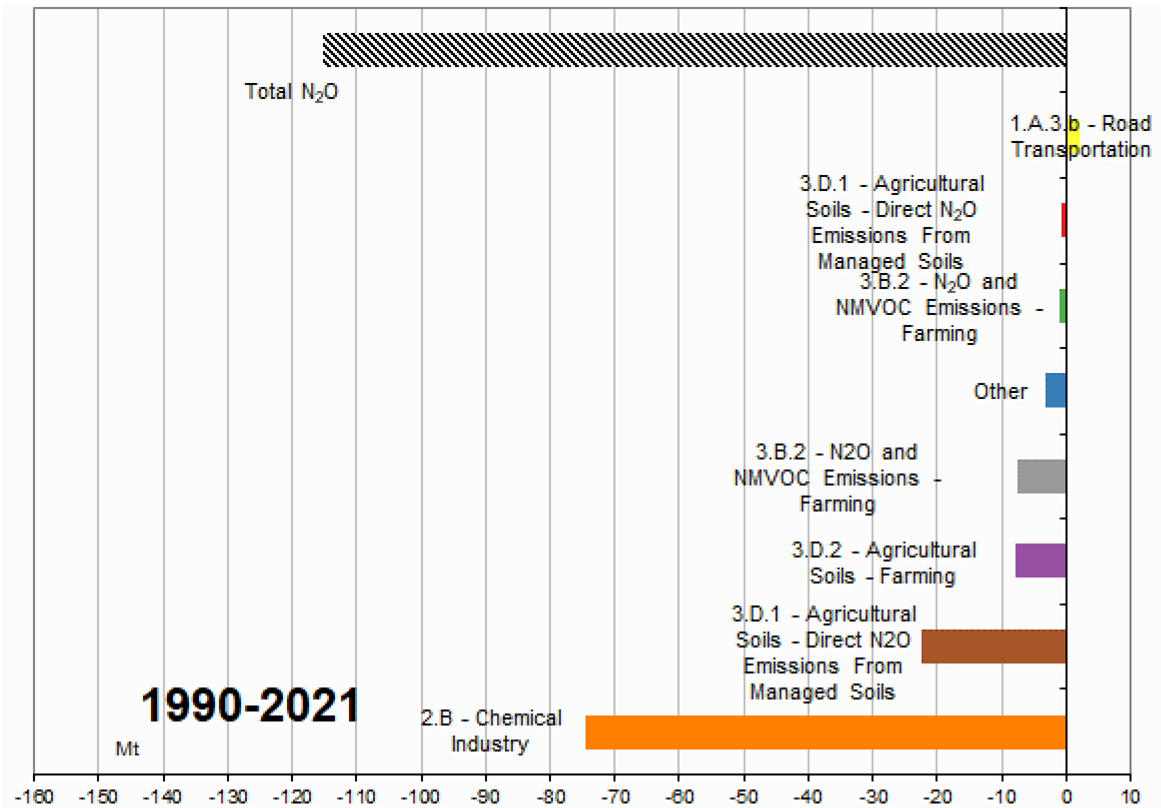
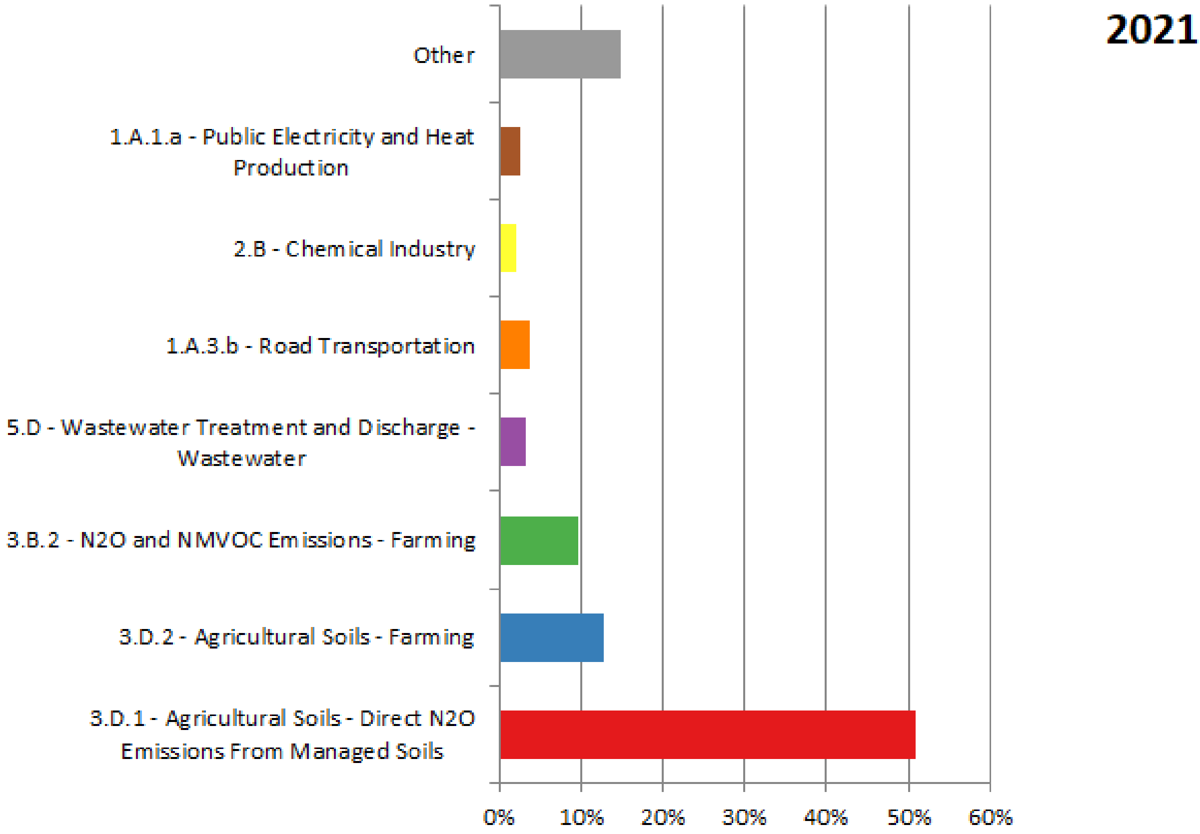


Figure 2.9 Absolute change of N_2O emissions by large key categories 1990 to 2021 in CO_2 equivalents (Mt) for EU



Note: Other is calculated by subtracting the presented categories from the sector total including LULUCF and international aviation

Figure 2.10 N_2O emissions: Share of key categories and all remaining categories in 2021 for EU



Note: Other is calculated by subtracting the presented categories from the sector total including LULUCF and international aviation
Percentages are rounded and may lead to a sum higher or lower than 100%

Fluorinated gas emissions account for 2.1 % of total EU GHG emissions. In 2021, emissions amounted to 78 Mt CO_2 equivalents, which was 57 % above 1990 levels (Figure 2.11). Refrigeration and air conditioning, the largest key category, accounts for 82 % of fluorinated gas emissions in 2021. Figure 2.12 reveals that HFCs from refrigeration and air conditioning showed large increases between 1990 and 2021. The main reason for this is the phase-out of ozone-depleting substances such as chlorofluorocarbons under the Montreal Protocol and the replacement of these substances with HFCs (mainly in refrigeration, air conditioning, foam production and as aerosol propellants). On the other hand, the sum of HFC emissions from categories not presented individually in Figure 2.12 (Other in Figure 2.12) decreased substantially.

Figure 2.11 Fluorinated gas emissions 1990 to 2021 in CO_2 equivalents (Mt)

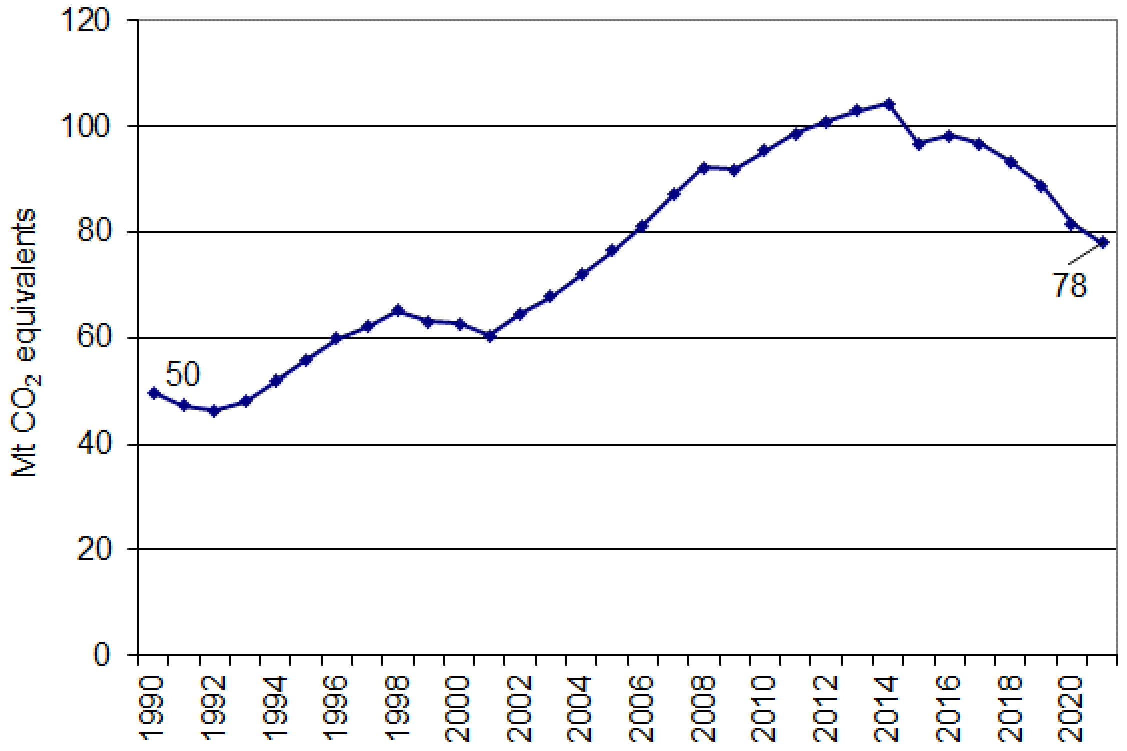
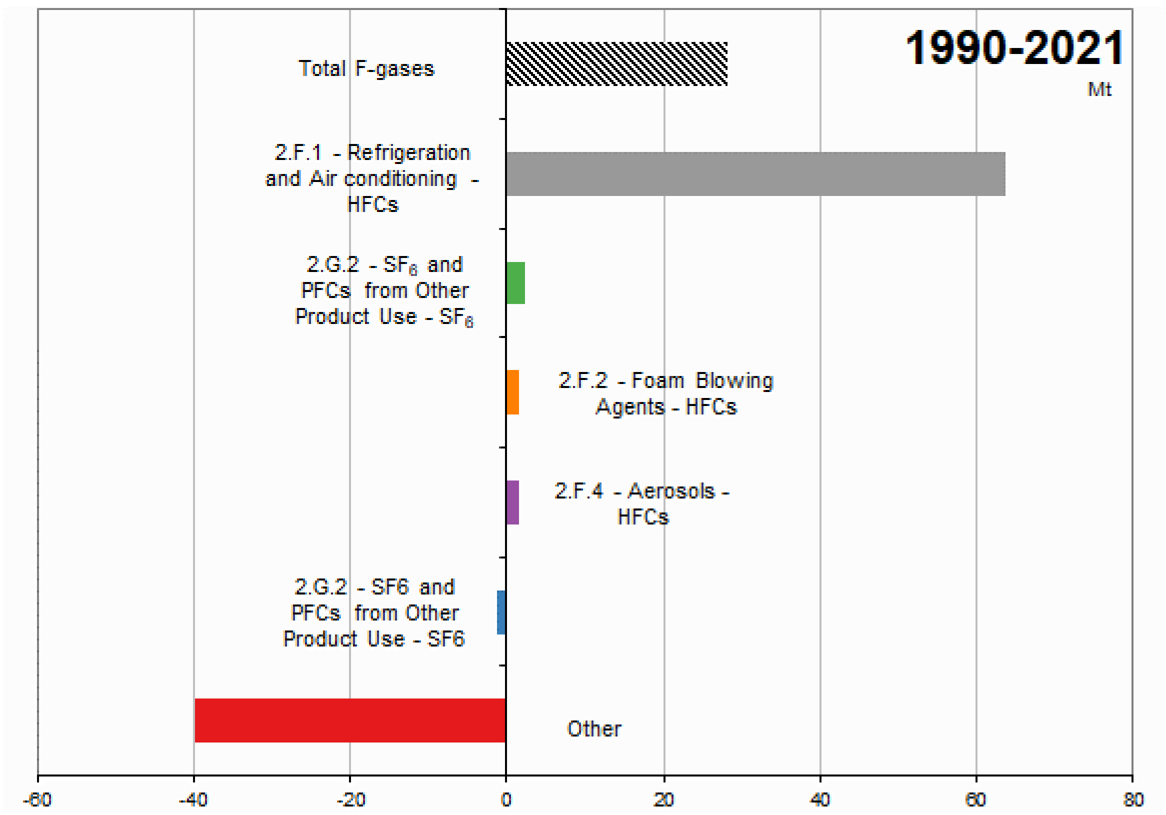
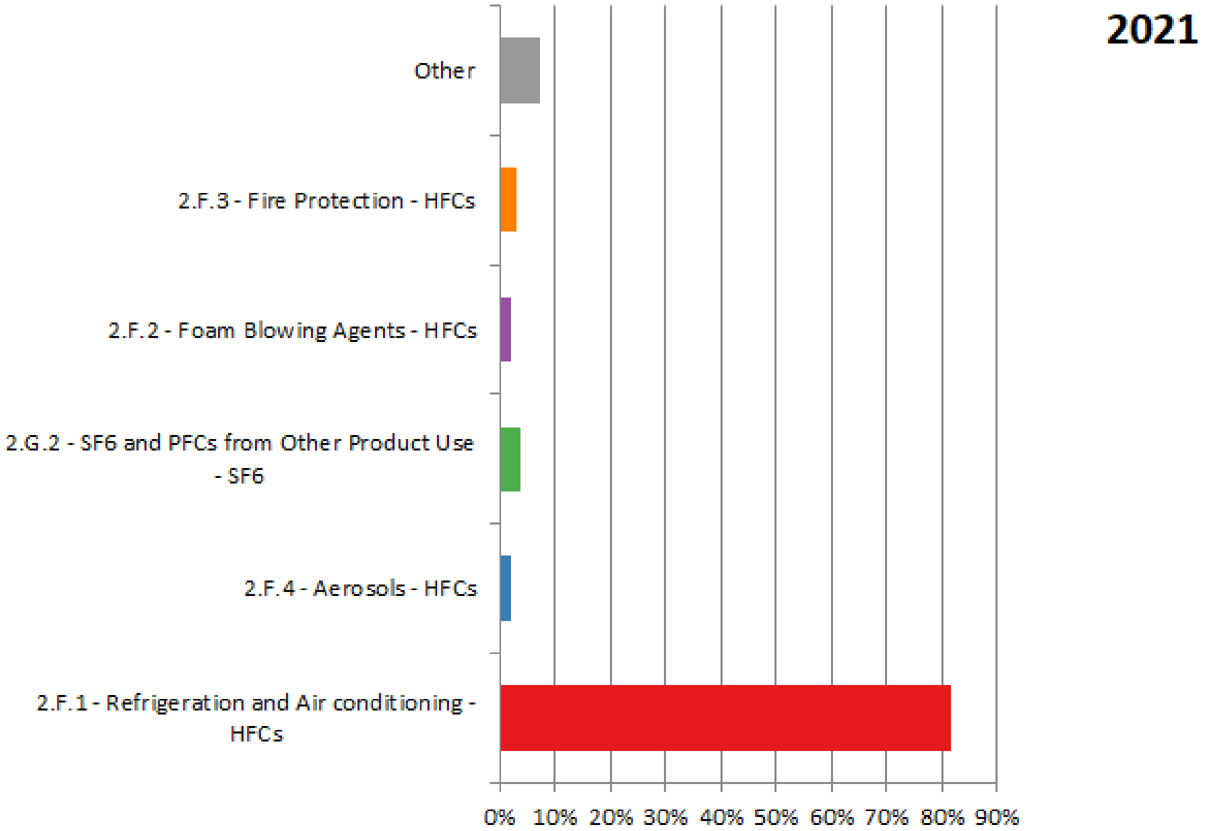


Figure 2.12 Absolute change of fluorinated gas emissions by large key categories 1990 to 2021 in CO_2 equivalents (Mt) for EU



Note: Other is calculated by subtracting the presented categories from the sector total including LULUCF and aviation

Figure 2.13 Fluorinated gas: Share of key source categories and all remaining categories in 2021 for EU



Note: Other is calculated by subtracting the presented categories from the sector total including LULUCF and aviation Percentages are rounded and may lead to a sum higher or lower than 100%

2.3 Emission trends by source

Table 2.5 gives an overview of EU emissions in the main source categories for 1990–2021. The most important sector in terms of GHG emissions is energy (i.e. combustion and fugitive emissions), which accounted for 80 % of total emissions including LULUCF and international aviation in 2021. The second largest sector is agriculture (11 %), followed by industrial processes (10 %). The LULUCF sector accounted for 6.5% of the EU's gross national total emissions (excluding LULUCF and including international aviation) in 2021. More detailed trend descriptions are included in the individual sector chapters (chapters 3-7) and chapter 9 on indirect CO_2 emissions.

Table 2.5 Overview of EU GHG emissions (in million tonnes CO_2 equivalent) in the main source and sink categories for the period 1990 to 2021

GHG SOURCE AND SINK	1990	1995	2000	2005	2010	2015	2020	2021
1. Energy	3 747	3 521	3 454	3 569	3 305	2 967	2 500	2 663
2. Industrial Processes	445	427	409	425	358	340	307	318
3. Agriculture	485	419	409	389	376	384	382	378
4. Land-Use, Land-Use Change and Forestry	-209	-316	-304	-342	-353	-322	-241	-230
5. Waste	184	188	174	154	137	118	111	109
6. Other	0	0	0	0	0	0	0	0
Indirect CO_2 emissions	6	6	5	5	4	3	3	3
Memo item: International aviation	54	66	85	96	100	109	56	70
Total (including LULUCF and aviation)	**4 712**	**4 310**	**4 233**	**4 296**	**3 929**	**3 599**	**3 119**	**3 311**
Total (without LULUCF and aviation)	**4 867**	**4 560**	**4 452**	**4 542**	**4 181**	**3 812**	**3 304**	**3 472**

2.4 Emission trends by Member State

Table 2.6 gives an overview of EU Member States' contributions to the EU emissions including LULUCF and international aviation for 1990–2021. Countries show large variations in GHG emission trends.

Table 2.6 Overview of countries contributions to total EU GHG emissions, including LULUCF, including indirect CO_2 emissions, and including international aviation from 1990 to 2021 in million tonnes CO_2-equivalent

Member State	1990	1995	2000	2005	2010	2015	2020	2021
Austria	67.7	61.5	68.0	76.1	67.0	74.5	69.7	68.4
Belgium	146.1	154.2	151.9	147.2	137.5	122.6	110.6	115.2
Bulgaria	83.4	56.6	40.6	46.6	48.1	53.3	39.1	45.3
Croatia	25.6	14.4	19.2	22.2	21.6	19.3	18.4	18.9
Cyprus	6.2	7.7	9.1	9.9	10.1	8.9	8.6	9.1
Czechia	192.8	150.8	143.7	142.8	135.0	123.3	125.3	127.8
Denmark	80.2	86.9	79.5	75.6	69.6	53.1	46.9	47.5
Estonia	36.7	16.8	12.8	16.5	15.7	17.3	14.0	15.6
Finland	46.5	48.0	46.9	42.6	51.3	40.3	39.6	49.2
France	531.0	522.4	540.2	515.6	482.3	435.2	379.0	406.2
Germany	1299.4	1112.6	1059.7	1016.0	954.2	910.2	748.9	782.7
Greece	104.2	109.2	126.7	135.8	118.4	94.6	71.4	74.5
Hungary	92.1	71.8	75.0	71.8	62.4	57.1	56.2	57.4
Ireland	62.7	67.9	78.9	81.7	72.4	70.5	67.3	70.8
Italy	522.3	517.6	546.4	567.2	490.7	411.4	356.2	395.1
Latvia	13.9	-2.1	-1.6	5.3	10.2	11.3	11.5	13.4
Lithuania	43.2	18.0	10.1	18.5	10.6	12.5	13.7	14.4
Luxembourg	13.1	10.1	10.0	13.7	13.3	11.3	10.2	10.7
Malta	2.8	3.0	3.1	3.3	3.3	2.5	2.3	2.4
Netherlands	233.6	245.7	235.6	231.9	230.1	211.3	175.6	179.3
Poland	447.0	430.2	360.7	354.2	376.3	356.7	354.3	382.3
Portugal	68.2	60.9	82.6	92.5	65.8	67.7	55.0	52.5
Romania	229.3	158.2	109.7	118.2	89.9	67.5	61.8	66.4
Slovakia	64.6	43.8	39.7	46.1	40.7	35.3	29.6	33.7
Slovenia	14.5	13.8	12.6	13.5	12.7	17.8	12.9	13.0
Spain	258.6	297.3	349.5	406.0	323.2	303.7	234.6	252.6
Sweden	26.5	32.1	22.1	25.1	16.2	9.3	5.9	7.1
EU-27	**4 712**	**4 310**	**4 233**	**4 296**	**3 929**	**3 599**	**3 119**	**3 311**

The overall EU GHG emission trend is dominated by the largest emitters Germany (24 %), France, Italy and Poland (12 % each), accounting for half of total EU GHG emissions in 2021. Germany, Romania, France and Italy accounted for 67% of EU emission reductions between 1990 and 2021.

The main reasons for the favourable trend in Germany were an increase in the efficiency of power and heating plants and the economic restructuring of the five new "Länder" after the German reunification, particularly in the iron and steel sector. Other important reasons include a reduction in the carbon intensity of fossil fuels (with the switch from coal to gas), a strong increase in renewable energy use and waste management measures that reduced the landfilling of organic waste.

France's emissions were 24 % below 1990 levels in 2021. France achieved large reductions in N_2O emissions in the chemical industry; also emissions in the large energy-related categories were below 1990 levels in 2021. However, HFC emissions from electronics industry and product uses as substitutes of ODS increased considerably between 1990 and 2021.

Italy's GHG emissions were 24 % below 1990 levels in 2021. Italian emissions decreased significantly since 2007 with a significant drop in 2009, which was mainly due to the economic crisis and reductions in industrial output. Since 2010 emissions were decreasing continuously with one exemption in 2015.

Poland's GHG emissions were 15 % below 1990 levels in 2021. The main factors for decreasing emissions in Poland — as with other Member States — were the decline of energy-inefficient heavy industry and the overall restructuring of the economy in the late 1980s and early 1990s. The notable exception was transport (especially road transport), where emissions increased.

Spain's emissions (accounting for 8% of EU emissions) were 2 % below 1990 levels in 2021. Emission increases from road transport and households and services where offset by emission reductions from electricity and heat production.

2.5 Emission trends for indirect greenhouse gases and sulphur dioxide

Emissions of CO, NO_X, NMVOC and SO_2 have to be reported to the UNFCCC Secretariat because they influence climate change indirectly: CO, NO_X and NMVOC are precursor substances for ozone which itself is a greenhouse gas. Sulphur emissions produce microscopic particles (aerosols) that can reflect sunlight back out into space and also affect cloud formation. Table 2.7 shows the total indirect GHG and SO_2 emissions in the EU between 1990 and 2021. All emissions were reduced significantly from 1990 levels: the largest reduction was achieved in SO_2 (-91 %) followed by, CO (-68 %), NO_X (-61 %) and NMVOC (-59 %).

Table 2.7 Overview of EU indirect GHG and SO_2 emissions for 1990–2021 (kt) (including international aviation)

	1990	1995	2000	2005	2010	2015	2020	2021
NO_x	15 206	13 259	11 840	11 015	9 025	7 742	5 827	5 888
CO	58 444	47 138	36 788	29 811	26 309	21 478	18 328	18 562
NMVOC	15 348	12 442	10 457	8 966	7 742	6 718	6 337	6 316
SO_2	20 365	13 022	8 191	6 522	3 788	2 804	1 657	1 750

Table 2.8 shows the NO_X emissions of the EU countries between 1990 and 2021. The largest emitters, Germany, France, Italy, Poland and Spain made up 64 % of total NO_X emissions in 2021. All countries reduced their NO_X emissions between 1990 and 2021.

Table 2.9 shows the CO emissions between 1990 and 2021. The largest emitters, France, Germany, Italy, Poland and Romania that made up 64 % of the total CO emissions in 2021, reduced their emissions from 1990 levels substantially. Also all other reduced CO emissions.

Table 2.10 shows the NMVOC emissions of the EU countries between 1990 and 2021. The largest emitters France, Germany, Italy and Poland that made up 67 % of the total NMVOC emissions in 2021, reduced their emissions from 1990 levels, together with all countries.

Table 2.11 shows the SO_2 emissions of the EU countries between 1990 and 2021. The largest emitters, Poland and Germany that made up 37 % of the total SO_2 emissions in 2021, reduced their emissions from 1990 levels substantially, together with all other countries.

Table 2.8 Overview of Member States' contributions to EU NO_X emissions (includes international aviation) for 1990–2021 (kt)

Party	1990	1995	2000	2005	2010	2015	2020	2021
Austria	221	202	218	254	213	192	128	127
Belgium	431	421	377	342	266	218	155	160
Bulgaria	266	173	145	159	139	138	100	118
Croatia	105	78	87	85	69	54	44	2
Cyprus	18	20	22	23	19	14	12	12
Czech Republic	737	377	298	287	242	187	141	145
Denmark	301	290	227	209	155	120	94	95
Estonia	84	49	43	40	42	36	31	31
Finland	302	269	239	205	186	140	101	101
France	2264	2083	1938	1727	1380	1156	801	828
Germany	2898	2236	1955	1722	1575	1488	1045	1059
Greece	325	330	360	411	325	245	213	219
Hungary	244	188	186	180	149	129	108	111
Ireland	172	174	187	184	129	122	100	105
Italy	2148	2021	1554	1335	993	783	619	635
Latvia	99	53	43	46	42	38	33	34
Lithuania	152	74	63	64	57	58	53	52
Luxembourg	41	35	41	57	39	29	15	14
Malta	8	10	10	11	11	8	6	6
Netherlands	603	504	419	363	300	252	192	189
Poland	1121	1080	869	858	845	721	605	591
Portugal	265	302	308	292	215	181	140	144
Romania	500	397	376	329	258	232	212	202
Slovakia	136	112	110	106	88	72	54	58
Slovenia	75	75	59	55	48	35	26	26
Spain	1398	1445	1484	1474	1071	943	679	708
Sweden	291	259	224	195	170	148	117	115
EU-27	**15206**	**13259**	**11840**	**11015**	**9025**	**7742**	**5827**	**5888**

Table 2.9 Overview of Member States' contributions to EU CO emissions (includes international aviation) for 1990–2021 (kt)

Party	1990	1995	2000	2005	2010	2015	2020	2021
Austria	1249	975	730	627	583	544	474	524
Belgium	1508	1281	1006	815	538	399	311	334
Bulgaria	1141	935	410	459	384	362	270	319
Croatia	558	447	469	418	329	268	217	0
Cyprus	43	38	29	26	14	12	10	10
Czech Republic	2045	1547	1105	945	928	854	790	791
Denmark	718	644	474	425	349	259	191	193
Estonia	224	175	159	134	145	113	111	109
Finland	726	643	572	506	436	358	314	330
France	10816	9125	6776	5719	4723	3057	2488	2732
Germany	13379	7254	5168	3883	3556	3121	2463	2598
Greece	1250	1074	1022	870	608	530	393	393
Hungary	1413	946	823	671	526	450	333	337
Ireland	560	418	325	284	218	180	122	124
Italy	6798	7071	4735	3445	3063	2268	1902	2050
Latvia	394	276	214	206	149	103	95	97
Lithuania	382	217	181	172	156	121	106	108
Luxembourg	469	213	47	40	30	22	16	20
Malta	22	25	19	14	10	6	4	4
Netherlands	1276	918	829	739	684	569	450	443
Poland	3659	4719	3359	3069	3407	2844	2582	2521
Portugal	762	786	643	486	359	288	232	263
Romania	2418	2341	3522	2516	2189	2136	2243	1882
Slovakia	1035	657	542	548	447	370	276	334
Slovenia	290	280	203	182	143	121	88	87
Spain	4211	3198	2784	2118	1928	1788	1563	1683
Sweden	1095	937	644	494	407	334	284	277
EU-27	**58444**	**47138**	**36788**	**29811**	**26309**	**21478**	**18328**	**18562**

Table 2.10 Overview of Member States' contributions to EU NMVOC emissions (includes international aviation) for 1990–2021 (kt)

Party	1990	1995	2000	2005	2010	2015	2020	2021
Austria	334	248	181	157	138	114	111	111
Belgium	354	312	236	185	146	120	119	122
Bulgaria	162	131	97	91	79	83	74	75
Croatia	162	114	99	109	88	68	68	25
Cyprus	10	10	9	7	5	4	5	5
Czech Republic	497	351	283	240	223	198	157	147
Denmark	212	210	181	154	131	115	107	107
Estonia	47	33	28	26	23	24	29	32
Finland	233	203	177	148	113	90	85	82
France	2967	2555	2178	1805	1484	1228	1141	1181
Germany	3952	2366	1816	1492	1365	1149	1030	1045
Greece	268	251	252	240	182	166	140	134
Hungary	306	210	188	173	130	127	114	115
Ireland	149	137	122	120	111	110	112	114
Italy	1982	2051	1626	1336	1114	901	844	869
Latvia	87	63	53	50	40	36	36	37
Lithuania	127	87	62	70	61	58	52	53
Luxembourg	28	21	16	15	12	10	10	11
Malta	5	6	5	4	4	4	4	4
Netherlands	424	283	224	180	182	171	151	150
Poland	841	951	826	797	776	734	753	715
Portugal	248	234	231	185	150	141	149	150
Romania	211	161	220	232	228	207	201	206
Slovakia	255	171	144	141	117	105	88	92
Slovenia	65	63	55	48	39	33	31	30
Spain	1056	945	925	758	621	566	592	566
Sweden	367	278	222	204	177	157	138	138
EU-27	**15348**	**12442**	**10457**	**8966**	**7742**	**6718**	**6337**	**6316**

Table 2.11 Overview of Member States' contributions to EU-27 SO_2 emissions (includes international aviation) for 1990–2021 (kt)

Party	1990	1995	2000	2005	2010	2015	2020	2021
Austria	74	48	32	26	17	15	11	11
Belgium	365	258	172	141	62	42	25	24
Bulgaria	446	379	336	373	411	428	258	323
Croatia	170	77	60	58	35	16	6	0
Cyprus	32	40	48	38	22	13	12	10
Czech Republic	1729	1042	221	199	161	126	66	69
Denmark	179	146	33	27	16	10	10	9
Estonia	181	93	77	63	77	48	11	16
Finland	251	105	81	70	68	43	24	24
France	1309	969	648	489	291	174	105	106
Germany	5467	1747	648	479	410	341	245	259
Greece	512	521	563	586	232	113	71	75
Hungary	829	613	427	43	30	24	16	14
Ireland	183	164	145	73	27	16	11	12
Italy	1785	1324	760	414	228	131	86	80
Latvia	101	49	18	9	4	4	4	4
Lithuania	218	86	40	28	18	15	11	11
Luxembourg	16	9	4	3	2	1	1	1
Malta	10	11	10	12	8	2	0	0
Netherlands	189	127	72	63	34	30	19	21
Poland	2553	2044	1325	1129	825	639	385	392
Portugal	318	322	295	190	63	46	38	42
Romania	874	707	502	616	376	163	74	80
Slovakia	140	121	117	86	68	67	13	14
Slovenia	202	124	93	39	10	5	3	3
Spain	2128	1824	1423	1234	266	275	137	133
Sweden	103	71	44	34	28	17	15	16
EU-27	**20365**	**13022**	**8191**	**6522**	**3788**	**2804**	**1657**	**1750**

3 ENERGY (CRF SECTOR 1)

This chapter starts with an overview on emission trends in CRF Sector 1 Energy. For each EU key category as well as other important subsector specific categories, overview tables are presented including the countries' contributions to the category in terms of level and trend. This chapter includes also, the reference approach, and international bunkers.

3.1 Overview of sector

CRF Sector 1 Energy comprises of the three sectors Fuel combustion activities (1.A), Fugitive emissions from fuels (1.B) and CO_2 Transport and storage (1.C). The energy sector contributes 76% to total GHG emissions and is the largest emitting sector in the EU. Total GHG emissions from this sector decreased by 29 % from 3747 Mt in 1990 to 2663 Mt in 2021 (Figure 3.1). In 2021, emissions increased by 6 % compared to 2020.

The most important energy-related gas is CO_2 that makes up 78 % of the total EU greenhouse gas emissions in 2021. CH_4 of the energy sector is responsible for 2 % and N_2O for 1 % of the total GHG emissions.

Figure 3.1 CRF Sector 1 Energy: EU GHG emissions in CO_2 equivalents (Mt) for 1990–2021

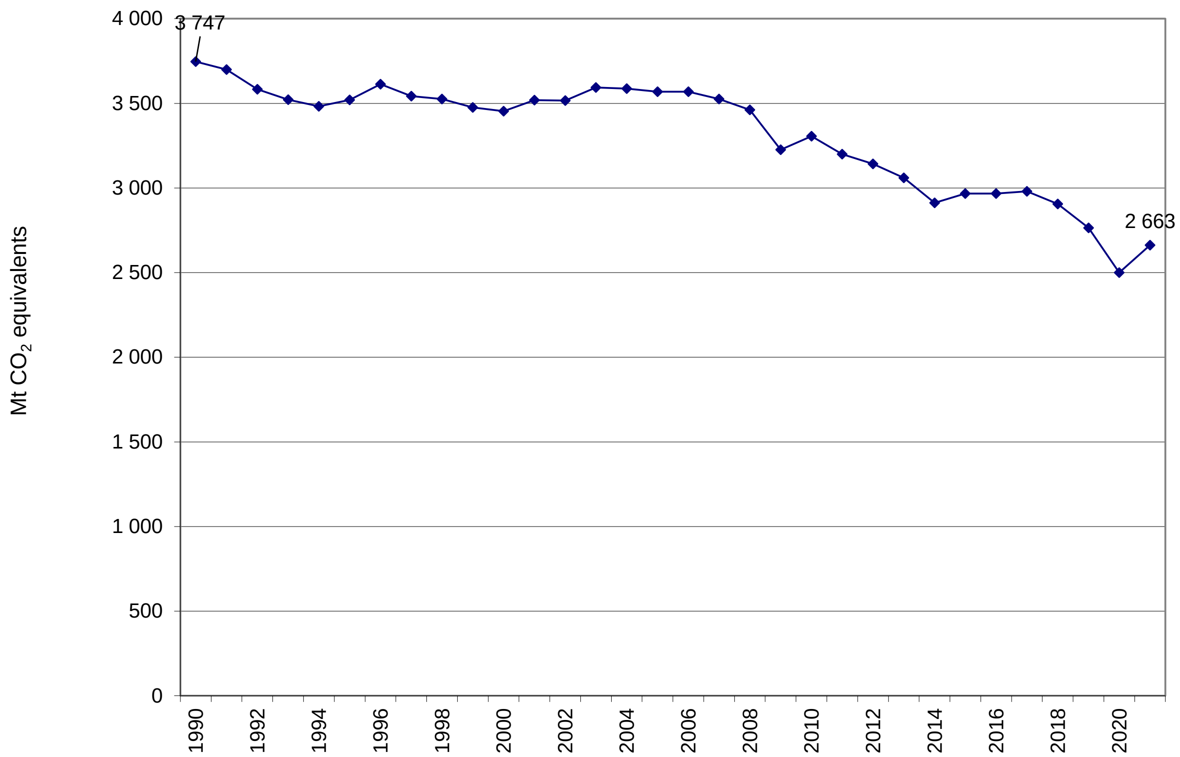
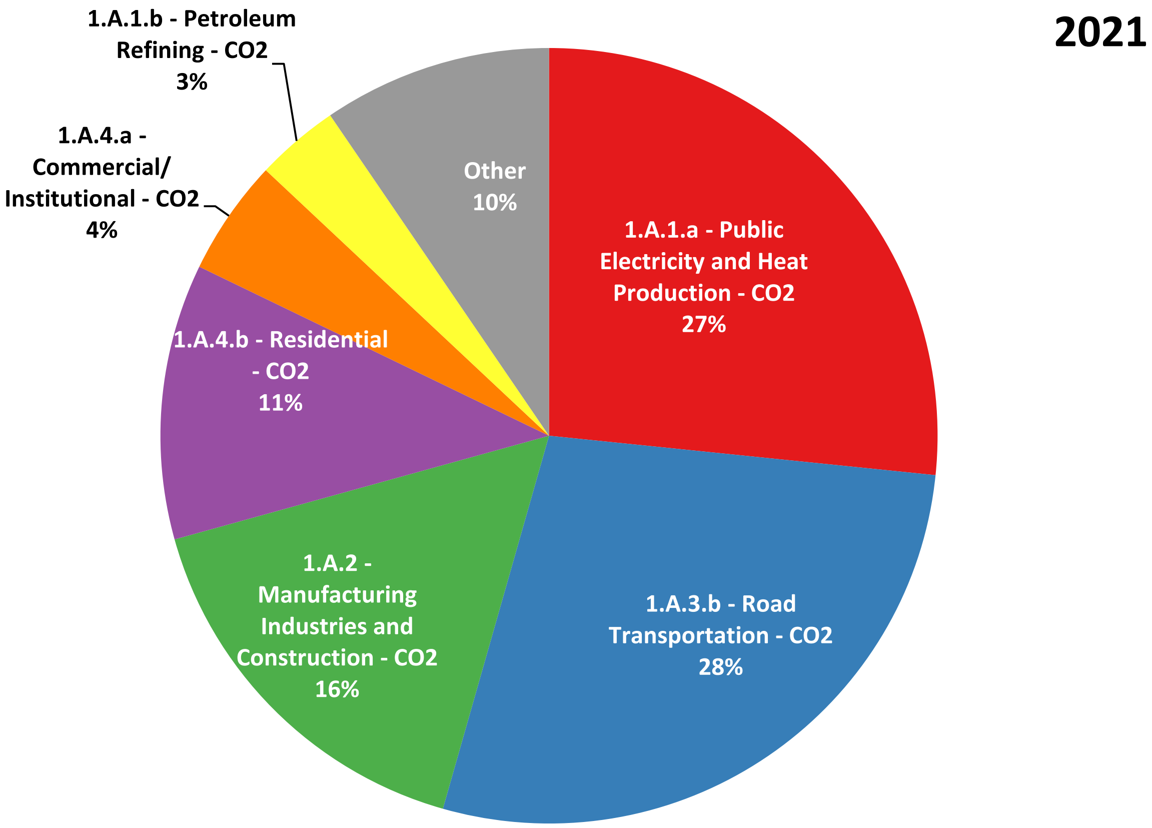


Figure 3.2 shows the share of the largest key categories in the sector Energy in 2022. The first chart illustrates that the three largest key categories account for 71 % and the largest six for 90 % of emissions in the whole sector 1. The two largest categories of the energy sector alone are responsible for 55 % of the total EU emissions in 2022.

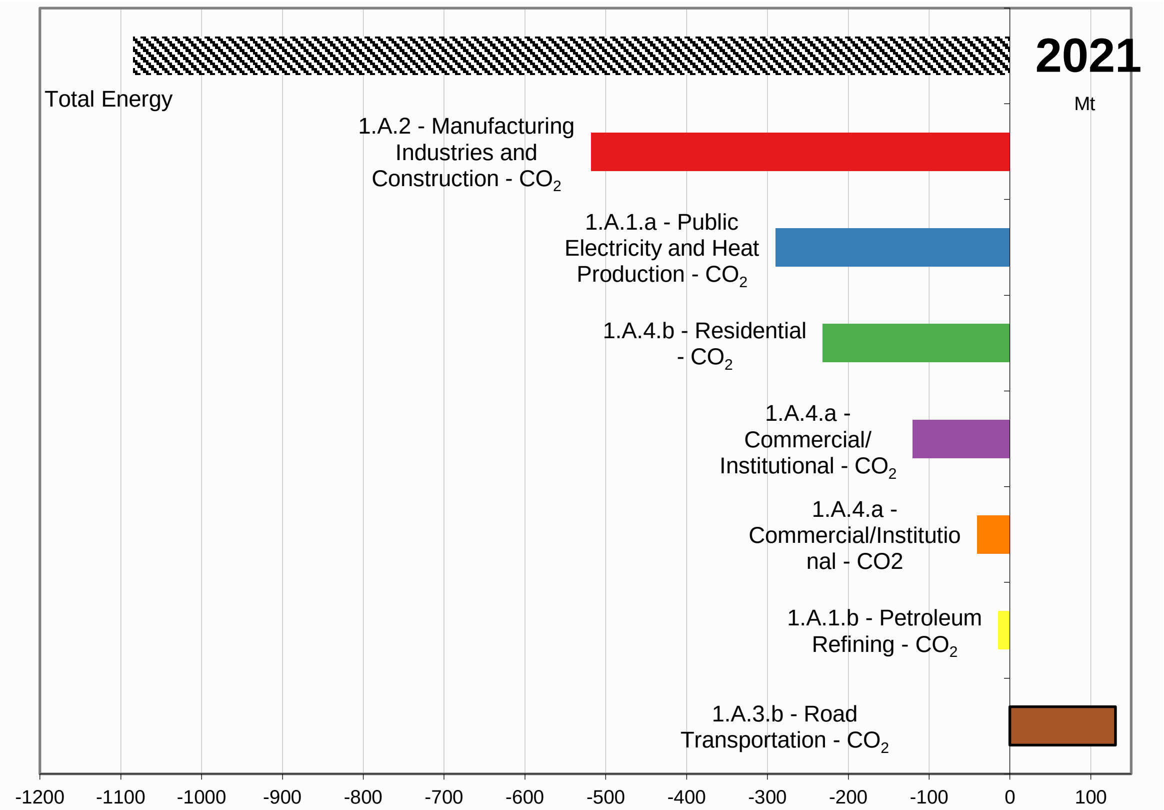
Figure 3.2 CRF Sector 1 Energy: Share of largest key source categories in 2021



Note: Remaining Energy categories is calculated by subtracting the presented categories (1.A.1.a, 1.A.1.b, 1.A.2, 1.A.3.b, 1.A.4.a and 1.A.4.b.) from the sector total

Furthermore, Figure 3.3 shows the absolute change of GHG emissions of these large key categories for the years 1990-2021. CO_2 emissions from 1.A.3.b Road Transportation had the highest increase in absolute terms of all energy-related emissions, while CO_2 emissions from 1.A.1.a Public Electricity and Heat Production as well as 1.A.2 Manufacturing Industries decreased substantially between 1990 and 2021. The decreases in Public Electricity and Heat Production and Manufacturing Industries as well as the increases in Road Transportation occurred in almost all countries. The decline of Fugitive Emissions from Fuels (CH_4) and decreasing CO_2 emissions from 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries are the main reasons for the large absolute emission reductions from “remaining Energy categories” in Figure 3.3.

Figure 3.3 CRF Sector 1 Energy: Absolute change of GHG emissions in CO_2 equivalents (Mt) by large key categories for 1990-2021



Note: Remaining Energy categories is calculated by subtracting the presented categories (1.A.1.a, 1.A.1.b, 1.A.2, 1.A.3.b, 1.A.4.a and 1.A.4.b.) from the sector total

The key categories in the energy sector are as follows:

- 1.A.1.a Public Electricity and Heat Production: Gaseous Fuels (CO_2)
- 1.A.1.a Public Electricity and Heat Production: Liquid Fuels (CO_2)
- 1.A.1.a Public Electricity and Heat Production: Other Fuels (CO_2)
- 1.A.1.a Public Electricity and Heat Production: Peat (CO_2)
- 1.A.1.a Public Electricity and Heat Production: Solid Fuels (CO_2)
- 1.A.1.b Petroleum Refining: Gaseous Fuels (CO_2)
- 1.A.1.b Petroleum Refining: Liquid Fuels (CO_2)
- 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Gaseous Fuels (CO_2)
- 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Solid Fuels (CO_2)
- 1.A.2.a Iron and Steel: Gaseous Fuels (CO_2)
- 1.A.2.a Iron and Steel: Liquid Fuels (CO_2)
- 1.A.2.a Iron and Steel: Solid Fuels (CO_2)
- 1.A.2.b Non-Ferrous Metals: Gaseous Fuels (CO_2)
- 1.A.2.c Chemicals: Gaseous Fuels (CO_2)
- 1.A.2.c Chemicals: Liquid Fuels (CO_2)
- 1.A.2.c Chemicals: Solid Fuels (CO_2)
- 1.A.2.d Pulp, Paper and Print: Gaseous Fuels (CO_2)
- 1.A.2.d Pulp, Paper and Print: Liquid Fuels (CO_2)
- 1.A.2.d Pulp, Paper and Print: Solid Fuels (CO_2)
- 1.A.2.e Food Processing, Beverages and Tobacco: Gaseous Fuels (CO_2)

- 1.A.2.e Food Processing, Beverages and Tobacco: Liquid Fuels (CO_2)
- 1.A.2.e Food Processing, Beverages and Tobacco: Solid Fuels (CO_2)
- 1.A.2.f Non-metallic minerals: Gaseous Fuels (CO_2)
- 1.A.2.f Non-metallic minerals: Liquid Fuels (CO_2)
- 1.A.2.f Non-metallic minerals: Other Fuels (CO_2)
- 1.A.2.f Non-metallic minerals: Solid Fuels (CO_2)
- 1.A.2.g Other Manufacturing Industries and Constructions: Gaseous Fuels (CO_2)
- 1.A.2.g Other Manufacturing Industries and Constructions: Liquid Fuels (CO_2)
- 1.A.2.g Other Manufacturing Industries and Constructions: Other Fuels (CO_2)
- 1.A.2.g Other Manufacturing Industries and Constructions: Solid Fuels (CO_2)
- 1.A.3.a Domestic Aviation: Jet Kerosene (CO_2)
- 1.A.3.b Road Transportation: Diesel Oil (CO_2)
- 1.A.3.b Road Transportation: Diesel Oil (N_2O)
- 1.A.3.b Road Transportation: Gaseous Fuels (CO_2)
- 1.A.3.b Road Transportation: Gasoline (CH_4)
- 1.A.3.b Road Transportation: Gasoline (CO_2)
- 1.A.3.b Road Transportation: Liquefied Petroleum Gases (LPG) (CO_2)
- 1.A.3.b Road Transportation: Other Fuels (CO_2)
- 1.A.3.c Railways: Liquid Fuels (CO_2)
- 1.A.3.d Domestic Navigation: Gas/Diesel Oil (CO_2)
- 1.A.3.d Domestic Navigation: Residual Fuel Oil (CO_2)
- 1.A.4.a Commercial/Institutional: Gaseous Fuels (CO_2)
- 1.A.4.a Commercial/Institutional: Liquid Fuels (CO_2)
- 1.A.4.a Commercial/Institutional: Other Fuels (CO_2)
- 1.A.4.a Commercial/Institutional: Solid Fuels (CO_2)
- 1.A.4.b Residential: Biomass (CH_4)
- 1.A.4.b Residential: Gaseous Fuels (CO_2)
- 1.A.4.b Residential: Liquid Fuels (CO_2)
- 1.A.4.b Residential: Solid Fuels (CH_4)
- 1.A.4.b Residential: Solid Fuels (CO_2)
- 1.A.4.c Agriculture/Forestry/Fishing: Gaseous Fuels (CO_2)
- 1.A.4.c Agriculture/Forestry/Fishing: Liquid Fuels (CO_2)
- 1.A.4.c Agriculture/Forestry/Fishing: Solid Fuels (CO_2)
- 1.A.5.a Other Other Sectors: Solid Fuels (CO_2)
- 1.A.5.b Other Other Sectors: Liquid Fuels (CO_2)
- 1.B.1.a Coal Mining and Handling: Operation (CH_4)
- 1.B.2.a Oil: Operation (CH_4)
- 1.B.2.a Oil: Operation (CO_2)
- 1.B.2.b Natural Gas: Operation (CH_4)

3.2 Source categories

3.2.1 Energy Industries (CRF Source Category 1.A.1)

Energy Industries (CRF 1.A.1) comprises emissions from fuels combusted by the fuel extraction or energy-producing industries and is subdivided in three categories: Public electricity and heat production (CRF 1.A.1.a), Petroleum-refining (CRF 1.A.1.b), and Manufacture of solid fuels and other energy industries (CRF 1.A.1.c). Each category is described in its own chapter.

Table 3.1 shows the nine key categories of sector 1.A.1, including information on whether the reasons for this categorization lie in their emission trend and/or level. Furthermore, it entails information on the share of higher tier methods used by the countries. In sector 1.A.1.a Germany, Poland and Italy have mainly been influencing this share of higher tier methods because of their weight of emissions. The same applies for Italy, Germany and Spain in sector 1.A.1.b and Germany, Italy and Czechia in sector 1.A.1.c.

Table 3.1: Key source categories for level and trend analyses and share of MS emissions using higher tier methods in sector 1.A.1

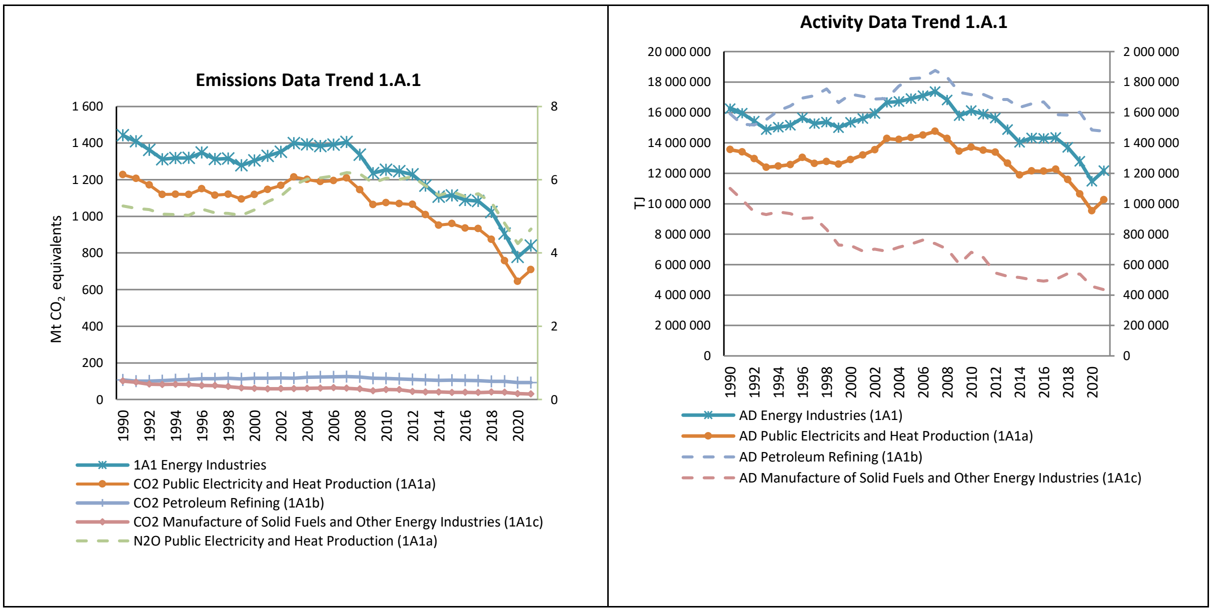
Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
1.A.1.a Public Electricity and Heat Production: Gaseous Fuels (CO_2)	107683	192682	T	L	L	99.0 %
1.A.1.a Public Electricity and Heat Production: Liquid Fuels (CO_2)	156335	23787	T	L	L	95.3 %
1.A.1.a Public Electricity and Heat Production: Other Fuels (CO_2)	10453	36428	T	L	L	95.8 %
1.A.1.a Public Electricity and Heat Production: Peat (CO_2)	9164	3829	T	L	0	99.1 %
1.A.1.a Public Electricity and Heat Production: Solid Fuels (CO_2)	943402	452135	T	L	L	96.2 %
1.A.1.b Petroleum Refining: Gaseous Fuels (CO_2)	5228	20529	T	0	L	98.3%
1.A.1.b Petroleum Refining: Liquid Fuels (CO_2)	97072	71844	T	L	L	97.7 %
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Gaseous Fuels (CO_2)	8199	7334	0	L	L	95.6 %
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Solid Fuels (CO_2)	88816	21620	T	L	L	96.4 %

Figure 3.4 shows the trends in emissions in Energy Industries for the EU between 1990 and 2021, which was mainly dominated by CO_2 emissions from public electricity and heat production. Carbon dioxide from 1.A.1.a currently represents about 85 % of greenhouse gas emissions in 1.A.1 in 1990 (i.e. including methane and nitrous oxide) and 84.3 % in 2021.

Total greenhouse gas emissions from 1.A.1 decreased by 41.7%, between 1990 and 2021. This was mainly due to a decrease of CO_2eq emission from Public Electricity and Heat Production (- 515.9 Mt CO_2eq) followed by -71.2 Mt CO_2eq of the manufacturing of solid fuels and -14.5 Mt CO_2eq from petroleum refining.

The decrease in fuel consumption since 2006 can be explained by the continuing effects of the economic downturn, the increased use of renewables, but also by enhanced energy efficiency in the newer EU Member States as well as mild winters. The reduction is particularly visible between 2019 and 2020 due to the COVID pandemic situation. Consumptions and emissions have increased again in 2021 but remain lower than the 2019 levels.

Figure 3.4 1.A.1 Energy Industries: Total GHG, CO_2 and N_2O emission trends and Activity Data



Note: Data displayed as dashed line refers to the secondary axis.

Table 3.2 breaks down the information by country. Between 1990 and 2021, greenhouse gas emissions from energy industries increased in two countries and fell in 27. The highest absolute increase was accounted for by Cyprus with 1.3 Mt CO_2e respectively 74.7 %. Germany, followed by Poland, Italy and Romania account for the largest part of reductions (-369.5 Mt CO_2eq). The change in the EU was a net decrease of about 601.6 Mt CO_2eq or 41.7% in 31 years. The table shows the emissions of GHG, N_2O and CH_4 separately expressed in CO_2eq. The latter two greenhouse gases only contribute a very small part (combined approximately 1 %) of the total emissions in energy industries.

In terms of absolute contributions to EU greenhouse gas emissions from energy industries, this sector is clearly dominated by Germany, Poland Italy followed by Netherlands. The first two combined are responsible for 47.7 %, all four countries represent 63.6% and the top six countries account for 73.4 % of the EU's greenhouse gas emissions from energy industries.

Table 3.2 1.A.1 Energy industries: Countries' contributions to CO_2, N_2O and CH_4 emissions

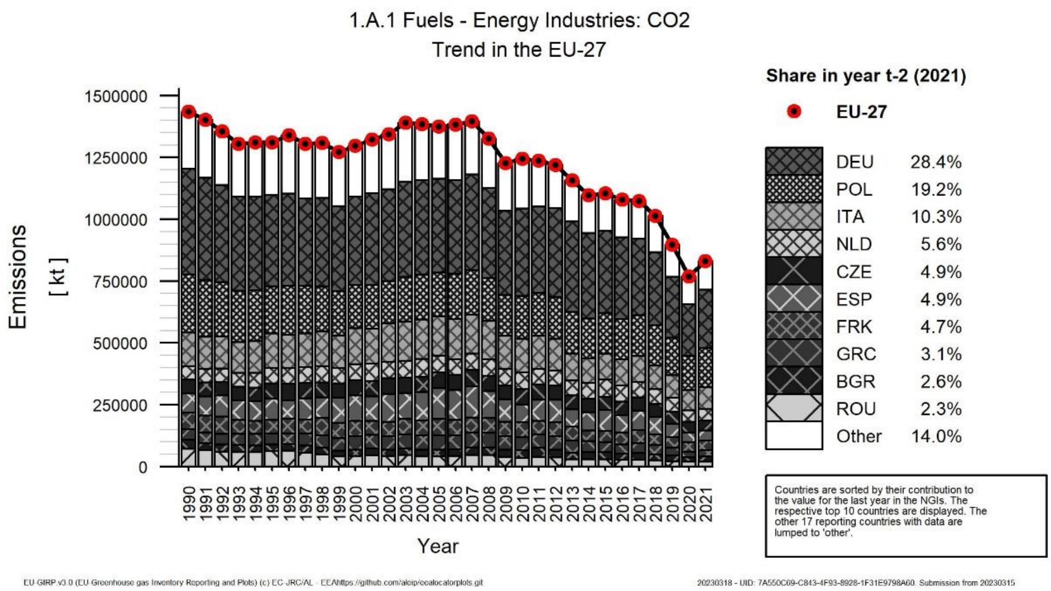
Member State	GHG emissions in kt CO2 equivalents		CO2 emissions in kt		N2O emissions in kt CO2 equivalents		CH4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021	1990	2021
Austria	14 008	8 855	13 961	8 739	37	87	9	29
Belgium	29 728	18 191	29 547	18 049	159	104	22	38
Bulgaria	36 526	22 101	36 401	21 963	111	106	15	31
Croatia	7 087	3 757	7 066	3 718	15	25	6	13
Cyprus	1 767	3 088	1 761	3 078	4	6	2	3
Czechia	56 830	41 054	56 594	40 829	218	184	19	41
Denmark	26 249	8 315	26 156	8 109	76	75	17	131
Estonia	28 285	6 995	28 269	6 948	13	29	3	18
Finland	18 958	13 390	18 843	13 122	104	231	11	37
France	66 293	39 357	65 821	39 085	399	215	74	56
Germany	430 973	240 461	427 843	235 974	2 816	1 753	314	2 734
Greece	43 238	25 473	43 094	25 420	129	40	16	13
Hungary	20 865	11 497	20 795	11 423	60	46	11	28
Ireland	11 216	10 170	11 145	10 063	64	96	7	12
Italy	137 620	86 428	136 941	86 009	425	289	254	130
Latvia	6 317	1 437	6 302	1 392	10	25	5	20
Lithuania	13 552	2 784	13 522	2 707	18	43	11	34
Luxembourg	35	222	32	214	1	4	1	3
Malta	1 765	773	1 759	772	5	0	1	0
Netherlands	53 356	47 387	53 147	46 957	132	265	77	165
Poland	235 229	160 223	234 294	159 532	905	660	30	31
Portugal	16 415	8 206	16 366	8 092	43	99	7	14
Romania	71 695	18 888	71 488	18 811	164	62	43	14
Slovakia	18 959	6 993	18 893	6 948	57	28	9	17
Slovenia	6 374	4 198	6 349	4 176	23	18	2	4
Spain	78 851	41 247	78 541	40 786	257	386	53	75
Sweden	9 858	8 961	9 746	8 714	99	182	12	65
EU-27	**1 442 050**	**840 447**	**1 434 674**	**831 628**	**6 343**	**5 059**	**1 033**	**3 759**

Abbreviations are explained in the Chapter 'Units and abbreviations'

Public heat and electricity production is the main source of emissions from energy industries. Furthermore, it is the largest source category in the EU greenhouse gas inventory. Differences in the intensity of greenhouse gas emissions of heat and electricity production between the countries are to a large extent explained by the mix of fuels or technologies, which are used. Some countries rely more on coal than on gas. At the EU level, 37.9 % of the fuel used in energy industries comes from solid fuels. Its contribution has been declining in favour of the relatively cleaner natural gas, with about 32.0 % in 2021. However, solid fuels represent the first source of energy in 2021. Biomass has been constantly increasing with a share of 14.7 % in 2021.

As can be seen in Figure 3.5 Germany, Poland and Italy contribute 57.9 % of the total CO_2 emissions in sector 1.A.1 Energy industries in the year 2021. The relatively low share of greenhouse gas emissions from energy industries in France can be partly explained by the use of nuclear and hydro energy for power generation.

Figure 3.5 1.A.1 Energy Industries, all fuels: Emission trend and share for CO_2



3.2.1.1 Public Electricity and Heat Production (1.A.1.a) (EU)

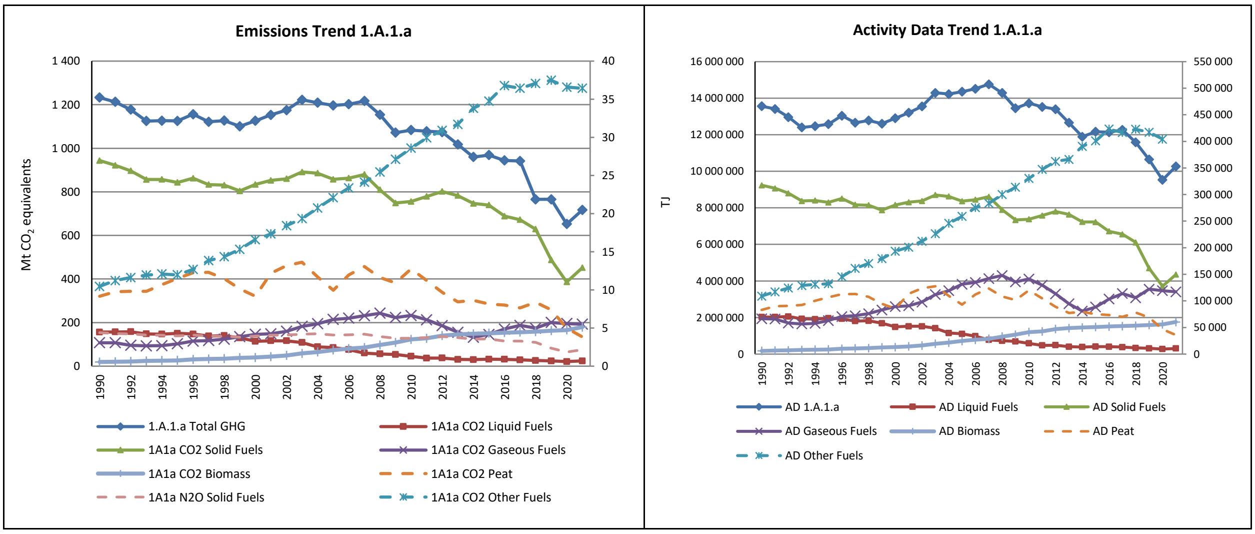
According to the 2006 IPCC guidelines, emissions from public electricity and heat production (CRF 1.A.1.a) should include emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants. Main activity producers (i.e. public utilities) are defined as those undertakings whose primary activity is to supply the public. They may be in public or private ownership. Emissions from own on-site use of fuel should be included. Emissions from autoproducers (undertakings which generate electricity/heat wholly or partly for their own use, as an activity that supports their primary activity) should be assigned to the sector where they were generated and not under 1.A.1.a. autoproducers may be in public or private ownership.

CO_2 emissions from electricity and heat production is the largest key category in the EU accounting for 21.4 % of total greenhouse gas emissions in 2021 and for 84.3 % of greenhouse gas emissions of the Energy Industries Sector. Between 1990 and 2021, CO_2 emissions from electricity and heat production decreased by 42.2 % in the EU.

Figure 3.6 shows the trends in emissions originating from the production of public electricity and heat by fuel in the EU between 1990 and 2021 as well as the underlying activity data[23].

[23] CO_2 emissions from the combustion of biomass fuels are reported as a memo item and are therefore not included in the emissions from public electricity and heat production. The biomass used as a fuel is however included in the national energy consumption (i.e. activity data). The fact that CO_2 emissions from biomass are treated differently from other fuel emissions does not imply emissions from the production of heat and electricity are due to fossil fuel combustion only. Biomass CO_2 emissions are just reported elsewhere. Non-CO_2 emissions from the combustion of biomass (CH_4 and N_2O) are reported under the energy sector.

Figure 3.6 1.A.1.a Public Electricity and Heat Production: Total, CO_2 and N_2O emission and activity data trends



Note: Data displayed as dashed line refers to the secondary axis.

Fuel used for public electricity and heat production decreased by 24 % in the EU between 1990 and 2021. Solid fuels represent 42.4 % of the fuel used in public conventional thermal power plants; its combustion has been declining by 52.9 % between 1990 and 2021. Gaseous fuels have increased very rapidly, by a factor of almost 3 between 1990 and 2010, declined until 2014 and now see a new increased use in the last years. In 2020, natural gas consumptions were higher than solid fuel consumptions for the 1st time. However, the situation is different in 2021 with a share of 33.2 % of all the fuels used for the production of heat and electricity in the EU. Liquid fuels still account for some 3.0 %, but its use has declined gradually during the past 30 years. The use of biomass has increased even more rapidly than the use of gas: its share in the fuel mix is now at 17.1 %. Finally, other fossil fuels consumptions have been multiplied by almost 4 between 1990 and 2021 and represent 4.0 % of total consumptions. Peat remains marginal with a share of 0.4 % in 2021.

Table 3.3 shows emissions arising from the production of public heat and electricity by country. Carbon dioxide emissions amount to 98.9 % of greenhouse gas emissions from public electricity and heat production. These emissions increased in two Countries and fell in 25 compared to 1990. Of the two countries where emissions were higher in 2021 than in 1990, 88 % of the increase was accounted for by Cyprus alone. Of the countries, where emissions fell, 50 % of the total reduction was accounted for by Germany (25.4 %), Poland (14.7 %) and Romania (9.9 %) followed by Italy and Spain. The change in the EU between 1990 and 2021 was a net decrease of 518.2 Mt CO_2 respectively of 42.2 %.

Table 3.3 1.A.1.a Public Electricity and Heat Production: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	11 056	5 665	5 635	0.8%	-5 421	-49%	-29	-1%	T1,T2	CS,D
Belgium	23 224	13 851	12 808	1.8%	-10 416	-45%	-1 043	-8%	T1,T3	D,PS
Bulgaria	35 179	16 981	21 232	3.0%	-13 947	-40%	4 251	25%	T1,T2	CS,D
Croatia	3 729	2 622	2 736	0.4%	-993	-27%	114	4%	T1,T2	CS,D
Cyprus	1 676	3 004	3 078	0.4%	1 402	84%	74	2%	CS	CS
Czechia	54 585	36 733	39 090	5.5%	-15 495	-28%	2 357	6%	T1,T2	CS,D
Denmark	24 717	5 369	6 277	0.9%	-18 440	-75%	908	17%	T1,T2,T3	CS,D,PS
Estonia	28 191	4 154	5 402	0.8%	-22 788	-81%	1 248	30%	T1,T2,T3	CS,D,PS
Finland	16 453	11 013	11 622	1.6%	-4 831	-29%	609	6%	T3	CS,D,PS
France	49 147	30 119	32 032	4.5%	-17 115	-35%	1 913	6%	T2,T3	CS,PS
Germany	338 451	179 508	207 345	29.3%	-131 106	-39%	27 837	16%	CS	CS
Greece	40 617	19 946	20 118	2.8%	-20 499	-50%	171	1%	T1,T2	D,PS
Hungary	17 850	10 356	9 642	1.4%	-8 207	-46%	-714	-7%	T1,T2,T3	CS,D,PS
Ireland	10 876	8 121	9 689	1.4%	-1 188	-11%	1 568	19%	T1,T3	CS,D,PS
Italy	108 670	59 921	64 806	9.1%	-43 864	-40%	4 885	8%	T3	CS
Latvia	6 097	1 280	1 339	0.2%	-4 758	-78%	59	5%	T1,T2	CS,D
Lithuania	12 003	1 296	1 454	0.2%	-10 549	-88%	158	12%	T1,T2,T3	CS,D,PS
Luxembourg	32	207	214	0.0%	182	560%	7	4%	T2	CS
Malta	1 759	810	772	0.1%	-987	-56%	-38	-5%	T2	CS
Netherlands	40 026	35 209	35 045	4.9%	-4 981	-12%	-165	0%	CS,T2	CS,D
Poland	227 279	131 217	151 555	21.4%	-75 725	-33%	20 338	15%	T1,T2	CS,D
Portugal	14 355	8 157	6 332	0.9%	-8 023	-56%	-1 825	-22%	T1,T3	D,PS
Romania	67 009	15 207	15 652	2.2%	-51 357	-77%	445	3%	T1,T2,T3	CS,D,PS
Slovakia	14 700	3 923	4 342	0.6%	-10 358	-70%	419	11%	T2	CS
Slovenia	6 096	4 492	4 176	0.6%	-1 920	-31%	-316	-7%	T1,T2	CS,D,PS
Spain	65 593	30 370	30 849	4.4%	-34 744	-53%	479	2%	T1,T2	S,D,OTH,PS
Sweden	7 668	5 091	5 620	0.8%	-2 048	-27%	529	10%	T2	CS
EU-27	**1 227 038**	**644 621**	**708 861**	**100%**	**-518 177**	**-42%**	**64 240**	**10%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

N_2O emissions currently represent 0.6 % of greenhouse gas emissions from public electricity and heat production. Between 1990 and 2021, emissions decreased by 12 % (Table 3.4). The largest decline in emissions from this source category was reported by Germany (-550 kt CO_2eq). The biggest increase occurred in Spain (+136 kt CO_2eq).

Table 3.4 1.A.1.a Public Electricity and Heat Production: Countries' contributions to N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27	Change 1990-2021		Change 2020-2021		Method	Emission factor
	1990	2020	2021	Emissions in 2021	kt CO2 equiv.	%	kt CO2 equiv.	%		Informa-tion
Austria	35	82	84	1.8%	48	138%	2	2%	T1	D
Belgium	45	76	64	1.4%	18	41%	-12	-16%	T1,T3	D
Bulgaria	109	79	106	2.3%	-3	-3%	27	34%	T1	D
Croatia	12	22	24	0.5%	13	111%	2	10%	T1	D
Cyprus	3	6	6	0.1%	3	84%	0	2%	T1	D
Czechia	215	166	180	3.9%	-35	-16%	13	8%	T1	D
Denmark	70	61	70	1.5%	0	0%	9	16%	T1,T2,T3	CS,D
Estonia	13	21	27	0.6%	14	115%	6	27%	T1,T2	CS,D
Finland	89	188	217	4.7%	128	143%	29	15%	T3	CS
France	373	211	212	4.6%	-161	-43%	1	1%	T2,T3	D,PS
Germany	2 141	1 410	1 591	34.2%	-550	-26%	181	13%	T2	CS
Greece	126	38	36	0.8%	-90	-71%	-2	-5%	T1	D
Hungary	56	46	45	1.0%	-11	-20%	-1	-2%	T1	D
Ireland	63	110	95	2.0%	32	51%	-15	-13%	T1,T2	D
Italy	273	174	174	3.7%	-100	-37%	0	0%	T3	CR,D
Latvia	10	21	24	0.5%	15	154%	3	16%	T1	D
Lithuania	17	33	42	0.9%	25	152%	8	25%	T1	D
Luxembourg	1	5	4	0.1%	3	231%	0	-6%	T1	D
Malta	5	1	0	0.0%	-5	-91%	0	-14%	T1	D
Netherlands	118	206	242	5.2%	124	105%	35	17%	D,T1	D
Poland	891	573	652	14.0%	-239	-27%	79	14%	T1	D
Portugal	41	109	98	2.1%	58	142%	-11	-10%	T1	D
Romania	160	54	59	1.3%	-101	-63%	5	8%	T1	D
Slovakia	52	24	26	0.5%	-27	-51%	2	8%	T1	D
Slovenia	22	19	18	0.4%	-4	-18%	-1	-5%	T1	D
Spain	244	364	380	8.2%	136	56%	16	4%	T2	D,OTH
Sweden	98	157	180	3.9%	82	83%	23	15%	T2	CS
EU-27	**5 283**	**4 255**	**4 655**	**100%**	**-628**	**-12%**	**400**	**9%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Finally, CH_4 emissions currently represent 0.5 % of greenhouse gas emissions from public electricity and heat production. Between 1990 and 2021, emissions increased by 481 %. The biggest increase was reported by Germany (2386 kt CO_2eq), which is also responsible for 74.4 % of the EU emissions in 2021.

Table 3.5 1.A.1.a Public Electricity and Heat Production: Countries' contributions to CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	7	24	25	0.7%	18	275%	1	3%	T1,T2	CS,D
Belgium	13	37	33	0.9%	20	159%	-4	-12%	T1,T3	D
Bulgaria	14	20	31	0.9%	17	125%	11	54%	T1	D
Croatia	4	11	13	0.4%	9	229%	1	11%	T1	D
Cyprus	2	3	3	0.1%	2	81%	0	2%	T1	D
Czechia	17	37	40	1.2%	23	130%	3	9%	T1	D
Denmark	16	101	130	3.7%	113	691%	29	28%	T1,T2,T3	CS,D
Estonia	3	13	17	0.5%	14	491%	4	31%	T1,T2	CS,D
Finland	10	32	36	1.0%	26	264%	5	14%	T3	CS
France	15	46	52	1.5%	37	242%	6	13%	T2	D
Germany	193	2 590	2 579	74.4%	2 386	1238%	-11	0%	T2	CS
Greece	14	9	10	0.3%	-4	-30%	0	4%	T1	D
Hungary	8	26	27	0.8%	19	232%	1	5%	T1	D
Ireland	7	12	11	0.3%	4	58%	0	-3%	T1,T2	D
Italy	106	113	113	3.3%	7	6%	0	0%	T3	CR,D
Latvia	5	17	19	0.6%	14	273%	3	16%	T1	D
Lithuania	10	26	33	1.0%	23	231%	7	25%	T1	D
Luxembourg	1	4	3	0.1%	2	233%	0	-6%	T1	D
Malta	1	0	0	0.0%	-1	-68%	0	-6%	T1	D
Netherlands	44	132	123	3.6%	79	181%	-9	-7%	T1,T2	CS,D
Poland	22	25	26	0.8%	4	18%	2	6%	T1,T2	CS,D
Portugal	5	14	14	0.4%	9	199%	0	-1%	T1	D
Romania	40	11	12	0.4%	-28	-70%	1	13%	T1	D
Slovakia	7	14	15	0.4%	9	136%	2	11%	T1	D
Slovenia	2	4	4	0.1%	2	86%	0	3%	T1	D
Spain	19	32	42	1.2%	23	119%	10	31%	T2	CR,CS,D
Sweden	12	44	54	1.6%	43	368%	10	22%	T2	CS
EU-27	**597**	**3 398**	**3 467**	**100%**	**2 870**	**481%**	**69**	**2%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

1.A.1.a Electricity and Heat Production - Liquid Fuels (CO_2)

CO_2 emissions arising from the combustion of liquid fuels for public electricity and heat generation account for about 3.3 % of all greenhouse gas emissions from 1.A.1.a. Within the EU, emissions fell by 85 % respectively by 131.7 Mt CO_2 between 1990 and 2021 (Table 3.6).

Table 3.6 1.A.1.a Public Electricity and Heat Production, Liquid Fuels: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 229	65	120	1%	-1 109	-90%	55	85%	T2	CS
Belgium	663	14	24	0%	-638	-96%	10	76%	T1, T3	D, PS
Bulgaria	3 245	38	68	0%	-3 177	-98%	30	78%	T1	D
Croatia	2 142	13	1	0%	-2 141	-100%	-12	-90%	T1	D
Cyprus	1 676	3 004	3 078	13%	1 402	84%	74	2%	CS	CS
Czechia	1 174	87	109	0%	-1 064	-91%	22	26%	T1	CS, D
Denmark	953	115	154	1%	-799	-84%	39	34%	T1, T2, T3	CS, D, PS
Estonia	3 519	108	62	0%	-3 456	-98%	-45	-42%	T1, T2, T3	CS, D, PS
Finland	1 234	528	697	3%	-536	-43%	169	32%	T3	CS, D, PS
France	8 209	3 622	3 827	16%	-4 383	-53%	205	6%	T2, T3	CS, PS
Germany	8 637	973	1 202	5%	-7 435	-86%	230	24%	CS	CS
Greece	5 416	3 083	3 151	13%	-2 265	-42%	68	2%	T2	PS
Hungary	1 443	32	47	0%	-1 395	-97%	15	47%	T1	D
Ireland	1 087	343	1 180	5%	94	9%	837	244%	T1, T3	CS, D, PS
Italy	64 597	805	1 517	6%	-63 081	-98%	712	88%	T3	CS
Latvia	3 079	4	7	0%	-3 072	-100%	3	77%	T2	CS
Lithuania	6 021	73	84	0%	-5 937	-99%	11	15%	T2, T3	CS, PS
Luxembourg	NO	1	0	0%	0	∞	0	-55%	T2	CS
Malta	1 049	74	33	0%	-1 016	-97%	-41	-55%	T2	CS
Netherlands	233	284	321	1%	88	38%	37	13%	T2	CS
Poland	5 198	1 276	1 455	6%	-3 743	-72%	178	14%	T1, T2	CS, D
Portugal	6 434	641	638	3%	-5 796	-90%	-3	0%	T1, T3	D, PS
Romania	20 430	317	326	1%	-20 104	-98%	9	3%	T1, T2, T3	CS, D, PS
Slovakia	1 033	6	6	0%	-1 028	-99%	0	-3%	T2	CS
Slovenia	272	13	56	0%	-216	-79%	43	327%	T1	D
Spain	6 087	5 384	5 207	22%	-880	-14%	-177	-3%	T2, T1	CS, PS, D
Sweden	1 277	C	416	2%	-861	-67%	416	∞	T2	CS
EU-27	**155 058**	**20 903**	**23 371**	**100%**	**-131 687**	**-85%**	**2 469**	**12%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.

Table 3.6 also shows that about 95.3 % of EU emissions are calculated using higher tier methods. Emissions from Sweden being reported as confidential in 2020, Sweden is not considered in the following analyse. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels and use default emission factors for fuels of minor importance. Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

Figure 3.7 shows the contribution to the emission trend for liquid fuels by the main countries. In 2021 Spain, France, Greece and Cyprus are responsible for about 64.1% of emissions in this category. The strongest decrease in emissions took place in Italy because less oil is used as a fuel in the power sector. In 1990 Italy was responsible for 41.7 % of the emissions in this category and now in 2021 only for 6.5 %.

Figure 3.7 1.A.1.a Public Electricity and Heat Production, Liquid Fuels: Emission trend and share for CO_2

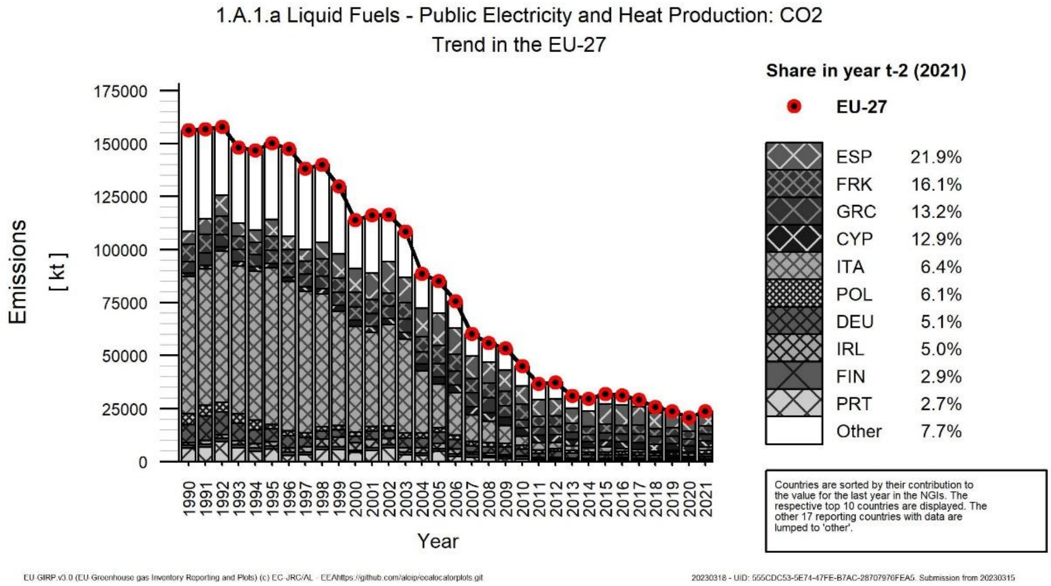
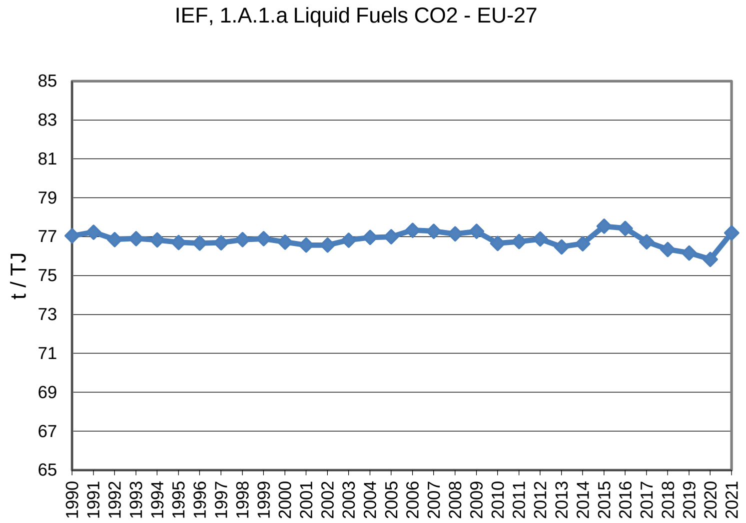
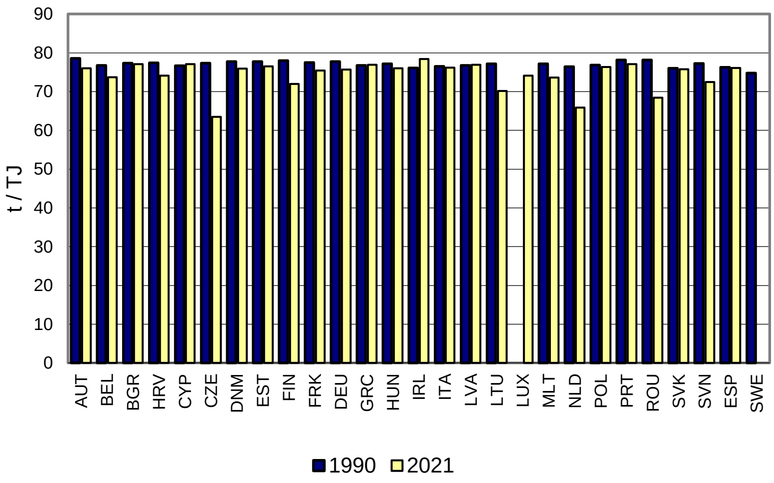


Figure 3.8 shows the implied emission factors for CO_2 emissions from liquid fuels used in public electricity and heat production. The IEFs in most countries range between 76 and 79 t/TJ on the entire time-series. The average IEF within the EU is 77.2 t/TJ in 2021. The IEF from Netherlands is one of the lowest among the countries in the year 2021. The low IEF is caused by the high share of waste gas use in the liquid fuel mix, which has a comparatively low IEF (53.0 t/TJ). The same explanation can be given for Czechia which consumes a high share of Refinery gas with an EF of about 55 t CO_2/TJ).

Figure 3.8 1.A.1.a Public Electricity and Heat Production, Liquid Fuels: Implied Emission Factors for CO_2



IEF, 1.A.1.a Liquid Fuels CO2



1.A.1.a Electricity and Heat Production - Solid Fuels (CO_2)

CO_2 emissions from the combustion of solid fuels represented about 63.1 % of all greenhouse gas emissions from public electricity and heat production. Within the EU, emissions fell by 52 % between 1990 and 2021 (Table 3.7). A reason for the recent decline is that coal is being phased out of the fuel mix especially in Germany as well as in Poland and Spain. Over the past 31 years Germany and Poland account for 46.3 % of the decline in the EU. However, emissions from solid fuels increased by 17 % between 2020 and 2021, Germany and Poland accounting for 73.4 % of this increase.

Table 3.7 1.A.1.a Public Electricity and Heat Production, Solid Fuels: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	6 247	356	NO	-	-6 247	-100%	-356	-100%	NA	NA
Belgium	19 148	3 779	4 323	1%	-14 825	-77%	544	14%	T3	PS
Bulgaria	25 638	15 022	18 812	4%	-6 826	-27%	3 790	25%	T1,T2	CS,D
Croatia	595	987	1 195	0%	600	101%	208	21%	T2	CS
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	52 368	32 956	35 421	8%	-16 947	-32%	2 465	7%	T2	CS,D
Denmark	22 225	2 718	3 687	1%	-18 538	-83%	969	36%	T1,T2,T3	CS,D,PS
Estonia	22 017	3 613	4 881	1%	-17 137	-78%	1 268	35%	T1,T2,T3	CS,D,PS
Finland	9 281	4 092	4 958	1%	-4 323	-47%	867	21%	T3,T3,T3	CS,D,PS
France	37 410	6 273	9 260	2%	-28 150	-75%	2 986	48%	T2,T3	CS,PS
Germany	307 246	129 709	157 714	35%	-149 532	-49%	28 006	22%	CS	CS
Greece	35 201	9 099	8 299	2%	-26 902	-76%	-801	-9%	T2	PS
Hungary	12 266	5 127	4 029	1%	-8 237	-67%	-1 098	-21%	T2,T3	CS,PS
Ireland	4 845	755	2 618	1%	-2 227	-46%	1 863	247%	T1,T3	CS,D,PS
Italy	27 756	12 581	13 020	3%	-14 736	-53%	439	3%	T3	CS
Latvia	211	3	7	0%	-204	-97%	4	106%	T2	CS
Lithuania	174	5	6	0%	-168	-97%	0	9%	T2,T3	CS,PS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	710	NO	NO	-	-710	-100%	-	-	NA	NA
Netherlands	25 862	11 159	16 718	4%	-9 144	-35%	5 559	50%	T2	CS
Poland	220 132	121 681	141 996	31%	-78 135	-35%	20 316	17%	T1,T2	CS,D
Portugal	7 921	2 079	691	0%	-7 230	-91%	-1 388	-67%	T1,T3	D,PS
Romania	25 734	9 450	9 794	2%	-15 940	-62%	345	4%	T2,T3	CS,PS
Slovakia	11 542	1 761	1 747	0%	-9 795	-85%	-14	-1%	T2	CS
Slovenia	5 712	4 158	3 790	1%	-1 922	-34%	-368	-9%	T2	PS
Spain	58 931	6 997	7 246	2%	-51 685	-88%	249	4%	T2	PS
Sweden	4 231	1 925	1 922	0%	-2 309	-55%	-3	0%	T2	CS
EU-27	**943 402**	**386 286**	**452 135**	**100%**	**-491 268**	**-52%**	**65 849**	**17%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Table 3.7 also shows that about 96.2 % of EU emissions are calculated using higher tier methods. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels (for example hard coal and lignite) and use default emission factors for fuels of minor importance (for example brown coal briquettes). Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

Figure 3.9 shows the trend of emissions for solid fuels for main contributing countries. In 2021 Germany has the largest share of emissions from solid fuels in the EU (34.9 %), followed by Poland (31.4 %) and then by a clear margin Czechia (7.8 %) and Bulgaria (4.2 %).

Figure 3.9 1.A.1.a Public Electricity and Heat Production, Solid Fuels: Emission trend and share for CO_2

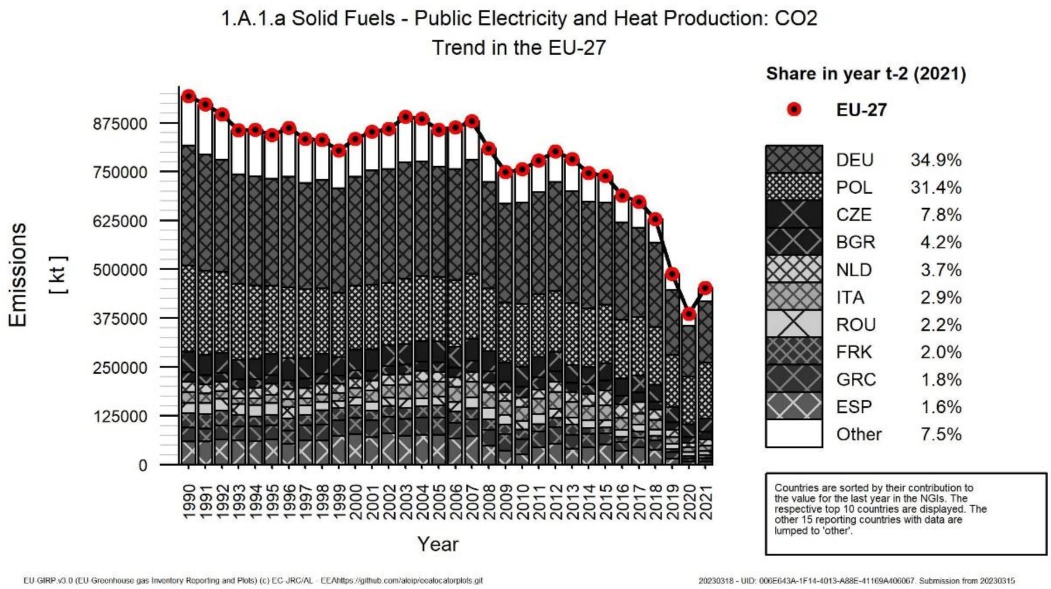
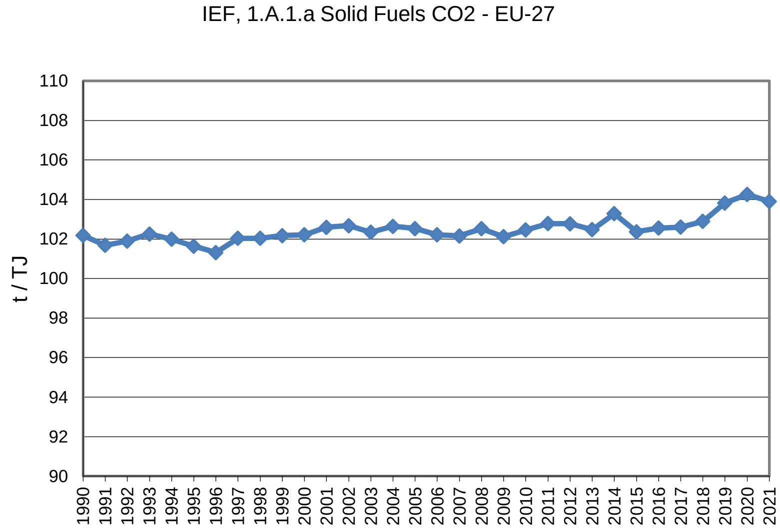
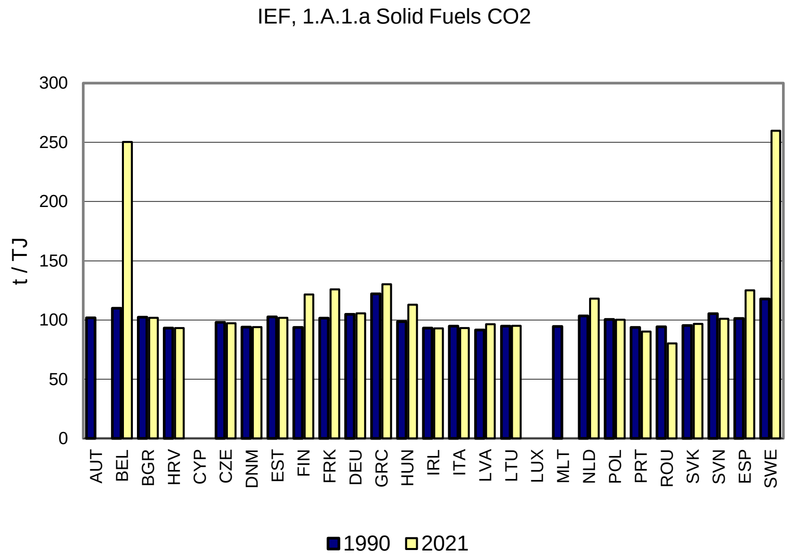


Figure 3.10 (on the next page) shows the relevant implied emission factors for solid fuels. The EU implied emission factor has remained fairly stable between 100 t/TJ and 102 t/TJ on the entire time-series with a slight increase in the last years (around 104 t/TJ in 2021). The comparatively high IEF of Greece is due to the large importance of domestic lignite use for electricity production. The Greek IEF is based on verified EU-ETS reports, ranging from 33.74 to 35.37 tC/TJ. These values lie out of the range suggested by the 2006 IPCC Guidelines. However, given that the net calorific value of the Greek lignite is one of the lowest, a high value for the carbon content is expected. This is the same observation for Hungary which consumes domestic lignite with very low NCV as well as blast furnace gas. In Belgium, Sweden and France, the emission factors increased sharply since the late 1990s due to the use of blast furnace gas which has a much higher carbon content. A significant increase of the Belgian IEF since 2015 can be observed. The reason for this strong increase lies in the large decrease of the consumption of coals and at the same time an increase in energy consumption of blast furnace gas.

Figure 3.10 1.A.1.a Public Electricity and Heat Production, Solid Fuels: Implied Emission Factors for CO_2





1.A.1.a Electricity and Heat Production - Gaseous Fuels (CO_2)

CO_2 emissions from the combustion of gaseous fuels accounted for 26.9 % of all greenhouse gas emissions from public electricity and heat generation in 2021. Emissions increased by 80 % in the EU between 1990 and 2021 (Table 3.8). Italy was responsible for about 53 % of the increase in the last 30 years.

Table 3.8 1.A.1.a Electricity and heat production, Gaseous Fuels: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	3 294	4 227	4 467	2%	1 173	36%	240	6%	T2	CS
Belgium	2 739	8 019	6 327	3%	3 588	131%	-1 692	-21%	T1,T3	D,PS
Bulgaria	6 295	1 921	2 352	1%	-3 944	-63%	431	22%	T2	CS
Croatia	991	1 622	1 540	1%	549	55%	-82	-5%	T2,T1	CS,D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	1 019	3 425	3 298	2%	2 279	224%	-127	-4%	T2	CS
Denmark	1 000	888	887	0%	-113	-11%	0	0%	T1,T2,T3	CS,D,PS
Estonia	1 812	238	314	0%	-1 498	-83%	76	32%	T1,T2,T3	CS,D,PS
Finland	1 989	2 100	2 059	1%	71	4%	-41	-2%	T3	CS
France	970	12 866	12 255	6%	11 285	1163%	-612	-5%	T2,T3	CS,PS
Germany	18 447	35 292	34 719	18%	16 271	88%	-574	-2%	CS	CS
Greece	IE,NO	7 764	8 668	4%	8 668	∞	904	12%	T2	PS
Hungary	4 111	5 000	5 346	3%	1 235	30%	345	7%	T2	CS
Ireland	1 881	5 415	4 972	3%	3 092	164%	-442	-8%	T1,T3	CS,D,PS
Italy	16 173	46 357	50 124	26%	33 951	210%	3 767	8%	T3	CS
Latvia	2 658	1 273	1 325	1%	-1 333	-50%	52	4%	T2	CS
Lithuania	5 797	909	897	0%	-4 900	-85%	-12	-1%	T2	CS
Luxembourg	NO	106	114	0%	114	∞	8	8%	T2	CS
Malta	NO	736	739	0%	739	∞	2	0%	T2	CS
Netherlands	13 329	21 057	15 334	8%	2 005	15%	-5 722	-27%	T2	CS
Poland	1 197	7 282	7 150	4%	5 953	497%	-132	-2%	T2	CS
Portugal	NO	4 969	4 593	2%	4 593	∞	-376	-8%	T1,T3	D,PS
Romania	20 845	5 440	5 532	3%	-15 313	-73%	92	2%	T3	PS
Slovakia	2 089	1 992	2 409	1%	320	15%	417	21%	T2	CS
Slovenia	113	301	311	0%	198	175%	10	3%	T2	CS
Spain	447	16 441	16 759	9%	16 311	3645%	318	2%	T2,T1	CS,PS
Sweden	486	C	192	0%	-293	-60%	192	∞	T2	CS
EU-27	**107 197**	**195 640**	**192 490**	**100%**	**85 292**	**80%**	**-3 150**	**-2%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.

Table 3.8 also shows that about 99 % of EU emissions are calculated using higher tier methods. Emissions being confidential for Sweden in 2020, it is not considered in the analysis. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels (for example hard coal and lignite) and use default emission factors for fuels of minor importance (for example brown coal briquettes). Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

In seven EU countries (including Sweden) the consumption of gaseous fuels was lower in 2021 than in 1990. Cyprus is not utilising gaseous fuels for public electricity and heat production. In the other 19 countries, gas consumption has increased in the last 31 years. From 1990 until 2008 the use of gaseous fuels shows a steep increasing trend, followed by strong decreasing trend from 2009 until 2014, which was mainly attributed to the increased prices for natural gas. After this steep decrease the emissions of gaseous fuels increased again by about 40 % in 2021 compared to 2014. Figure 3.11 shows the trend of emissions from gaseous fuels by the main contributing countries which are Italy (26.0 %), and Germany (18.0 %). One of the reasons for the recent increase is that coal is in the process of being phased out of the fuel mix and replaced by gaseous fuels in many countries (2021 is an exception in the recent years).

Figure 3.11 1.A.1.a Public Electricity and Heat Production, Gaseous Fuels: Emission trend and share for CO_2

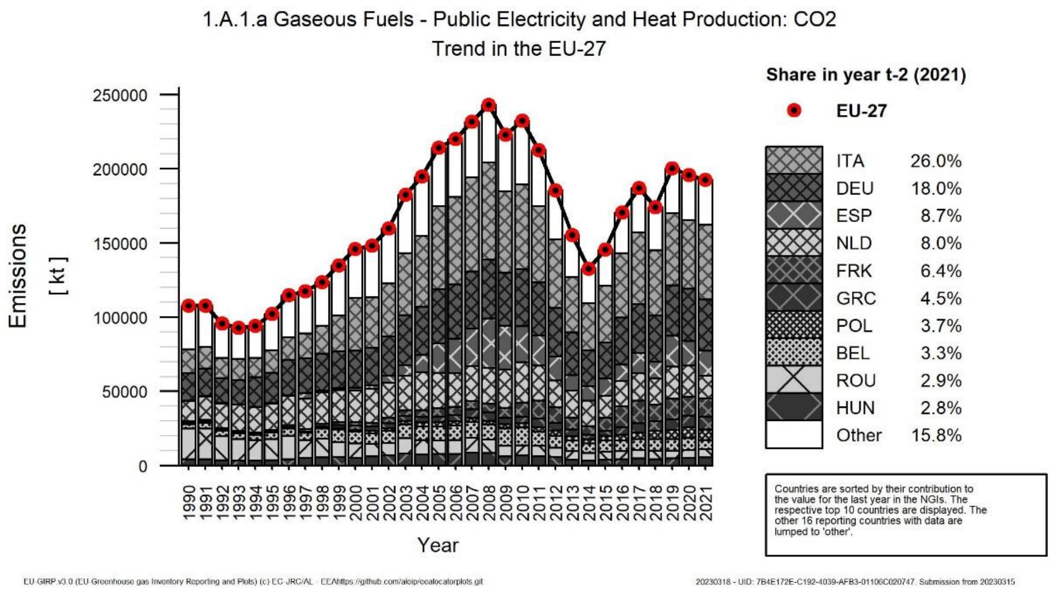
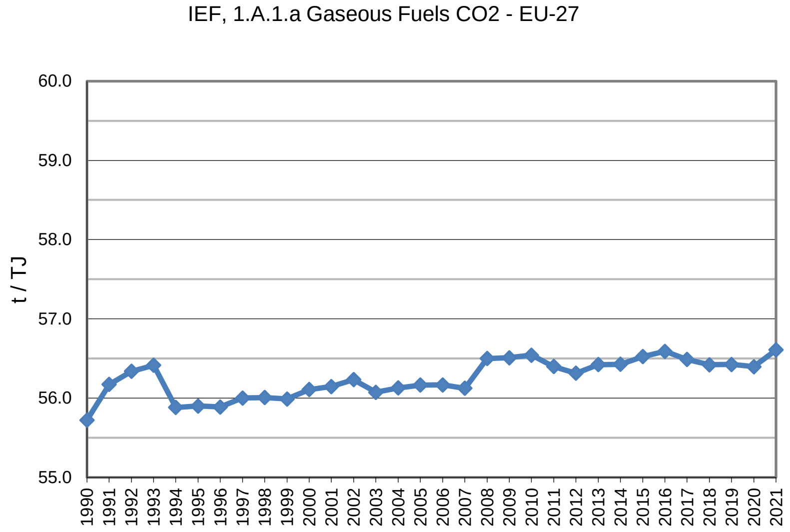
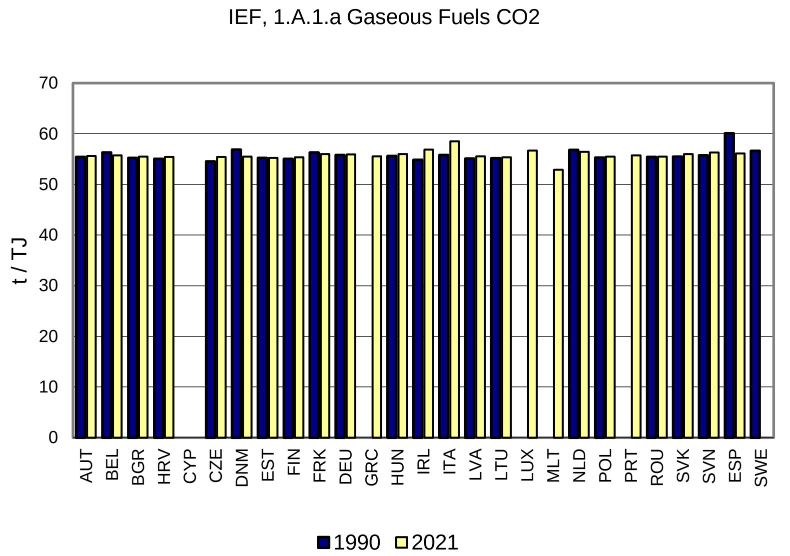


Figure 3.12 (on the next page) shows the implied emission factors from gaseous fuels for CO_2. The EU implied emission factor has remained fairly stable (56.6 t/TJ in 2021) which is very close to the default emission factor of natural gas (56.1 t/TJ). In the early 1990s, the IEF for Spain was high. It is explained by the total CO_2 emissions allocation amongst fuels which does not impact total CO_2 emissions.

Figure 3.12   1.A.1.a Public Electricity and Heat Production, Gaseous Fuels: Implied Emission Factors for CO_2





1.A.1.a Electricity and Heat Production - Other Fuels (CO_2)

In 2021, the share of CO_2 emissions from other fuels amounts to 5.1 % of total greenhouse gas emissions from public electricity and heat generation. Other fuels cover mainly the fossil part of municipal solid waste incineration where there is energy recovery, including plastics, hazardous waste, bulky waste and waste sludge (Table 3.9). Emissions increased by 248 % at EU level between 1990 and 2021 and increased in all countries except for Latvia. Germany alone is responsible for 36.9 % of the increase in the whole EU over the last 31 years.

Table 3.9 1.A.1.a Public Electricity and Heat Production, Other Fuels: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	286	1 016	1 049	3%	762	266%	33	3%	T2	CS
Belgium	674	2 039	2 134	6%	1 460	217%	95	5%	T3	PS
Bulgaria	NO	NO	NO	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	24	265	261	1%	237	987%	-3	-1%	T1	D
Denmark	539	1 648	1 548	4%	1 010	187%	-99	-6%	T1,T2,T3	CS,D,PS
Estonia	NO	128	124	0%	124	∞	-4	-3%	T1,T2,T3	CS,D,PS
Finland	1	601	661	2%	660	65966%	61	10%	T3	CS
France	2 557	7 357	6 691	18%	4 134	162%	-666	-9%	T2,T3	CS,PS
Germany	4 121	13 534	13 710	38%	9 589	233%	175	1%	CS	CS
Greece	NO	NO	NO	-	-	-	-	-	NA	NA
Hungary	30	197	220	1%	190	633%	23	12%	T2	CS
Ireland	NO	596	585	2%	585	∞	-11	-2%	T1,T3	CS,D,PS
Italy	143	178	146	0%	2	2%	-32	-18%	T3	CS
Latvia	3	NO	NO	-	-3	-100%	-	-	NA	NA
Lithuania	NO	295	448	1%	448	∞	154	52%	T1,T2	CS,D
Luxembourg	32	100	99	0%	67	206%	0	0%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	601	2 709	2 671	7%	2 070	344%	-38	-1%	CS,NA	CS
Poland	753	978	954	3%	201	27%	-24	-2%	T1	NA,D
Portugal	NO	469	410	1%	410	∞	-59	-13%	T1,T3	D,PS
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	36	163	180	0%	144	405%	16	10%	T2	NA
Slovenia	NO	20	19	0%	19	∞	-1	-3%	T1	D
Spain	128	1 547	1 637	4%	1 509	1183%	89	6%	T2	CS,PS
Sweden	524	2 746	2 880	8%	2 356	449%	135	5%	T2	CS
EU-27	**10 453**	**36 586**	**36 428**	**100%**	**25 975**	**248%**	**-157**	**0%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Table 3.9 also shows that more than 95.8 % of EU emissions are calculated using higher tier methods. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels (for example hard coal and lignite) and use default emission factors for fuels of minor importance (for example brown coal briquettes). Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

Figure 3.13 illustrates clearly the strong increase of emissions caused by other fuels over the past 31 years. The largest emitters of other fuels in 2021 were Germany (37.6 %) and France (18.4 %). Together these two countries accounted for 56.0 % of the total EU emissions in this category.

Figure 3.13 1.A.1.a Public Electricity and Heat Production, Other Fuels: Emission trend and share for CO_2

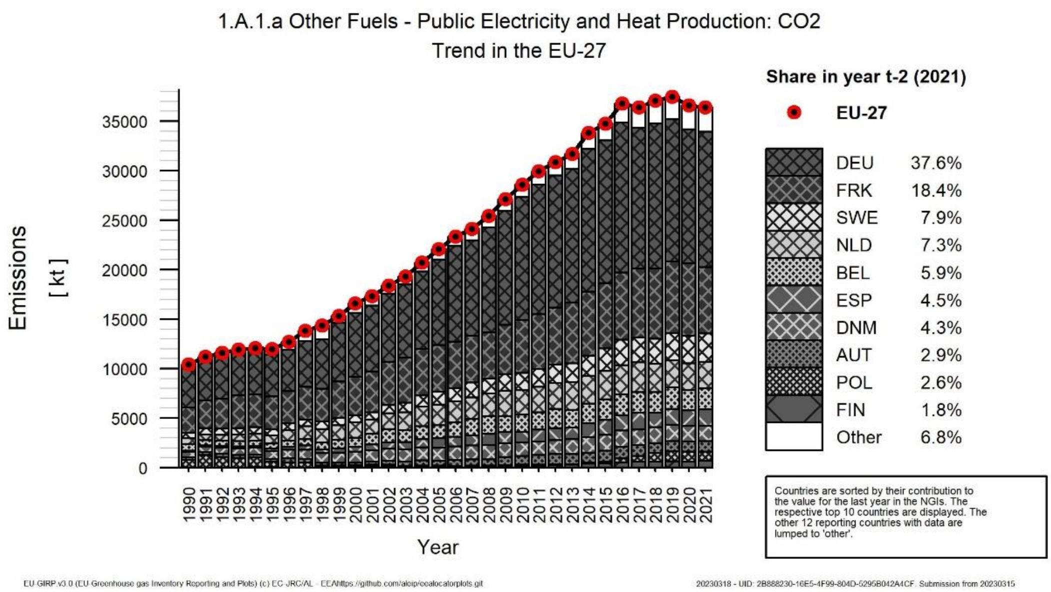
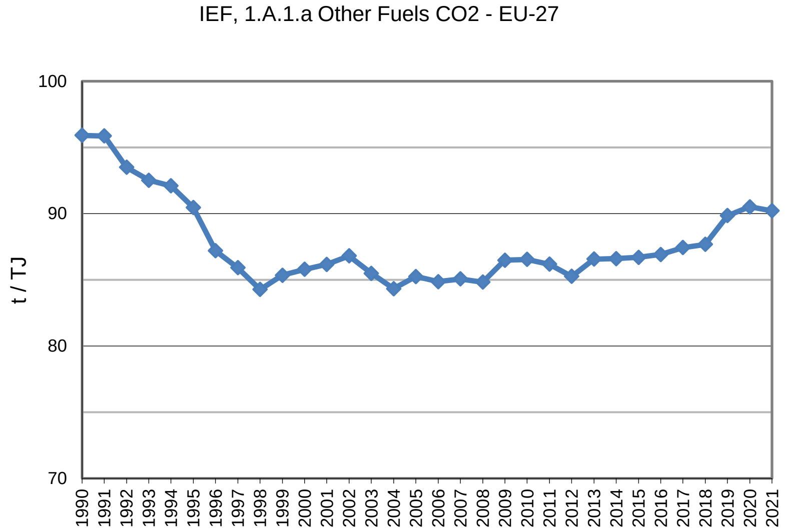
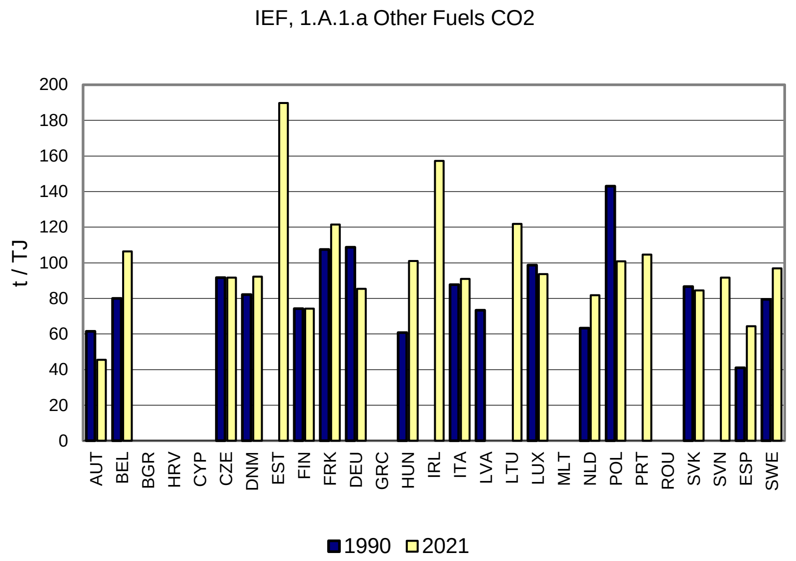


Figure 3.14 (on the next page) shows the implied emission factors from other fuels for CO_2. The EU implied emission factor has gradually fallen until 1998, then levelled out between 85 and 90 t/TJ on the entire time-series. In Germany, the IEF declined continuously between 1990 and 2021 (from 109 to 85.1 t/TJ). This is because the combustion of industrial waste has been greatly reduced in the early 1990s whereas the combustion of residential waste for electricity and heat has increased in the complete reporting period; furthermore, the calorific value of the applied waste has increased due to a better national waste separation management. There is a large diversity in waste composition across countries leading to the differences in countries' IEFs.

Figure 3.14   1.A.1.a Public Electricity and Heat Production, Other Fuels: Implied Emission Factors for CO_2





1.A.1.a Electricity and Heat Production - Peat (CO_2)

CO_2 emissions from the combustion of peat represented 0.5 % of all greenhouse gas emissions from public electricity and heat production. Peat in its raw state is a fossil sedimentary deposit of vegetal origin with high water content. Only 5 countries report emissions from peat combustion. Latvia did not consume Peat anymore since 2020. Within the EU, emissions declined by 58 % respectively 5.3 Mt CO_2 between 1990 and 2021 and by 23 % between 2020 and 2021 (Table 3.10).

Table 3.10 1.A.1.a Public Electricity and Heat Production, Peat: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	NO	NO	NO	-	-	-	-	-	NA	NA
Belgium	NO	NO	NO	-	-	-	-	-	NA	NA
Bulgaria	NO	NO	NO	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	843	68	21	1%	-822	-97%	-47	-69%	T1,T2,T3	CS,D,PS
Finland	3 950	3 692	3 246	85%	-703	-18%	-446	-12%	T3	CS
France	NO	NO	NO	-	-	-	-	-	NA	NA
Germany	NO	NO	NO	-	-	-	-	-	NA	NA
Greece	NO	NO	NO	-	-	-	-	-	NA	NA
Hungary	NO	NO	NO	-	-	-	-	-	NA	NA
Ireland	3 065	1 012	333	9%	-2 732	-89%	-679	-67%	T1,T3	CS,D,PS
Italy	NO	NO	NO	-	-	-	-	-	NA	NA
Latvia	146	0	0	0%	-146	-100%	0	0%	T2	CS
Lithuania	11	15	19	0%	8	71%	4	27%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	-	-	-	-	-	-	-	-	-	-
Poland	NO	NO	NO	-	-	-	-	-	NA	NA
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	NO	NO	NO	-	-	-	-	-	NA	NA
Sweden	1 150	202	210	5%	-940	-82%	8	4%	T2	CS
EU-27	**9 164**	**4 988**	**3 829**	**100%**	**-5 335**	**-58%**	**-1 159**	**-23%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Note: Peat is not used as a fuel in the Netherlands. Nevertheless, the Netherlands did not report Peat as notation key

Table 3.10 also shows that about 99.1 % of EU emissions are calculated using higher tier methods. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels (for example hard coal and lignite) and use default emission factors for fuels of minor importance (for example brown coal briquettes). Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

Figure 3.15 illustrates the trend of peat emissions throughout the last 31 years, which is predominately influenced by the emission fluctuation over the years by Finland and Ireland. Several parameters such as weather conditions greatly influence the peat consumption: in Finland, peat represents 4 % of electricity production and is the third most important energy source in district heat production (with

15 % of the district heat produced). In 2021, the two largest emitters, Finland and Ireland, are responsible for 93.5 % of the total emissions in this category.

Figure 3.15 1.A.1.a Public Electricity and Heat Production, Peat: Emission trend and share for CO_2

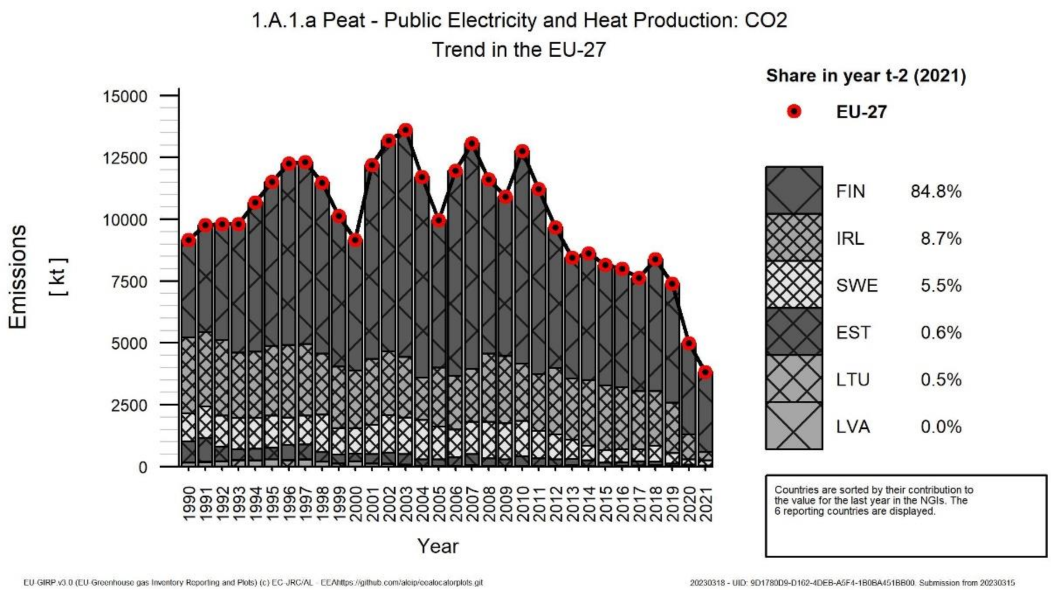
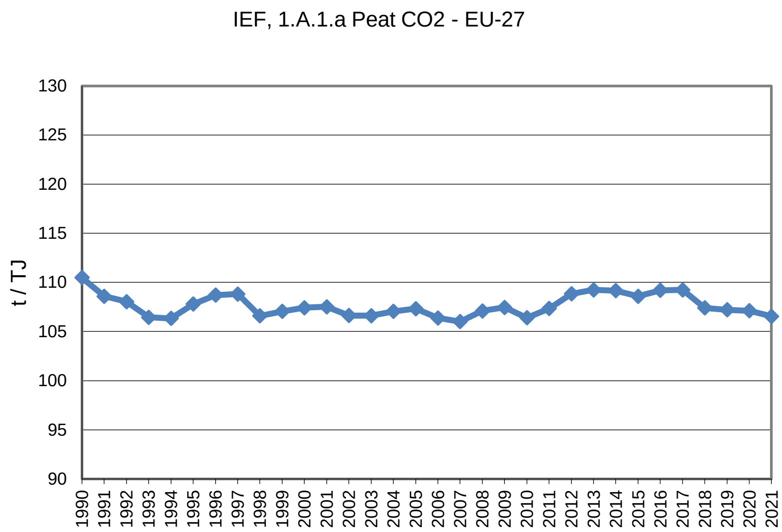
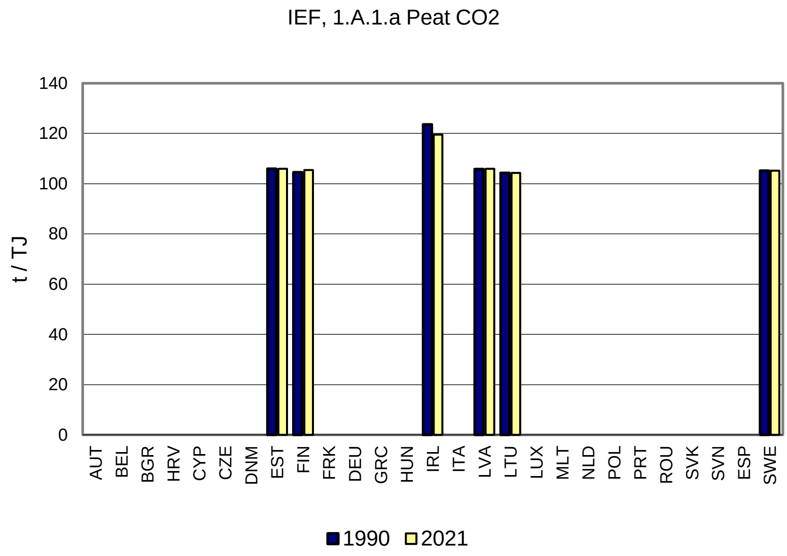


Figure 3.16 shows the implied emission factors of peat for CO_2. The EU implied emission factor amounts to 106.5 t/TJ in 2021 and has been quite stable over the last 31 years. It is mainly influenced by the IEF of the two largest emitters (Finland and Ireland). The default emission factor for peat is 106 t/TJ according to the 2006 IPCC guidelines. Only Ireland has an IEF continuously above the default value. The reason for this is the use of the plant specific emission factor (112.9 t/TJ) for three milled peat power plants in use.

Figure 3.16 1.A.1.a Public Electricity and Heat Production, Peat: Implied Emission Factors for CO_2




IEF, 1.A.1.a Peat CO2
140
120
100
80
60
40
20
0
t / TJ
AUT
BEL
BGR
HRV
CYP
CZE
DNM
EST
FIN
FRK
DEU
GRC
HUN
IRL
ITA
LVA
LTU
LUX
MLT
NLD
POL
PRT
ROU
SVK
SVN
ESP
SWE
1990
2021

3.2.1.2 Petroleum Refining (1.A.1.b) (EU)

According to the 2006 IPCC guidelines, Petroleum Refining (CRF 1.A.1.b) should include all combustion activities supporting the refining of petroleum products including on-site combustion for the generation of electricity and heat for own use. It does not include evaporative emissions occurring at the refinery. These emissions should be reported separately under 1.B.2.a as well as venting and flaring under 1.B.2.c.

Total emissions from Petroleum Refining are accounting for 2.8 % of total greenhouse gas emissions in year 2021. Between 1990 and 2021, EU CO_2 emissions decreased by 13 % (Table 3.11). Emissions in 2021 were above 1990 levels in 8 countries, whereas they were decreasing in 15 and reported as not occurring for the whole time series in 4 countries. Poland, Greece and Sweden had the largest emission increases. In contrast France reports the largest decrease accounting for 49.1 % of the decrease in emissions in this period. The decrease at European level can be explained by the reduction of Liquid fuels consumptions (-26.0 % for sector 1.A.1.b Liquid fuels between 1990 and 2021).

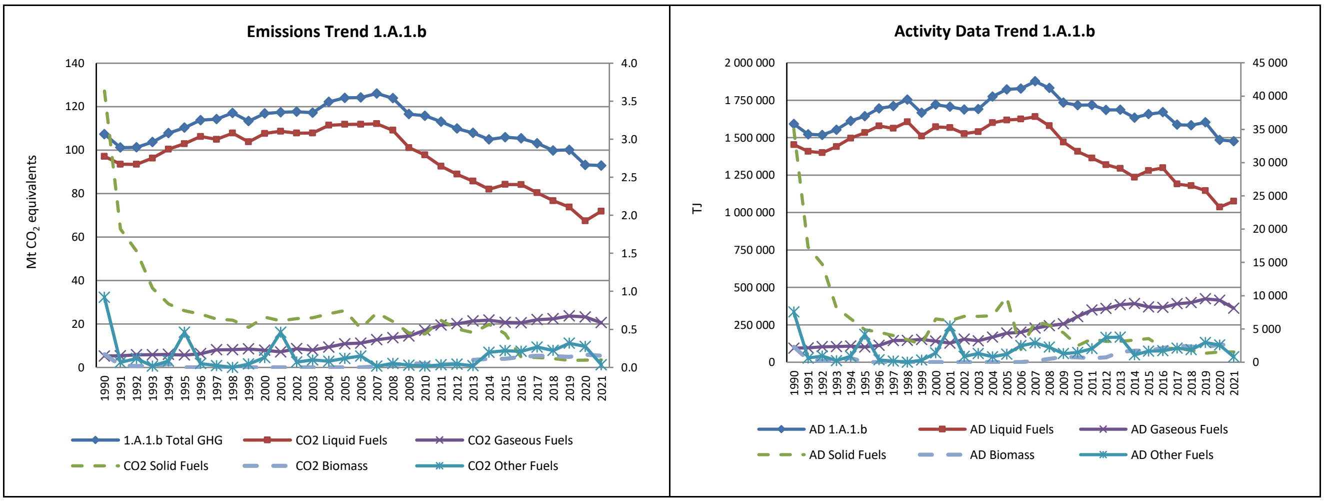
Table 3.11 1.A.1.b Petroleum Refining: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	2 394	2 732	2 750	3.0%	355	15%	18	1%	T2	CS
Belgium	4 299	4 826	5 081	5.5%	782	18%	255	5%	CS,T3	PS
Bulgaria	860	803	729	0.8%	-131	-15%	-74	-9%	T1,T2	CS,D
Croatia	2 425	836	745	0.8%	-1 679	-69%	-90	-11%	T1	D
Cyprus	86	NO	NO	-	-86	-100%	-	-	NA	NA
Czechia	493	433	479	0.5%	-13	-3%	46	11%	T1,T2	CS,D
Denmark	908	910	938	1.0%	30	3%	28	3%	T1,T2,T3	CS,D,PS
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	2 042	1 560	1 171	1.3%	-872	-43%	-389	-25%	T3	CS,PS
France	11 935	5 095	4 893	5.3%	-7 043	-59%	-203	-4%	T2,T3	CS,PS
Germany	24 103	20 102	19 984	21.6%	-4 119	-17%	-118	-1%	CS	CS
Greece	2 375	4 448	5 277	5.7%	2 902	122%	828	19%	T2	PS
Hungary	2 376	1 611	1 515	1.6%	-860	-36%	-95	-6%	T2,T3	CS,PS
Ireland	168	301	294	0.3%	126	75%	-7	-2%	T3	CS,PS
Italy	15 817	17 448	16 548	17.9%	731	5%	-900	-5%	T3	CS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	1 510	1 222	1 210	1.3%	-300	-20%	-12	-1%	T2,T3	CS,PS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	11 010	9 123	9 471	10.2%	-1 540	-14%	348	4%	T2	CS,D
Poland	2 169	4 585	4 403	4.8%	2 234	103%	-182	-4%	T1,T2	CS,D
Portugal	1 870	2 094	1 761	1.9%	-109	-6%	-333	-16%	T2	CR,D,PS
Romania	4 333	2 078	1 923	2.1%	-2 409	-56%	-154	-7%	T1,T2,T3	CS,D,PS
Slovakia	2 873	1 504	1 522	1.6%	-1 351	-47%	18	1%	T3	PS
Slovenia	171	NO	NO	-	-171	-100%	-	-	NA	NA
Spain	10 858	9 236	9 044	9.8%	-1 814	-17%	-192	-2%	T2,T3	PS
Sweden	1 778	1 895	2 766	3.0%	989	56%	872	46%	T2	CS
EU-27	**106 853**	**92 841**	**92 505**	**100%**	**-14 348**	**-13%**	**-336**	**0%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Figure 3.17 shows the trends in activity data and the associated emissions originating from the refining of petroleum by fuel in the EU between the years 1990 and 2021. Fuel used for petroleum refining decreased by 7.2 % in the EU between 1990 and 2021. In the year 2021, liquid fuels represent 72.8 % of all fuel used in the refining of petroleum. Gaseous fuels almost fully account for the remaining part (24.4 %) of the activity data. Gaseous fuels use is almost four times higher in 2021 compared to 1990. There remains a small amount of solid fuels used accounting for 0.11 % in petroleum refining; in Germany (lignite and coke oven gas) and Poland (hard coal and lignite) as well as 0.17 % of biomass and 2.45 % of other fuels use.

Figure 3.17 1.A.1.b Petroleum Refining: Total and CO_2 emission and activity trends



Note: Data displayed as dashed line refers to the secondary axis.

1.A.1.b Petroleum Refining - Liquid Fuels (CO_2)

CO_2 emissions from the combustion of liquid fuels used for petroleum refining accounted for 77.4 % of all greenhouse gas emissions from petroleum refining in 2021. Emissions decreased by 27 % between 1990 and 2021 (Table 3.12). Greece had the largest emission increase accounting for 55.1 % of the whole increase between 1990 and 2021. In contrast France reports the largest decrease accounting for 30.6 % of the whole decrease in emissions in this period.

Table 3.12 1.A.1.b Petroleum Refining, Liquid Fuels: Countries' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 958	2 235	2 217	3.2%	259	13%	-18	-1%	T2	CS
Belgium	4 285	2 325	3 267	4.7%	-1 018	-24%	942	41%	CS,T3	PS
Bulgaria	791	701	617	0.9%	-174	-22%	-84	-12%	T1	D
Croatia	2 411	424	396	0.6%	-2 015	-84%	-28	-7%	T1	D
Cyprus	86	NO	NO	-	-86	-100%	-	-	NA	NA
Czechia	176	246	294	0.4%	118	67%	48	20%	T1	CS,D
Denmark	908	881	902	1.3%	-6	-1%	21	2%	T1,T2,T3	CS,D,PS
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	1 383	1 302	983	1.4%	-400	-29%	-318	-24%	T3	CS,PS
France	11 413	3 805	3 459	5.0%	-7 954	-70%	-345	-9%	T2,T3	CS,PS
Germany	19 354	16 146	17 381	25.1%	-1 973	-10%	1 235	8%	CS	CS
Greece	2 375	4 448	5 277	7.6%	2 902	122%	828	19%	T2	PS
Hungary	1 683	956	878	1.3%	-805	-48%	-78	-8%	T3	PS
Ireland	168	287	280	0.4%	112	66%	-7	-2%	T3	CS,PS
Italy	15 656	13 610	13 028	18.8%	-2 628	-17%	-582	-4%	T3	CS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	1 510	1 064	1 123	1.6%	-387	-26%	59	6%	T2,T3	CS,PS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	9 968	6 267	6 946	10.0%	-3 022	-30%	679	11%	T2	CS,D
Poland	1 326	2 255	2 472	3.6%	1 146	86%	217	10%	T1,T2	CS,D
Portugal	1 870	997	925	1.3%	-946	-51%	-73	-7%	T2	CR,D,PS
Romania	4 333	1 772	1 613	2.3%	-2 720	-63%	-160	-9%	T2,T3	CS,PS
Slovakia	2 786	1 284	1 301	1.9%	-1 485	-53%	17	1%	T3	PS
Slovenia	43	NO	NO	-	-43	-100%	-	-	NA	NA
Spain	10 812	6 382	5 982	8.6%	-4 830	-45%	-400	-6%	T2,T3	PS
Sweden	1 778	C	2 504	3.6%	726	41%	2 504	∞	T2	CS
EU-27	**95 294**	**67 384**	**69 340**	**100%**	**-25 954**	**-27%**	**1 956**	**3%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.

Table 3.12 also shows that 97.7 % of EU emissions are calculated using higher tier methods. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels (for example hard coal and lignite) and use default emission factors for fuels of minor importance (for example brown coal briquettes). Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

Figure 3.18 illustrates that Germany and Italy are the countries contributing most in terms of CO_2 emissions in 2021. It also can be seen that the trend for liquid fuels was continuously decreasing since the year 2008 with a stabilization between 2014 and 2016. An increase can be observed between 2020 and 2021 following the COVID crisis.

Figure 3.18   1.A.1.b Petroleum Refining, Liquid Fuels: Emission trend and share for CO_2

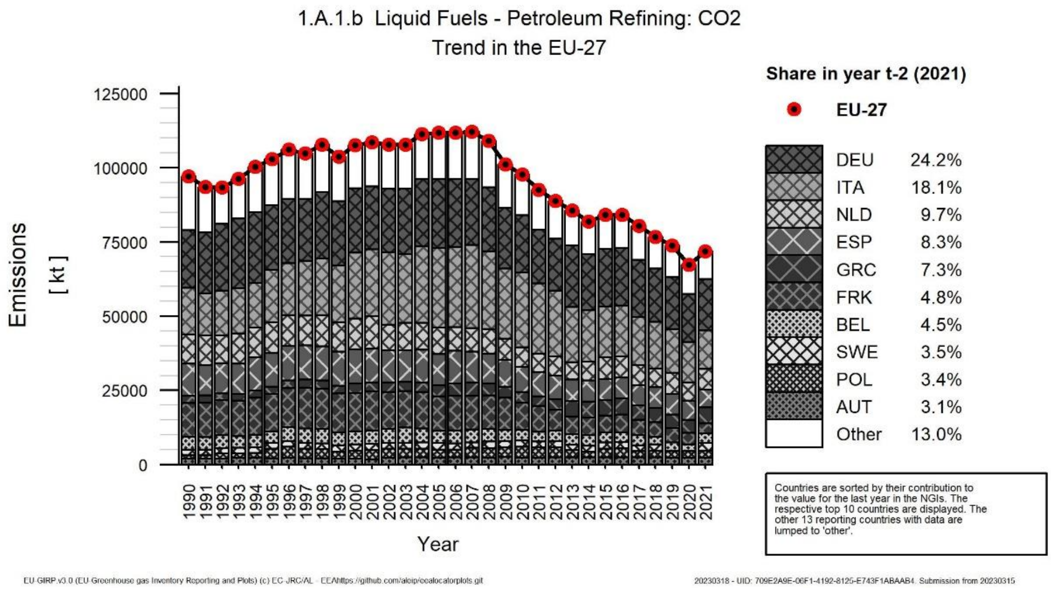
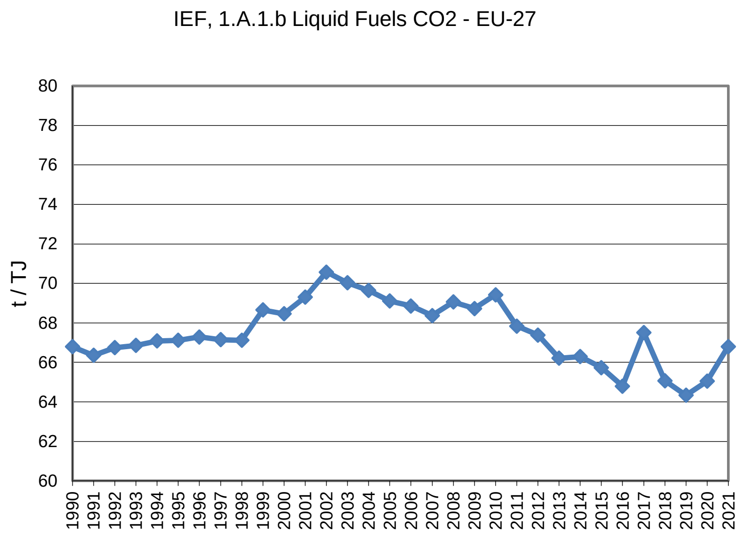


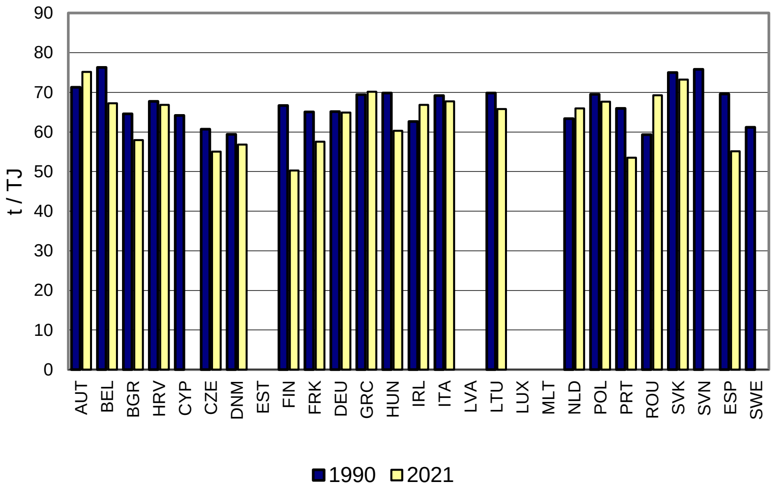
Figure 3.19 (on the next page) shows the emission factors for CO_2 emissions from liquid fuels. The EU implied emission factor shows variations around 68 t/TJ over the time series and amounts 66.8 t/TJ in 2021. In general, the fluctuating IEF is due to the annual variations of fuel consumption with different carbon content. The IEF declining trend observed since 2002 is due to the higher share of refinery gas in the energy mix. However, an increase in the IEF is observed since 2019.

For example, in Italy the main fuels used are refinery gases, fuel oil and petroleum coke, which have very different emission factors, and every year the amount used changes resulting in an annual variation of the IEF.

Figure 3.19   1.A.1.b Petroleum Refining, Liquid Fuels: Implied Emission Factors for CO_2



IEF, 1.A.1.b Liquid Fuels CO2



1.A.1.b Petroleum Refining - Solid Fuels (CO_2)

CO_2 emissions from the combustion of solid fuels in petroleum refining represented less than 0.1 % of all greenhouse gas emissions from 1.A.1.b in 2021. There are only three countries reporting emissions in the EU in 2021 (Poland, Germany and Romania). Thereof only Poland reports increasing emissions between 1990 and 2021. Emissions from Romania also increased but remain very low. Poland is responsible for 58.1 % of emissions in 2021 in the EU. Over the whole times series emissions fell by 97 % on average (Table 3.13).

Table 3.13 1.A.1.b Petroleum Refining, Solid Fuels: Countries' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	NO	NO	NO	-	-	-	-	-	NA	NA
Belgium	NO	0.02	NO	-	-	-	0	-100%	NA	NA
Bulgaria	NO	NO	NO	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	12	NO	NO	-	-12	-100%	-	-	NA	NA
France	486	NO	NO	-	-486	-100%	-	-	NA	NA
Germany	3 131	37	37	38.1%	-3 093	-99%	0	-1%	CS	CS
Greece	NO	NO	NO	-	-	-	-	-	NA	NA
Hungary	NO	NO	NO	-	-	-	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	NO	NO	NO	-	-	-	-	-	NA	NA
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	4	51	57	58.1%	52	1231%	6	12%	T1,T2	CS,D
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	NO	6	4	3.8%	4	∞	-2	-38%	T3	PS
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	NO	NO	NO	-	-	-	-	-	NA	NA
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**3 633**	**94**	**98**	**100%**	**-3 535**	**-97%**	**3**	**4%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Table 3.13 also shows that 94.2 % of EU emissions are calculated using higher tier methods. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels (for example hard coal and lignite) and use default emission factors for fuels of minor importance (for example brown coal briquettes). Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

Figure 3.20 illustrates the trend of emissions in 1.A.1.b for solid fuels for the past 31 years. The use of solid fuels in petroleum refining has declined drastically since 1990. Emissions are down by 97 %.

Germany is responsible for the strong declining trend in the 1990s and due to the recent overall trend, Poland is now responsible for 58.1 % of the total emissions in the EU for this category in 2021.

Figure 3.20 1.A.1.b Petroleum Refining, Solid Fuels: Emission trend and share for CO_2

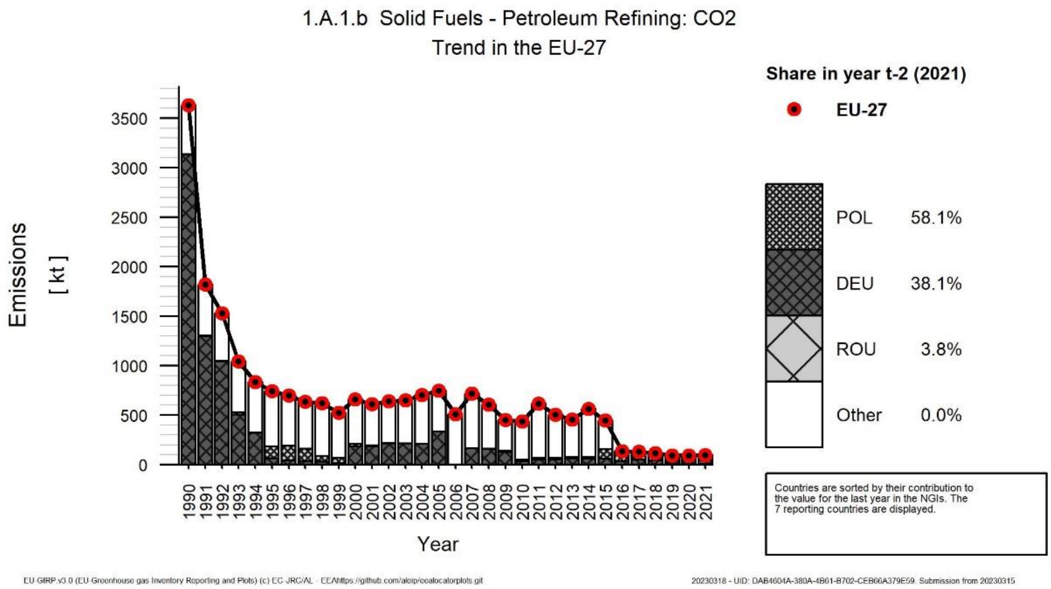
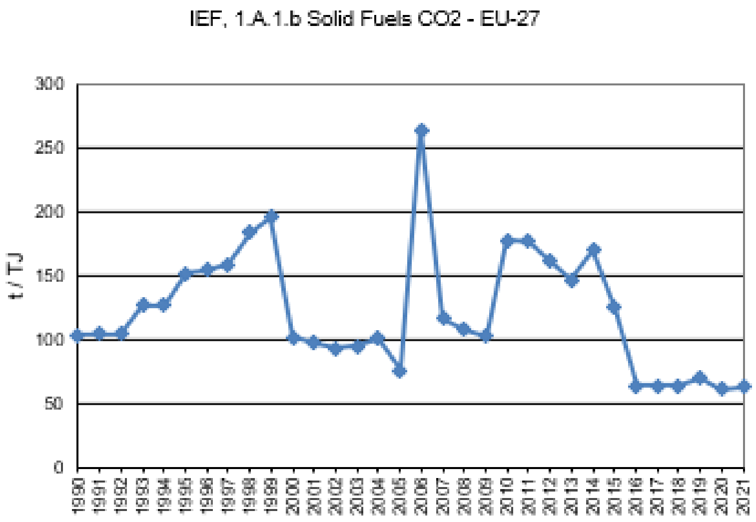
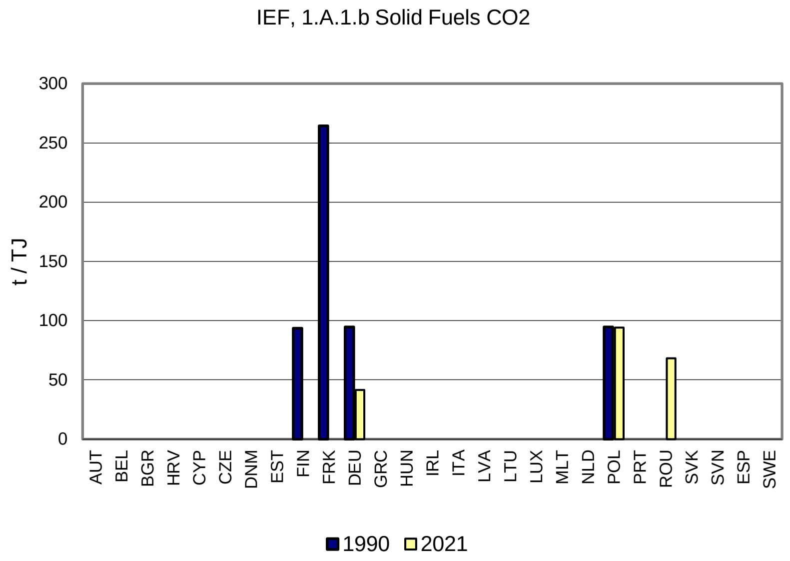


Figure 3.21 (on the next page) shows the relevant implied emission factors. The EU implied emission factor showed strong fluctuations and amounts 62.8 t/TJ in 2021. One explanation for this is the low number of countries reporting this category. Apart from that, the variation in the EU factor can be partly explained by the declining use of solid fuels in petroleum refining in Germany between 1990 and 1999. This explains the gradual increase of the EU IEF up to 1999 through the growing weight of the much higher implied emission factor of France. The high emission factor in France was due to the use of blast furnace gas. In Germany, there was a decline in the IEF in the early 1990s compared to a rather stable IEF since the mid-1990s. The reason is that the use of - mainly - lignite has constantly been reduced in favour of coke oven gas. The increased EU solid fuel combustion in 2000-2005 and 2007-2009 is due to an increase in fuel combustion in Germany in these years. The higher weight of the German IEF also explains the lower IEF at EU level during these years. For 2006 Germany reports only negligible amounts of solid fuel use in petroleum refining. Therefore, the EU IEF was almost entirely dominated by the high French IEF in this year. The drop in the implied emission factor since 2014 can be explained by the increased weight of Poland with their lower IEF (compared to France). Since there is no more solid fuel consumption in France since 2017, the average IEF is driven by Poland and Germany which have similar CO_2 EF.

Figure 3.21 1.A.1.b Petroleum Refining, Solid Fuels: Implied Emission Factors for CO_2





1.A.1.b Petroleum Refining - Gaseous Fuels (CO_2)

In 2021, CO_2 emissions from the combustion of gaseous fuels used for petroleum refining accounted for about 22.1 % of total greenhouse gas emissions from 1.A.1.b. Emissions in the EU increased by 288 % between 1990 and 2021 (Table 3.14). Only four countries reduced their emissions: Czechia, Finland, Hungary and Slovenia over the whole time series. Belgium, Germany, Italy, Poland, Spain and Netherlands together account for 83.4 % of the total increase between 1990 and 2021.

Table 3.14 1.A.1.b Petroleum Refining, Gaseous Fuels: Countries' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27	Change 1990-2021		Change 2020-2021		Method	Emission factor
	1990	2020	2021	Emissions in 2021	kt CO2	%	kt CO2	%		Informa-tion
Austria	437	497	533	2.6%	96	22%	35	7%	T2	CS
Belgium	14	2 283	1 810	8.9%	1 796	12927%	-473	-21%	CS,T3	PS
Bulgaria	69	102	112	0.6%	43	62%	10	10%	T2	CS
Croatia	14	412	350	1.7%	336	2407%	-62	-15%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	317	187	185	0.9%	-132	-42%	-2	-1%	T2	CS
Denmark	NO	29	36	0.2%	36	∞	7	25%	T2	CS
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	648	258	188	0.9%	-460	-71%	-71	-27%	T3	CS
France	36	1 291	1 433	7.1%	1 397	3860%	143	11%	T2,T3	CS,PS
Germany	1 444	3 918	2 566	12.7%	1 121	78%	-1 353	-35%	CS	CS
Greece	NO	IE	IE	-	-	-	-	-	NA	NA
Hungary	693	641	620	3.1%	-72	-10%	-20	-3%	T3	PS
Ireland	NO	14	14	0.1%	14	∞	0	0%	T3	CS,PS
Italy	161	3 838	3 520	17.4%	3 359	2090%	-318	-8%	T3	CS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	159	87	0.4%	87	∞	-72	-45%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	1 042	2 856	2 524	12.5%	1 482	142%	-332	-12%	T2	CS
Poland	92	2 280	1 875	9.3%	1 782	1928%	-405	-18%	T2	CS
Portugal	NO	1 096	836	4.1%	836	∞	-260	-24%	T2	CR,D,PS
Romania	NO	300	307	1.5%	307	∞	7	2%	T2,T3	CS,PS
Slovakia	88	220	221	1.1%	134	152%	1	1%	T3	PS
Slovenia	128	NO	NO	-	-128	-100%	-	-	NA	NA
Spain	46	2 811	3 050	15.0%	3 004	6533%	239	8%	T2,T3	PS
Sweden	NO	C	263	1.3%	263	∞	263	∞	T2	CS
EU-27	**5 228**	**23 192**	**20 267**	**100%**	**15 039**	**288%**	**-2 925**	**-13%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.

Table 3.14 also shows that about 98.3 % of EU emissions are calculated using higher tier methods. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS.

Figure 3.22 illustrates the trend of increasing emissions from gaseous fuels in category 1.A.1.b in the last 31 years. As can be seen, the six largest contributors to CO_2 emissions in this sector account together for 74.7% of the total emissions in this category. Emissions have decreased by 13% between 2020 and 2021 after the peak observed in 2019.

Figure 3.22 1.A.1.b Petroleum Refining, Gaseous Fuels: Emission trend and share for CO_2

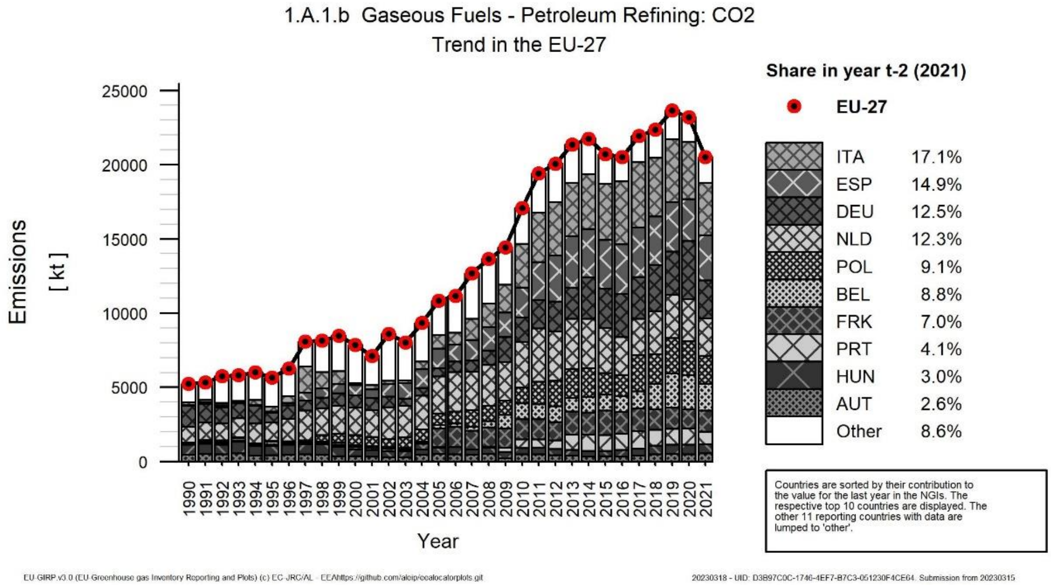
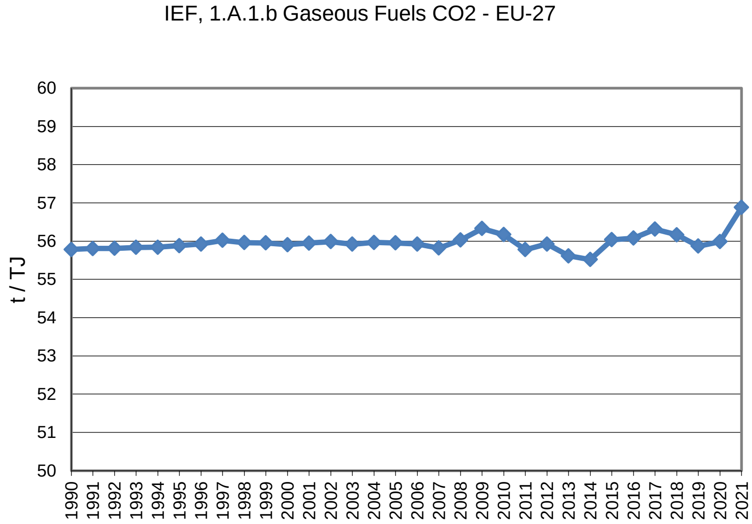
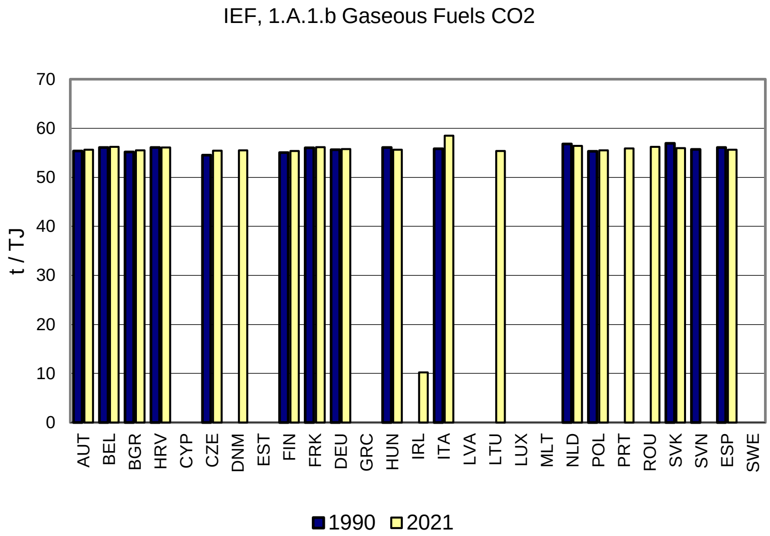


Figure 3.23 (on the next page) shows the implied emission factors for CO_2 emissions from gaseous fuels. The EU implied emission factor has remained broadly stable around 56 t/TJ on the entire time-series with a peak to 56.9 t/TJ in 2021 which remains in the IPCC range. The very low IEF from Ireland is due to inconsistencies between CO_2 emissions originating from ETS data and activity data derived from the energy balance which aggregates different types of gases. This impacts only the IEF as total fuel reported under ETS is very similar to total fuel reported in the energy balance.

Figure 3.23 1.A.1.b Petroleum Refining, Gaseous Fuels: Implied Emission Factors for CO_2





3.2.1.3 Manufacture of Solid Fuels and Other Energy Industries (1.A.1.c) (EU)

According to the 2006 IPCC guidelines, the manufacture of solid fuels and other energy industries includes combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. It comprises combustion emissions from the production of coke, brown coal briquettes and patent fuel. It can also cover the emissions from own-energy use in coal mining and gas extraction. Emissions from own on-site fuel use should be included. In addition, this category includes emissions from fuel combustion in oil and natural gas production.

Total emissions from this category accounted for 0.9 % of total EU greenhouse gas emissions in 2021. Between 1990 and 2021, CO_2 emissions fell by 70 % in the EU (Table 3.15). Germany, Italy and Poland together are responsible for 55.8 % of the total EU emissions in 2021. Germany is responsible for 80 % of the whole decrease in this category between 1990 and 2021.

Table 3.15 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Countries' contributions to CO_2 emissions

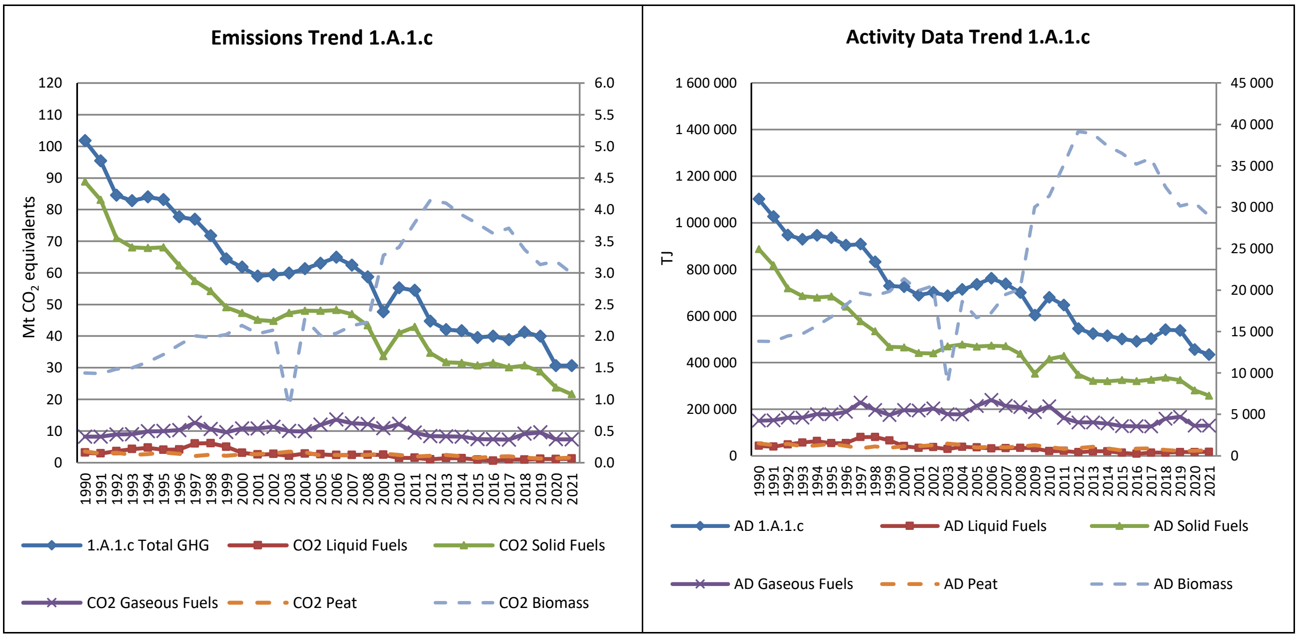
Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	510	289	354	1.2%	-156	-31%	64	22%	T2	CS
Belgium	2 024	140.71	160	0.5%	-1 864	-92%	19	14%	T3	PS
Bulgaria	362	2	2	0.0%	-360	-99%	0	14%	T2	CS
Croatia	912	202	237	0.8%	-675	-74%	35	17%	T1	D
Cyprus	NO	19	NO	-	-	-	-19	-100%	T1	D
Czechia	1 516	4 209	1 260	4.2%	-256	-17%	-2 949	-70%	T1,T2	CS,D
Denmark	530	902	894	3.0%	363	69%	-8	-1%	T2,T3	CS,PS
Estonia	78	1 560	1 545	5.1%	1 467	1872%	-14	-1%	T3	PS
Finland	347	271	329	1.1%	-18	-5%	58	21%	T3	CS
France	4 738	2 101	2 160	7.1%	-2 578	-54%	59	3%	T2	CS
Germany	65 289	9 215	8 645	28.6%	-56 644	-87%	-569	-6%	CS	CS
Greece	102	34	26	0.1%	-76	-75%	-8	-24%	T2	PS
Hungary	570	294	265	0.9%	-305	-54%	-29	-10%	T1,T2,T3	CS,D,PS
Ireland	100	92	80	0.3%	-20	-20%	-11	-12%	T3	CS
Italy	12 454	3 844	4 654	15.4%	-7 800	-63%	810	21%	T3	CS
Latvia	205	48	53	0.2%	-152	-74%	4	9%	T2	CS
Lithuania	9	66	43	0.1%	34	362%	-23	-35%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	2 110	2 551	2 442	8.1%	331	16%	-109	-4%	T2	CS,D
Poland	4 846	3 191	3 574	11.8%	-1 272	-26%	383	12%	T1,T2	CS,D
Portugal	141	NO	NO	-	-141	-100%	-	-	NA	NA
Romania	146	1 164	1 236	4.1%	1 090	746%	72	6%	T1,T2,T3	CS,D,PS
Slovakia	1 319	977	1 084	3.6%	-235	-18%	106	11%	T2	CS
Slovenia	82	0	0	0.0%	-82	-100%	0	107%	T2	CS
Spain	2 089	749	892	2.9%	-1 197	-57%	143	19%	T1,T2	CS,D,PS
Sweden	300	360	327	1.1%	27	9%	-33	-9%	T2	CS
EU-27	**100 783**	**32 280**	**30 262**	**100%**	**-70 521**	**-70%**	**-2 018**	**-6%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Figure 3.24 shows the trends in emissions from this source category by fuel in the EU between 1990 and 2021. The largest share of greenhouse gas emissions from the manufacture of solid fuels can be accounted to CO_2 emissions from solid (70.6 %) and gaseous (23.9 %) fuels. Emissions from solid fuels fell markedly during the 1990s and then stabilized for a few years. Since 2006 they began to decrease again. The strong drop in 2009 was due to the drop-in coke production associated with the iron and steel production triggered by the economic downturn.

Fuel used for manufacturing solid fuels fell by 60.6 % in the EU between 1990 and 2021. The strongest decline was reported for solid fuels (-70.9 %), followed by liquid fuels (-59.7 %). Only biomass consumptions increased in the period from 1990 to 2021. Germany is responsible for the increase in energy use and emissions from biomass (according to the energy balance of Germany, biomass mainly consists of biogas that is used in gasification plants). In the year 2021, solid fuels and gaseous fuels represented 59.5 % and 29.8 % respectively of all fuel used. Biomass consumptions represent 6.7 % of fuel consumptions. Almost no other fossil fuels and peat are used in this category; together accounting for less than 0.2 % of the total fuel used in 2021.

Figure 3.24 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Total and CO_2 emission and activity trends



Note: Data displayed as dashed line refers to the secondary axis.

1.A.1.c Manufacture of Solid Fuels and Other Energy Industries – Solid Fuels (CO_2)

CO_2 emissions from the combustion of solid fuels used for the manufacture of solid fuels accounted for 70.6 % of total greenhouse gas emissions from 1.A.1.c in 2021. Emissions in the EU declined by 76% since 1990. This was mainly driven by a strong decline in emissions in Germany (-53 665 kt CO_2), which amounts to about 80 % of the total decline in this category.

Table 3.16 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries, Solid Fuels: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	IE	IE	IE	-	-	-	-	-	NA	NA
Belgium	2 017	141	160	1%	-1 857	-92%	19	14%	T3	PS,NA
Bulgaria	274	0	0	0%	-274	-100%	0	-49%	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	-	-
Czechia	1 352	4 188	1 245	6%	-107	-8%	-2 943	-70%	T2	CS,D
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	78	1 560	1 545	7%	1 467	1872%	-14	-1%	-	-
Finland	347	271	329	2%	-18	-5%	58	21%	T3	CS,NA
France	4 054	2 101	2 160	10%	-1 894	-47%	59	3%	-	-
Germany	61 101	7 921	7 436	34%	-53 665	-88%	-485	-6%	CS	CS
Greece	NO	NO	NO	-	-	-	-	-	NA	NA
Hungary	220	148	142	1%	-78	-36%	-6	-4%	T1,T2	D,PS
Ireland	NO	NO	NO	-	-	-	-	-	-	-
Italy	10 891	2 891	3 646	17%	-7 245	-67%	755	26%	-	-
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	-	-
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	916	1 144	1 151	5%	235	26%	7	1%	T2	CS
Poland	4 009	1 847	2 139	10%	-1 871	-47%	292	16%	T1,T2	CS,D
Portugal	91	NO	NO	-	-91	-100%	-	-	NA	NA
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	1 319	947	1 046	5%	-272	-21%	100	11%	T2	CS
Slovenia	37	NO	NO	-	-37	-100%	-	-	NA	NA
Spain	1 809	207	294	1%	-1 515	-84%	87	42%	T1,T2	D,PS
Sweden	300	360	327	2%	27	9%	-33	-9%	T2	CS
EU-27	**88 816**	**23 724**	**21 620**	**100%**	**-67 196**	**-76%**	**-2 104**	**-9%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Note: Austria includes the emissions from 1.A.1.c Solid fuels (occurring in coke ovens) in 1.A.2.a Iron and Steel Industries.

Table 3.16 also shows that than 96.4 % of EU emissions are calculated using higher tier methods. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels (for example hard coal and lignite) and use default emission factors for fuels of minor importance (for example brown coal briquettes). Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

Solid fuels have fallen steadily to one third of the 1990 levels. The decline in emissions (see Figure 3.25 below) in Germany is mainly due to a large decline in lignite production in the 1990s. Lignite use decreased strongly in the new German Länder from usage levels of the industry of the former GDR. From raw lignite, a range of refined products used to be produced for industry, households and small commercial operations. A comprehensive transition from lignite to other fuels then took place until the end of the 1990s. The three largest emitters in 2021 were Germany, Italy and France jointly responsible for 61.3 % of all EU emissions in this category.

Figure 3.25 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries, Solid Fuels: Emission trend and share for CO_2

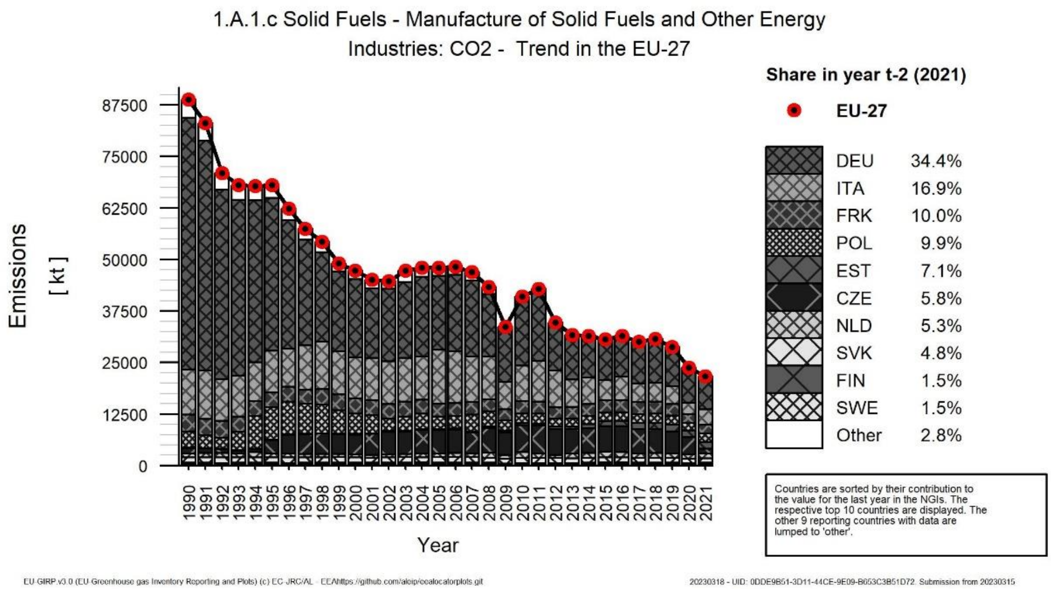
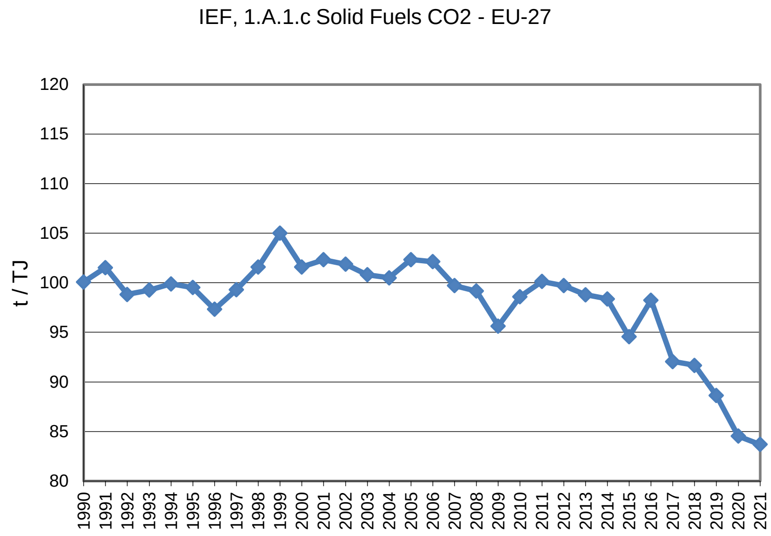
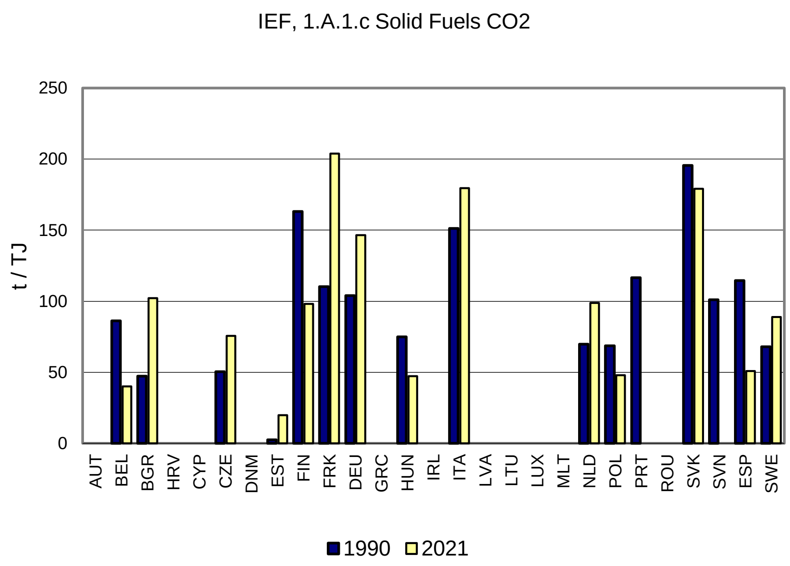


Figure 3.26 shows the relevant implied emission factors for solid fuels. The EU implied emission factor amounted to 83.7 t/TJ in 2021: it is the lowest of the entire time-series.

In general, the variation can be explained by the mix of different fuels and the shifts of their energy consumptions between years. The high implied emission factor for solid fuels in Slovakia and France can be explained with their use of blast furnace gas. Alike, the high implied emission factor for solid fuels in Italy is due to the large use of derived steel gases and in particular blast furnace gas to produce electricity in the iron and steel plant plants. Estonia has a low IEF, because the EF is calculated by using the carbon balance of the shale oil plant. The measured results are provided by the oil plants to the Estonian Ministry of Environment. To calculate the amount of carbon in flue gases into the atmosphere the carbon in the oil shale is subtracted from the carbon of shale oil, semi-coke gas, gasoil and black ash.

Figure 3.26 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries, Solid Fuels: Implied Emission Factors for CO_2





1.A.1.c Manufacture of Solid Fuels and Other Energy Industries – Gaseous Fuels (CO_2)

CO_2 emissions from the combustion of gaseous fuels used in category 1.A.1.c accounted for 23.9 % of total greenhouse gas emissions from this category in 2021. Emissions in the EU decreased by 11 % (Table 3.17 below) between the years 1990 and 2021. After a strong increase in the 1990s and stabilisation in the 2000s there has been a significant reduction in the last few years. The top three countries (Netherlands, Poland and Germany) together account for 52 % of emissions in this category.

Table 3.17 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries, Gaseous Fuels: Countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	506	289	354	5%	-153	-30%	64	22%	T2	CS
Belgium	3	NO	NO	-	-3	-100%	-	-	NA	NA
Bulgaria	NO	1	2	0%	2	∞	1	43%	T2	CS
Croatia	875	202	237	3%	-638	-73%	35	17%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	-	-
Czechia	NO	6	6	0%	6	∞	0	-5%	T2	CS
Denmark	525	877	878	12%	353	67%	1	0%	T3	CS,PS
Estonia	IE	IE	IE	-	-	-	-	-	-	-
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	531	NO	NO	-	-531	-100%	-	-	-	-
Germany	2 622	1 284	1 197	16%	-1 425	-54%	-87	-7%	CS	CS
Greece	102	34	26	0%	-76	-75%	-8	-24%	T2	PS
Hungary	311	145	123	2%	-188	-60%	-22	-15%	T3,T2	PS,CS
Ireland	IE	22	5	0%	5	∞	-17	-79%	-	-
Italy	621	953	1 008	14%	388	62%	55	6%	-	-
Latvia	105	27	29	0%	-76	-72%	2	7%	T2	CS
Lithuania	NO	53	32	0%	32	∞	-21	-39%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	-	-
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	1 184	1 407	1 290	18%	106	9%	-116	-8%	T2	CS
Poland	684	1 247	1 348	18%	663	97%	100	8%	T2	CS
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	NO	245	172	2%	172	∞	-73	-30%	T2,T3	CS,PS
Slovakia	NO	31	37	1%	37	∞	7	21%	T2	CS
Slovenia	42	0	0	0%	-42	-99%	0	107%	T2	CS
Spain	89	535	589	8%	500	559%	54	10%	T2	D,CS
Sweden	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
EU-27	**8 199**	**7 359**	**7 334**	**100%**	**-865**	**-11%**	**-26**	**0%**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'.

Note: Estonia includes the emissions from 1.A.1.c in 1A1a.
Sweden includes emissions from 1.A.1.c in 1.A.2.g

Table 3.17 also shows that about 95.6 % of EU emissions are calculated using higher tier methods. Many countries are using country specific information from the EU ETS and apply default emission factors for emissions that are not covered by the EU ETS. Similarly, countries may use country specific emission factors for the most common fuels (for example hard coal and lignite) and use default emission factors for fuels of minor importance (for example brown coal briquettes). Therefore, countries might use apparently contradicting information such as "T1, T2" for Methods used and "CS, D" for Emission Factors applied. In such cases we assumed, that 90 % of emissions are calculated using a higher tier method and 10 % of emissions are calculated using the tier 1 method. When countries have reported country specific methods and emission factors it has been assumed, that a higher tier method has been used.

Figure 3.27 illustrates the emission trend for gaseous fuels split by countries over the last 31 years. Although the emissions in the year 2021 compared to 1990 decreased by 11 % over the whole time series, there was a strong increase in the 1990s and a decline after 2009.

Figure 3.27 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries, Gaseous Fuels: Emission trend and share for CO_2

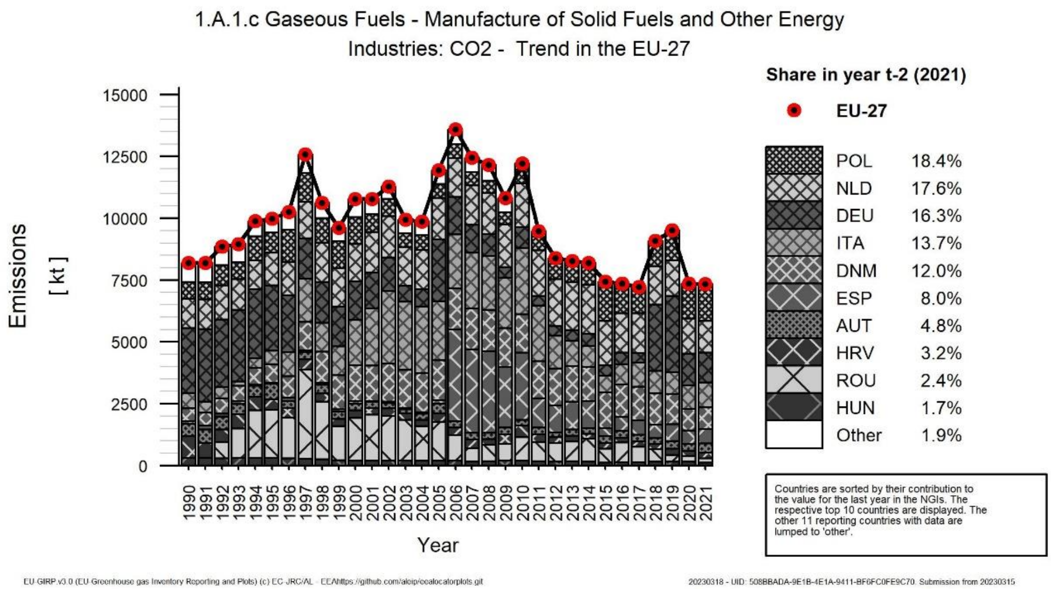
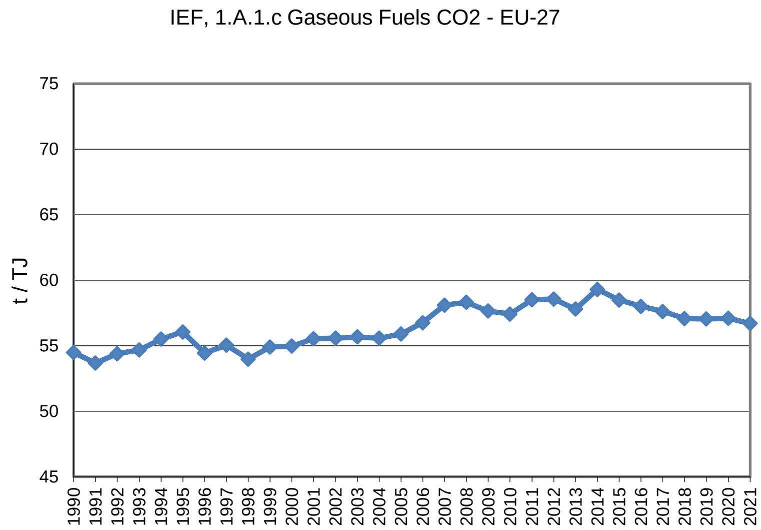
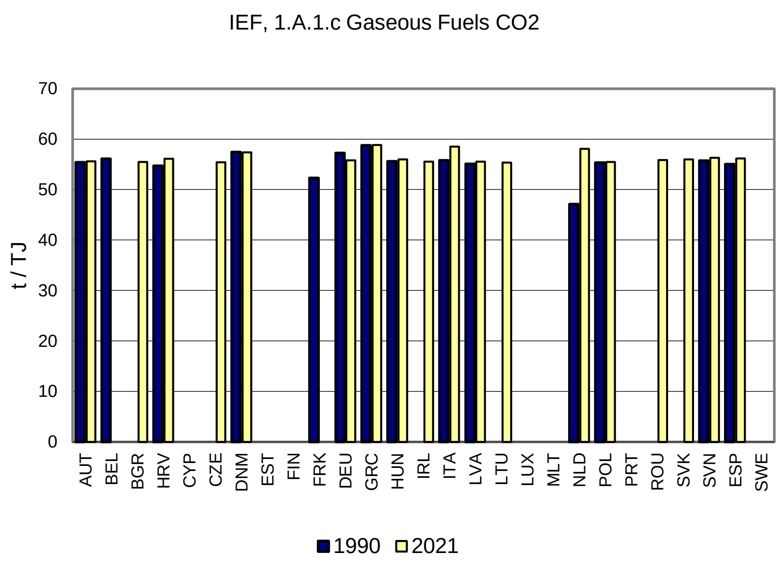


Figure 3.28 (on the next page) shows the implied emission factors for gaseous fuels. The EU implied emission factor amounts 56.7 t/TJ in 2021 and varies between 55 and 59 t/TJ over the last 31 years. The IPCC default values range between 54.3 t/TJ (lower) and 58.3 t/TJ (upper).

Figure 3.28 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries, Gaseous Fuels: Implied Emission Factors for CO_2





3.2.2 Manufacturing industries and construction (CRF Source Category 1.A.2.)

Category 1A2 includes emissions from combustion of fuels in manufacturing industries and construction including fuel use of non-public electricity and heat generation (auto producers). According to the guidelines, emissions from fuel combustion in coke oven plants are reported under 1.A.1.c. Austria reports emissions from onsite coke ovens of integrated iron and steel plants under category 1.A.2.a. Some MS report emissions of blast furnace and coke oven gas combustion under categories 1.A.1.a public electricity and heat production or 1.A.4 other sectors and some MS are reporting emissions from refinery gas under 1.A.2. Emissions from category 1.A.2 are specified by the sum of subsectors that correspond to the International Standard Industrial Classification of All Economic Activities (ISIC, see listing below). Emissions from transport used by industry are reported under category 1.A.3 Transport. Most countries report emissions arising from off-road and other mobile machinery used in industry (e.g. construction machinery) under category 1.A.2.g. Emissions from non-energy fuel use (e.g. reducing agents used in blast furnaces or natural gas used for ammonia production) should be reported under category 2 Industrial Processes.

The following enumeration shows the correspondence of 1A2 subcategories and ISIC Rev 3.1 codes:

- 1 A 2 a Iron and Steel: ISIC Group 271 and Class 2731.
- 1 A 2 b Non-Ferrous Metals: ISIC Group 272 and Class 2732.
- 1 A 2 c Chemicals: ISIC Division 24.
- 1 A 2 d Pulp, Paper and Print: ISIC Divisions 21 and 22
- 1 A 2 e Food Processing, Beverages and Tobacco: ISIC Divisions 15 and 16.
- 1 A 2 f Non-metallic Minerals: ISIC Division 26
- 1 A 2 g Other manufacturing industries: ISIC Divisions 17 to 20, 25, 28 to 37 and 45.

The following table shows the share of specific tier methods used for each 1.A.2 category emission estimates. It can be seen that most countries use Tier 2 methodology for emission estimates.

*Table 3.18**:** Share of Tier methods for 1.A.2 by type of reported method and method combinations.*

Methods and method combinations	Share of emissions which are estimated by the specific Tier method'
CS	12.7%
T1	5.9%
T1,T2	14.0%
T1,T3	4.0%

T2	35.2%
T2,T3	7.9%
T3	4.0%
T1,T2,T3	6.0%
CS,T1	8.9%
CS,T1,T3	0.0%
Other combination	0.0%

Information about methodology used by countries for calculating emissions from category 1.A.2.g is not included in submission files for specific fuels but only as overall methodology information.

Table 3.19: Key categories for sector 1.A.2. (Table excerpt)

Source category gas	kt CO_2 equivalent		Trend	Level		Share of higher Tiers [%]
	1990	2021		1990	2021	
1.A.2.a Iron and Steel: Gaseous Fuels (CO_2)	29392	17973	0	L	L	99.79
1.A.2.a Iron and Steel: Liquid Fuels (CO_2)	8753	882	T	L	0	99.00
1.A.2.a Iron and Steel: Solid Fuels (CO_2)	112412	60381	T	L	L	99.95
1.A.2.b Non-Ferrous Metals: Gaseous Fuels (CO_2)	3013	7496	T	0	L	95.78
1.A.2.c Chemicals: Gaseous Fuels (CO_2)	50492	39145	T	L	L	99.42
1.A.2.c Chemicals: Liquid Fuels (CO_2)	36118	21347	T	L	L	92.63
1.A.2.c Chemicals: Solid Fuels (CO_2)	11972	9021	0	L	L	99.97
1.A.2.d Pulp, Paper and Print: Gaseous Fuels (CO_2)	11115	18452	T	L	L	92.81
1.A.2.d Pulp, Paper and Print: Liquid Fuels (CO_2)	10783	1710	T	L	0	92.06
1.A.2.d Pulp, Paper and Print: Solid Fuels (CO_2)	6770	1882	T	0	0	96.13
1.A.2.e Food Processing, Beverages and Tobacco: Gaseous Fuels (CO_2)	15813	29679	T	L	L	97.49
1.A.2.e Food Processing, Beverages and Tobacco: Liquid Fuels (CO_2)	17725	2593	T	L	0	68.80
1.A.2.e Food Processing, Beverages and Tobacco: Solid Fuels (CO_2)	11536	3785	T	L	0	95.46
1.A.2.f Non-metallic minerals: Gaseous Fuels (CO_2)	27662	34005	T	L	L	99.05
1.A.2.f Non-metallic minerals: Liquid Fuels (CO_2)	45759	20068	T	L	L	96.29
1.A.2.f Non-metallic minerals: Other Fuels (CO_2)	1438	14429	T	0	L	69.43
1.A.2.f Non-metallic minerals: Solid Fuels (CO_2)	52433	13887	T	L	L	95.98
1.A.2.g Other Manufacturing Industries and Constructions: Gaseous Fuels (CO_2)	79637	79482	T	L	L	98.34
1.A.2.g Other Manufacturing Industries and Constructions: Liquid Fuels (CO_2)	82994	35833	T	L	L	98.34
1.A.2.g Other Manufacturing Industries and Constructions: Other Fuels (CO_2)	2451	4481	T	0	0	98.34
1.A.2.g Other Manufacturing Industries and Constructions: Solid Fuels (CO_2)	90752	11653	T	L	L	98.34

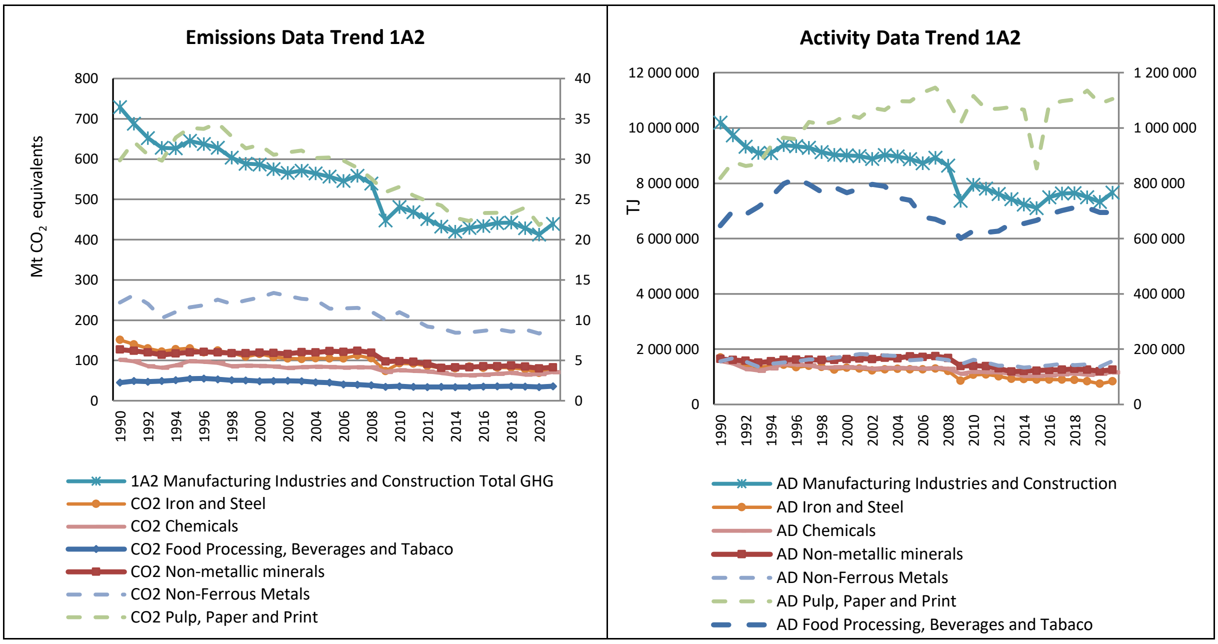
In 2021, category 1.A.2 contributed to 439 540 kt CO_2 equivalents of which 98.7% share belongs to CO_2 emissions, 0.8% to N_2O emissions and 0.5% to CH_4 emissions.

Figure 3.29 shows the emission trends within source category 1.A.2, which is dominated by CO_2 from category 1.A.2.g Other which contributes to total kt CO_2 equivalents emissions by 30.4% followed by 1.A.2.f Non-metallic Minerals contributing by 19.2%, 1.A.2.a Iron and steel contributing by 18.1%, 1.A.2.c Chemicals by 16.3%, 1.A.2.e Food processing, beverages and tobacco by 8.4%, 1.A.2.d Pulp, paper and print by 5% and 1.A.2.b Non-ferrous metals by 2%. Some Member States do not allocate emissions to all sub-categories under 1.A.2., which is one reason for 1.A.2.g being the largest sub-category within 1.A.2 source category.

Greece reports the rest of industrial sector emissions in category 1.A.2.f instead of category 1.A.2.g for whole time series. Germany reports some fuels of subcategories 1.A.2.a-1.A.2.e as included elsewhere (Notation key 'IE') and reports the specific emissions and activity data under 1.A.2.g. For the years 2013 to 2021 Sweden makes excessive use of confidential reporting (Notation key 'C'), which implies that sub-categories include emissions without providing detailed fuel specific emissions.

However, all Swedish confidential emissions are included in the total emissions of 1.A.2 and have been included in ‘other fossil fuels’ of the EU inventory.

Figure 3.29: 1.A.2. Manufacturing Industries and Construction: Total and CO_2 emission trends



Data displayed as dashed line refers to the secondary axis.

Table 3.19 summarizes information by countries on GHG emissions and CO_2 emissions from 1.A.2 Manufacturing Industries and Construction in 1990 and 2021. The highest shares on total kt CO_2 equivalents emissions (above the average share calculated for EU) are Germany (29%), Italy (12%), Spain (10.5%), France (10%),Poland (7%) and the Netherlands (6%). Together those countries contribute to 75% of total emissions from 1.A.2.

Table 3.20: 1.A.2. Manufacturing Industries and Construction: Member States contributions to total GHG and CO_2 emissions

Member State	**GHG emissions in kt CO2 equivalents**		**CO2 emissions in kt**	
	1990	**2021**	**1990**	**2021**
Austria	9 609	10 923	9 533	10 792
Belgium	23 527	13 995	23 388	13 841
Bulgaria	17 757	4 573	17 664	4 527
Croatia	5 234	2 430	5 209	2 418
Cyprus	505	531	502	522
Czechia	47 105	12 893	46 824	12 770
Denmark	5 729	3 812	5 666	3 734
Estonia	3 474	399	3 465	394
Finland	13 358	6 409	13 192	6 249
France	65 054	44 255	64 521	43 680
Germany	185 673	126 072	184 187	124 987
Greece	9 400	4 825	9 338	4 780
Hungary	13 398	5 211	13 364	5 160
Ireland	4 065	4 624	4 047	4 604
Italy	92 150	53 863	90 772	52 791
Latvia	3 965	656	3 910	604
Lithuania	6 158	1 275	6 106	1 257
Luxembourg	6 244	1 194	6 229	1 171
Malta	53	54	53	54
Netherlands	35 474	27 830	35 362	27 716
Poland	42 831	30 106	42 621	29 829
Portugal	9 002	7 335	8 855	7 166
Romania	54 108	14 511	53 970	14 439
Slovakia	16 095	7 032	16 027	6 983
Slovenia	3 095	1 733	3 066	1 710
Spain	45 201	46 697	44 857	45 392
Sweden	10 858	6 301	10 718	6 170
EU-27	**729 125**	**439 540**	**723 448**	**433 740**

Abbreviations explained in the Chapter 'Units and abbreviations'.

1.A.2 Manufacturing Industries and Construction is the fourth largest sector in the EU accounting for 16% of total GHG emissions from Energy sector in 2021. Between 1990 and 2021, CO_2 emission,s from 1.A.2. Manufacturing Industries and Construction declined by 66%. Decrease of total emissions is caused by decrease of fossil fuel consumption in category 1.A.2. Manufacturing Industries and Construction.

A shift from solid and liquid fuels to mainly natural gas took place and an increase of biomass CO_2 emissions by 106% and an increase of other fossil fuels CO_2 emissions by 184% have been recorded in 2021 compared to 1990.

Between 1990 and 2021, CO_2 emissions were significantly reduced by Estonia (89%), Latvia (85%), Luxembourg (81%), Lithuania (79%), Bulgaria (74%) and Czechia and Romania (73%) compared to the level of CO_2 emissions in 1990. Only Austria, Cyprus, Ireland, Malta and Spain report emission increases.

The main reason for the decline of emissions in Latvia for 1990 to 2001 could be explained with recession of Soviet Union and following reformations and reorganizations within Latvia after that. Decrease of emissions in 2006 to 2008 were influenced by the features of national economy development when in-country industrial production already started to diminish due to increasing costs of the production and dominance of imported products. Crisis in national economy in the second part of 2008 also caused a significant decrease in total emissions. The main reasons for the large decline in Czechia were the loss of markets and the energy saving behavior of newly privatized enterprises, following the political changes in the country in the early 1990s. Main reasons of the decline in Romania were the transition to a market economy and the reduction of energy intensive activities. The main reason for the decline of emissions in Germany (38%) was the restructuring of the industry and efficiency improvements after German reunification.

3.2.2.1 Iron and Steel (1.A.2.a)

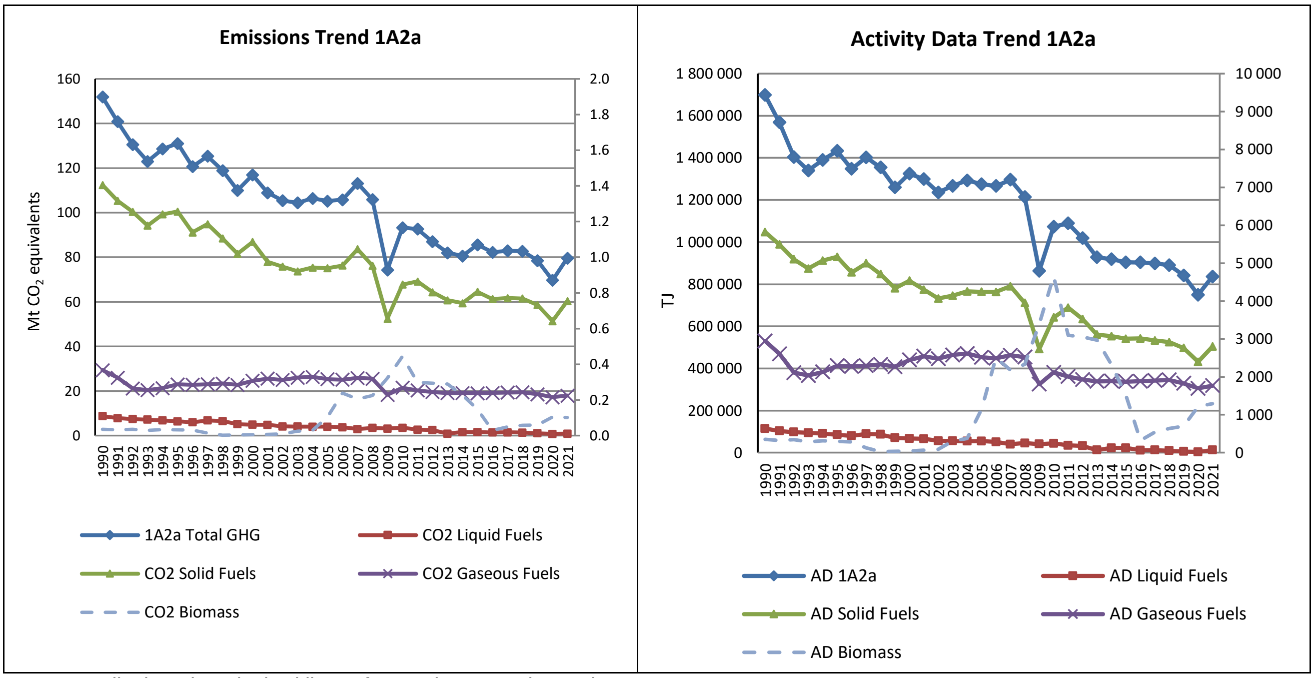
This chapter provides information about European emission trend, Member States contribution to the overall emission trend, activity data and emission factors used for emission estimates by countries for category 1.A.2.a Iron and Steel.

Category 1.A.2.a (more specifically CO_2 emissions from use of gaseous, liquid and solid fuels) was identified as a key category by level and trend and thus the following description focuses only on CO_2 emissions. CO_2 emissions trend and activity data trends can be observed in *Figure 3.30*. Detailed data related to countries CO_2 emissions and percentage differences is depicted in Table 3.21. CO_2 emissions have almost 100% share on total emissions from 1.A.2.a. The strong increase of emissions (17%) observed between 2009 and 2010 correlates with crude steel production which was higher by 24% in 2010. Between 1990 and 2021 CO_2 emissions decreased by 48%. Between 2020 and 2021 CO_2 emissions increased by 14%.

Total CO_2 emissions from 1.A.2.a amounted to 79 248 kt CO_2 eq. in 2021. The trend of total CO_2 emissions for 1990 to 2021 from category 1.A.2.a is depicted in *Figure 3.30*. Total CO_2 emissions decreased by 48% since 1990, mainly due to improved efficiency of restructured iron and steel plants and ongoing consequences of the economic crisis in 2009. Total CO_2 emissions decreased by 14% between 2020 and 2021. CO_2 emissions from 1.A.2.a Iron and Steel accounted for 18% of 1.A.2. source category. The share of liquid fuels on CO_2 emissions from 1.A.2.a decreased from 6% in 1990 to 5.6% in 2021. The share of solid fuels on CO_2 emissions from 1.A.2.a was 76% in 2021 and 73% in 1990. The share of gaseous fuels on CO_2 emissions from 1.A.2.a increased from 21% in 1990 to 23% in 2021.

Almost all countries reported lower level of CO_2 emissions in 2021 compared to 1990 except Germany and Slovakia. Highest shares on total EU emissions concern Germany (48%) followed by Italy (12%), the Netherlands (5.6%), France (5.3%) and Poland (5.2%). Most rapid decrease of emissions compared to 1990 can be observed for Latvia (100%), Ireland (99%), Croatia and Bulgaria (95%), Luxembourg and Hungary (94%) and Romania (90%). Emissions are reported as ‘NO’ (not occurring) for Cyprus, Lithuania and Malta.

Figure 3.30: 1.A.2.a Iron and Steel: CO_2 emissions and activity data trends



Data displayed as dashed line refers to the secondary axis.

Table 3.21: 1.A.2.a Iron and Steel: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 833	1 803	1 774	2.2%	-59	-3%	-29	-2%	T1,T2	CS,D
Belgium	5 662	1 239.17	1 251	1.6%	-4 410	-78%	12	1%	T1,T3	D,PS
Bulgaria	2 705	115	123	0.2%	-2 582	-95%	9	7%	T2	CS
Croatia	1 062	34	56	0.1%	-1 006	-95%	23	67%	T1	D
Cyprus	NO,IE	0	NO	-	-	-	0	-100%	NA	NA
Czechia	14 861	1 886	2 111	2.7%	-12 750	-86%	225	12%	T1,T2	CS,D
Denmark	136	90	95	0.1%	-41	-30%	5	5%	T1,T2,T3	CS,D
Estonia	NO	0	1	0.0%	1	∞	0	53%	T2	CS
Finland	2 499	809	890	1.1%	-1 609	-64%	80	10%	T3	CS,PS
France	8 511	3 844	4 223	5.3%	-4 288	-50%	379	10%	T2,T3	CS,PS
Germany	35 269	32 259	37 835	47.7%	2 566	7%	5 577	17%	CS	CS
Greece	447	94	116	0.1%	-331	-74%	22	23%	T2	CS,PS
Hungary	2 490	173	146	0.2%	-2 344	-94%	-26	-15%	T1,T2	CS,D
Ireland	175	2	2	0.0%	-173	-99%	0	0%	T2	CS
Italy	25 255	8 005	9 590	12.1%	-15 665	-62%	1 585	20%	T2	CS
Latvia	389	0	0	0.0%	-389	-100%	0	14%	T2	CS
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	5 393	266	308	0.4%	-5 084	-94%	42	16%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	5 599	4 259	4 400	5.6%	-1 198	-21%	141	3%	T2	CS
Poland	16 247	3 703	4 103	5.2%	-12 145	-75%	400	11%	T1,T2	CS,D
Portugal	373	98	85	0.1%	-288	-77%	-13	-13%	T2	CR,D,PS
Romania	9 154	891	870	1.1%	-8 284	-90%	-21	-2%	T1,T2,T3	CS,D,PS
Slovakia	2 682	2 179	3 164	4.0%	482	18%	985	45%	T2	CS
Slovenia	423	197	212	0.3%	-211	-50%	15	8%	T1,T2	CS,D
Spain	8 339	6 224	6 548	8.3%	-1 790	-21%	324	5%	T1,T2,T3	CS,D,PS
Sweden	1 706	1 200	1 341	1.7%	-365	-21%	141	12%	T2	CS
EU-27	**151 210**	**69 372**	**79 248**	**100%**	**-71 962**	**-48%**	**9 876**	**14%**	**-**	**-**

Malta includes emissions under 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

1.A.2.a Iron and Steel - Liquid Fuels (CO_2)

CO_2 emissions from the use of liquid fuels in category 1.A.2.a amounted 882 kt in 2021 for EU. CO_2 emissions decreased compared to the year 1990 by 90% and increased by 19% compared to 2020. This category corresponds to 0.2% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 89% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.22. Cyprus, Czechia, Estonia, Hungary, Ireland, Latvia, Lithuania, Luxembourh and Malta report emissions as 'NO' (not occurring). Two Member States use for emission estimates Tier 1 methodology, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 99% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.a – Liquid Fuels (CO_2)). All countries reported lower level of emissions in 2021 than in 1990.

Table 3.22: 1.A.2.a Iron and Steel, liquid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	76	7	20	2.3%	-56	-74%	13	189%	T2	CS
Belgium	885	12.69	16	1.8%	-869	-98%	3	26%	T1,T3	D,PS
Bulgaria	37	1	1	0.1%	-37	-98%	0	28%	NA	NA
Croatia	208	4	7	0.8%	-201	-97%	3	69%	T1	D
Cyprus	IE	0	NO	-	-	-	0	-100%	NA	NA
Czechia	427	NO	NO	-	-427	-100%	-	-	NA	NA
Denmark	25	4	7	0.8%	-18	-72%	3	82%	T1,T2	CS,D
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	305	20	20	2.3%	-285	-93%	0	0%	T3	CS
France	1 455	88	104	11.8%	-1 351	-93%	16	18%	T2,T3	CS,PS
Germany	916	12	12	1.3%	-904	-99%	0	-3%	CS	CS
Greece	447	28	30	3.4%	-417	-93%	1	5%	T2	PS
Hungary	553	NO	NO	-	-553	-100%	-	-	NA	NA
Ireland	16	NO	NO	-	-16	-100%	-	-	NA	NA
Italy	156	2	14	1.6%	-142	-91%	12	657%	T2	CS
Latvia	92	NO	NO	-	-92	-100%	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	37	NO	NO	-	-37	-100%	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	19	9	10	1.1%	-9	-49%	1	6%	NA	NA
Poland	870	14	15	1.7%	-855	-98%	1	10%	T1,T2	CS,D
Portugal	109	0	0	0.0%	-109	-100%	0	-4%	T2	CR,D,PS
Romania	NO	1	1	0.2%	1	∞	0	41%	T1,T2,T3	CS,D,PS
Slovakia	164	1	3	0.3%	-161	-98%	2	138%	T2	CS
Slovenia	54	2	2	0.2%	-52	-96%	0	-6%	T1	D
Spain	1 069	80	91	10.3%	-977	-91%	11	14%	T1,T2,T3	CS,D,PS
Sweden	831	454	529	60.0%	-301	-36%	76	17%	T2	CS
EU-27	**8 753**	**739**	**882**	**100%**	**-7 871**	**-90%**	**143**	**19%**	**-**	**-**

Cyprus reports an 'IE' for liquid fuels (included in 1.A.2.b).
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.31 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Sweden (60%), France (12%) and Spain (10%), which together represent 82% share on EU emissions.

Figure 3.31: 1.A.2.a Iron and Steel, Liquid fuels: Emission trend and share for CO_2

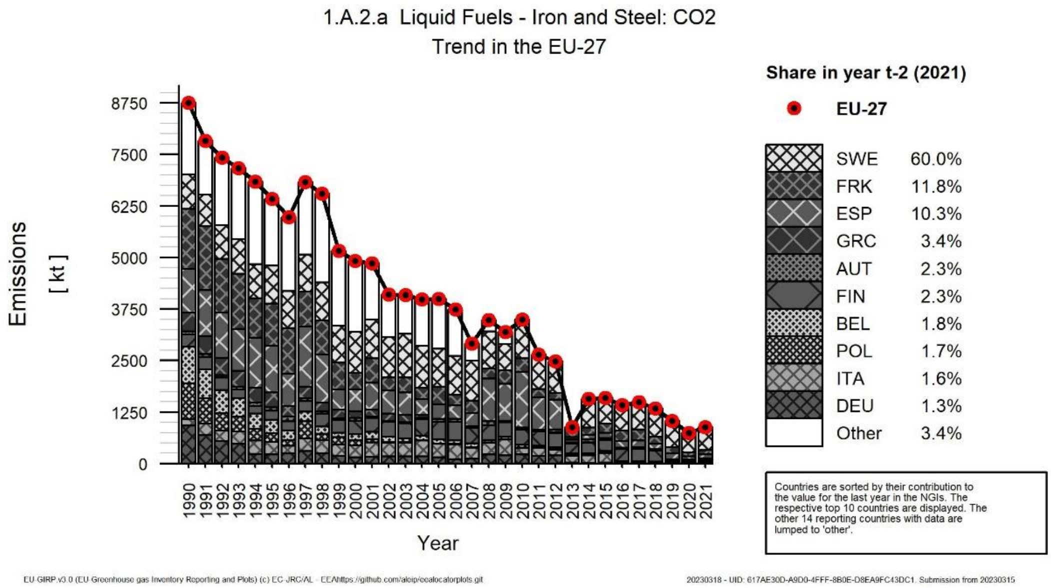
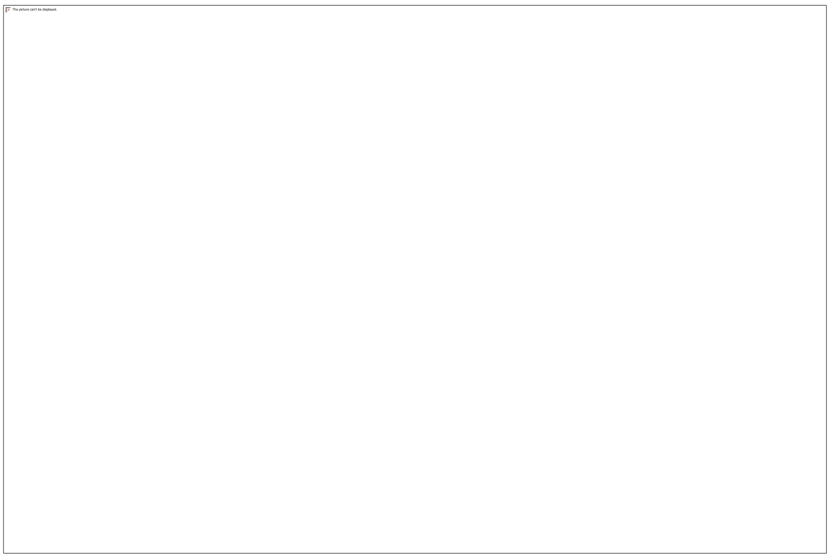


Figure 3.32 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. In the graph, data from Sweden aren't included due to reported confidential data. Nevertheless, Swedish emissions are included in the calculation of IEF in EU CRF.

The high CO_2 IEF reported for 2008–2012 is mainly due to the contribution of Spain's CO_2 emissions to the EU total (up to 5% between 2007 and 2008) and its high CO_2 IEF (ranging from 92.4 to 96.1 t/TJ) for those years. The EU CO_2 IEF equaled 73.6 t/TJ in 2021 excluding Sweden.

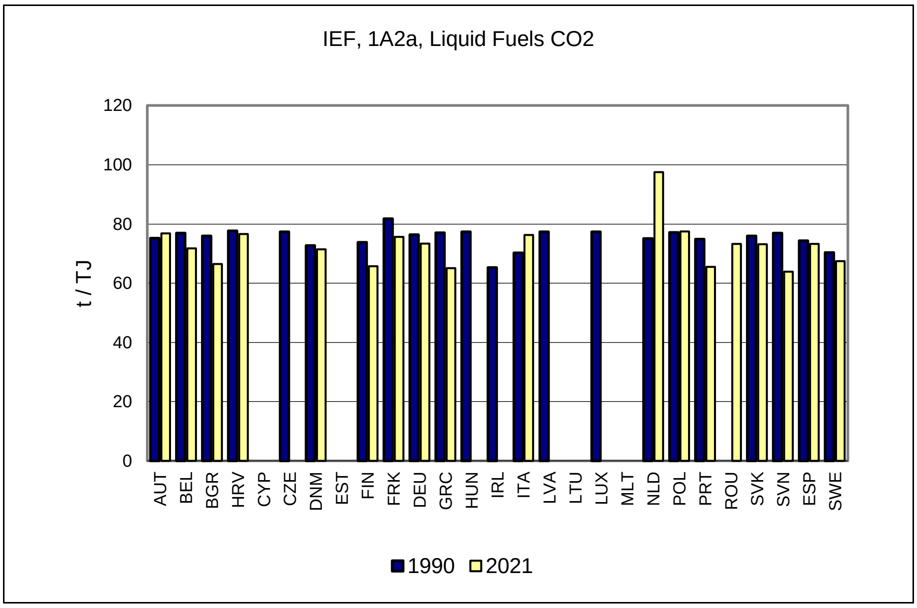
Figure 3.32: 1.A.2.a Iron and Steel, Liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)



Note: The EU IEF for CO_2 emissions of category 1.A.2.a. liquid fuels displayed in this graph does not include data from SWE due to reported confidential data.

Figure 3.33 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. For the year 2021, Sweden reports activity data as C ('confidential') and thus CO_2 IEF is not depicted in Figure 3.33.

Figure 3.33: 1.A.2.a Iron and Steel, Liquid fuels: Implied Emission Factors for CO_2 by Member States and Iceland (in t/TJ)



1.A.2.a Iron and Steel - Solid Fuels (CO_2)

CO_2 emissions from the use of solid fuels in category 1.A.2.a amounted 60 381 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 46% and decreased compared to 2020 by 17.5%. This category represents 76% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 52% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.23. Cyprus, Denmark, Estonia, Greece, Ireland, Latvia, Lithuania, Luxembourg, Malta and Portugal report emissions as 'NO' (not occurring). Two Member States use Tier 1 methodology for emission estimates, the rest of the Member States use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 99.95% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.a – Solid Fuels (CO_2)). All Member States reported lower level of emissions in 2021 than in 1990 except Germany and Slovakia.

Table 3.23: 1.A.2.a Iron and Steel, solid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 107	715	760	1.3%	-347	-31%	45	6%	T2	CS
Belgium	3 284	15.46	19	0.0%	-3 265	-99%	4	24%	T3	PS
Bulgaria	1 631	0	0	0.0%	-1 631	-100%	0	20%	NA	NA
Croatia	625	4	11	0.0%	-614	-98%	8	219%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	13 709	1 425	1 490	2.5%	-12 219	-89%	65	5%	T2	CS,D
Denmark	5	NO	NO	-	-5	-100%	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	2 084	449	506	0.8%	-1 577	-76%	57	13%	T3	CS,PS
France	4 271	1 815	2 153	3.6%	-2 118	-50%	338	19%	T2,T3	CS,PS
Germany	29 912	29 273	34 903	57.8%	4 991	17%	5 630	19%	CS	CS
Greece	NO	NO	NO	-	-	-	-	-	NA	NA
Hungary	625	46	53	0.1%	-571	-91%	7	15%	T1,T2	CS,D
Ireland	115	NO	NO	-	-115	-100%	-	-	NA	NA
Italy	20 762	4 253	5 462	9.0%	-15 300	-74%	1 209	28%	T2	CS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	4 959	NO	NO	-	-4 959	-100%	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	4 913	3 627	3 720	6.2%	-1 192	-24%	93	3%	T2	CS
Poland	11 870	2 503	2 805	4.6%	-9 065	-76%	302	12%	T1,T2	CS,D
Portugal	264	NO	NO	-	-264	-100%	-	-	NA	NA
Romania	2 599	182	196	0.3%	-2 403	-92%	13	7%	T1,T2	CS,D
Slovakia	2 296	2 024	3 020	5.0%	724	32%	996	49%	T2	CS
Slovenia	57	21	19	0.0%	-38	-66%	-1	-7%	T1	D
Spain	6 475	4 473	4 672	7.7%	-1 803	-28%	199	4%	T1,T2,T3	CS,PS
Sweden	850	558	590	1.0%	-259	-31%	32	6%	T2	CS
EU-27	**112 412**	**51 384**	**60 381**	**100%**	**-52 030**	**-46%**	**8 998**	**18%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.34 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Germany (58%), Italy (9%), Spain (8%) and Netherlands (6%), which together represent 81% share of EU emissions.

Figure 3.34: 1.A.2.a Iron and Steel, solid fuels: Emission trend and share for CO_2

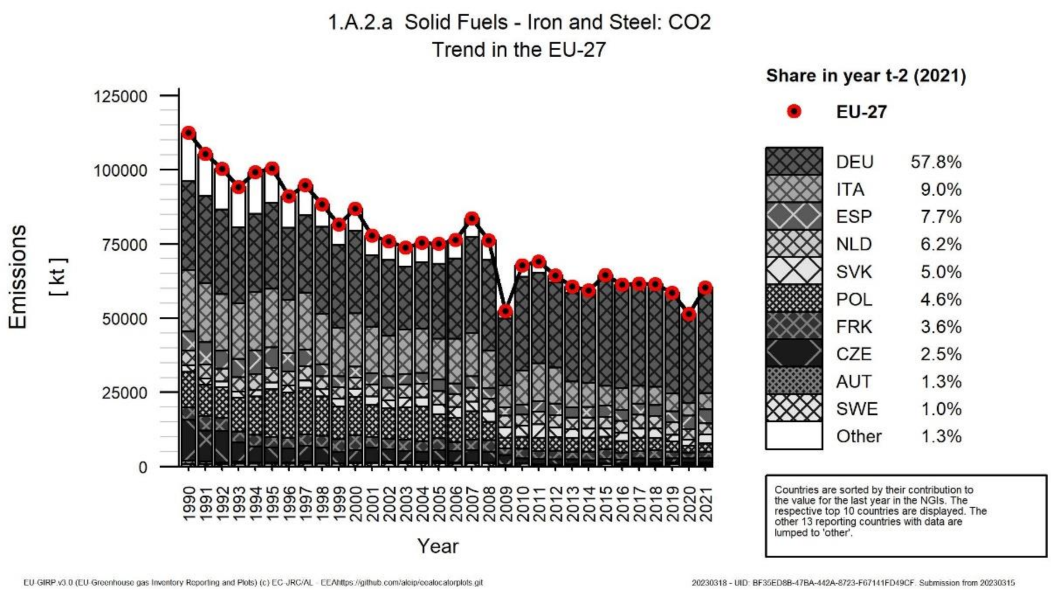


Figure 3.35 shows implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that CO_2 IEF fluctuate during the whole time series. Lowest CO_2 IEF was calculated for year 2011 and since that CO_2 IEF has increasing but still fluctuating trend. The main reason for the increase in the CO_2 IEF between 2012 and 2013 is Italy's decrease in CO_2 emissions. For these years, the share of Germany's CO_2 emissions in the EU total increased from 37% to 40%, and Germany's CO_2 IEF was one of the highest reported, increasing from 155.17 t/TJ in 2012 to 158.47 t/TJ in 2013. CO_2 IEF equalled to 119.86 t/TJ in 2021.

Figure 3.35: 1.A.2.a Iron and Steel, Solid fuels: Implied Emission Factors for CO_2 (in t/TJ)

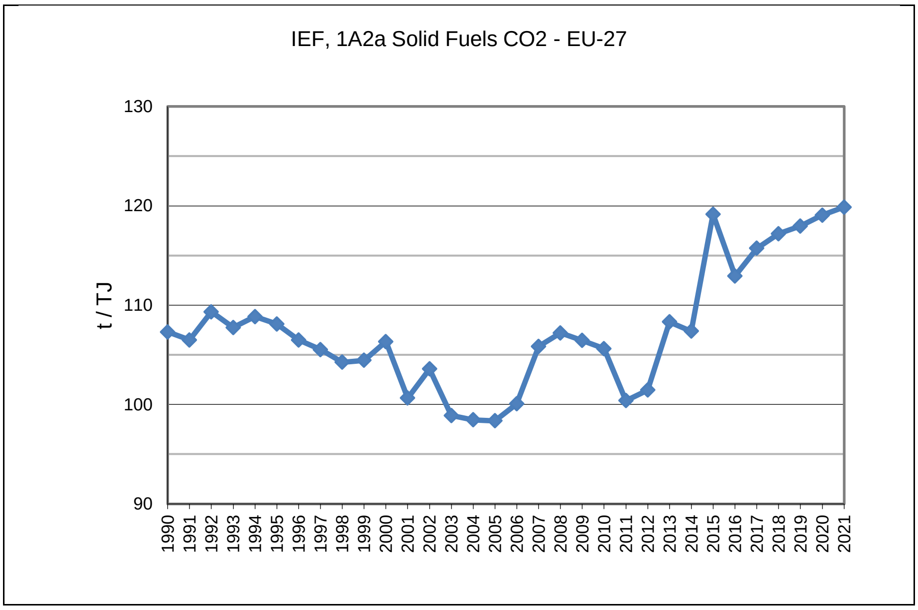
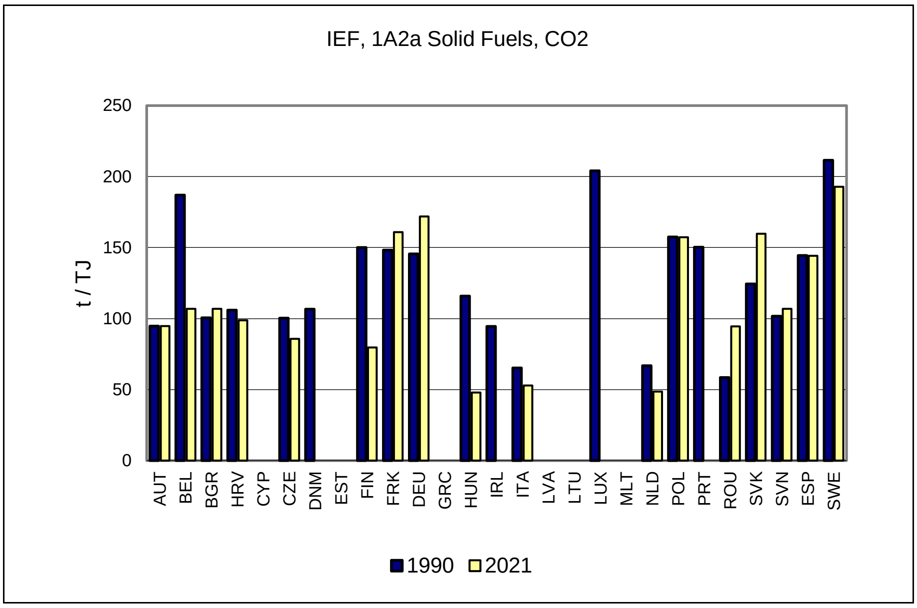


Figure 3.36 shows comparison of CO_2 IEF used by Member States for emission estimates in 1990 and 2021. The high variation of the CO_2 IEFs across MS is due to usage of derived coal gases which have significant lower (coke oven gas) or higher carbon content (blast furnace gas) than coal.

Figure 3.36: 1.A.2.a Iron and Steel, Solid fuels: Implied Emission Factors for CO_2 by Member States and Iceland (in t/TJ)



1.A.2.a Iron and Steel - Gaseous Fuels (CO_2)

CO_2 emissions from the use of gaseous fuels in category 1.A.2.a amounted 17 973 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 39% and decreased compared to 2020 by 4%. This category represents 23% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption increased by 3% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.24. Cyprus, Lithuania and Malta report emissions as 'NO' (not occurring). Croatia uses Tier 1 methodology for emission estimates, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 99.8% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.a – Gaseous Fuels (CO_2)). Austria, Finland, France, Spain and Sweden report higher level of emissions in 2021 than in 1990. Highest increase of emissions (779%) is observed for Sweden with a 1% share on total EU emissions in 2021.

Table 3.24: 1.A.2.a Iron and Steel, gaseous fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	650	1 081	994	5.5%	344	53%	-87	-8%	T2	CS
Belgium	1 493	1 205.81	1 211	6.7%	-282	-19%	5	0%	T1,T3	D,PS
Bulgaria	1 037	114	123	0.7%	-914	-88%	8	7%	T2	CS
Croatia	229	26	38	0.2%	-190	-83%	12	46%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	724	461	621	3.5%	-104	-14%	160	35%	T2	CS
Denmark	106	87	88	0.5%	-18	-17%	2	2%	T3	CS
Estonia	NO	0	1	0.0%	1	∞	0	53%	T2	CS
Finland	110	340	363	2.0%	254	231%	23	7%	T3	CS
France	2 777	1 914	1 961	10.9%	-815	-29%	48	3%	T2,T3	CS,PS
Germany	4 442	2 973	2 921	16.3%	-1 521	-34%	-53	-2%	CS	CS
Greece	NO	66	86	0.5%	86	∞	20	31%	T2	CS
Hungary	1 312	126	93	0.5%	-1 219	-93%	-33	-27%	T2	CS
Ireland	44	2	2	0.0%	-41	-95%	0	0%	T2	CS
Italy	4 338	3 750	4 113	22.9%	-224	-5%	363	10%	T2	CS
Latvia	236	0	0	0.0%	-235	-100%	0	14%	T2	CS
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	397	266	308	1.7%	-89	-22%	42	16%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	667	623	670	3.7%	3	0%	47	8%	T2	CS
Poland	2 924	1 186	1 283	7.1%	-1 641	-56%	96	8%	T2	CS
Portugal	NO	98	85	0.5%	85	∞	-13	-13%	T2	CR,D,PS
Romania	6 556	706	672	3.7%	-5 884	-90%	-34	-5%	T2,T3	CS,PS
Slovakia	221	154	141	0.8%	-80	-36%	-13	-8%	T2	CS
Slovenia	312	174	191	1.1%	-121	-39%	17	10%	T2	CS
Spain	795	1 671	1 785	9.9%	990	125%	113	7%	T2,T3	CS,PS
Sweden	25	188	222	1.2%	196	779%	33	18%	T2	CS
EU-27	**29 392**	**17 214**	**17 973**	**100%**	**-11 419**	**-39%**	**759**	**4%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.37 shows CO_2 emissions trend as well as the share of countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Italy (23%), Germany (16%), France (11%), Spain (10%), Belgium (7%), Poland (7%) and Austria (6%) which together represent 79% share of EU emissions.

Figure 3.37: 1.A.2.a Iron and Steel, Gaseous fuels: Emission trend and share for CO_2

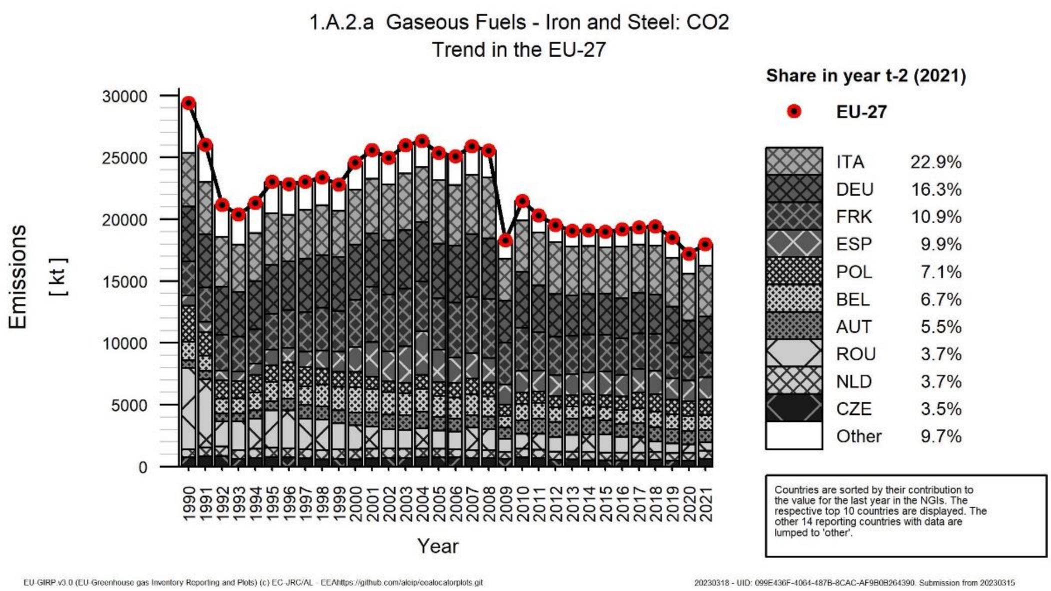


Figure 3.38 shows implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that the CO_2 IEF is fluctuating. The strong increase from 2011 to 2013 is caused by strong increase of Romania IEF in these years. CO_2 IEF equaled to 56.46 t/TJ in 2021.

Figure 3.38: 1.A.2.a Iron and Steel, Gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)

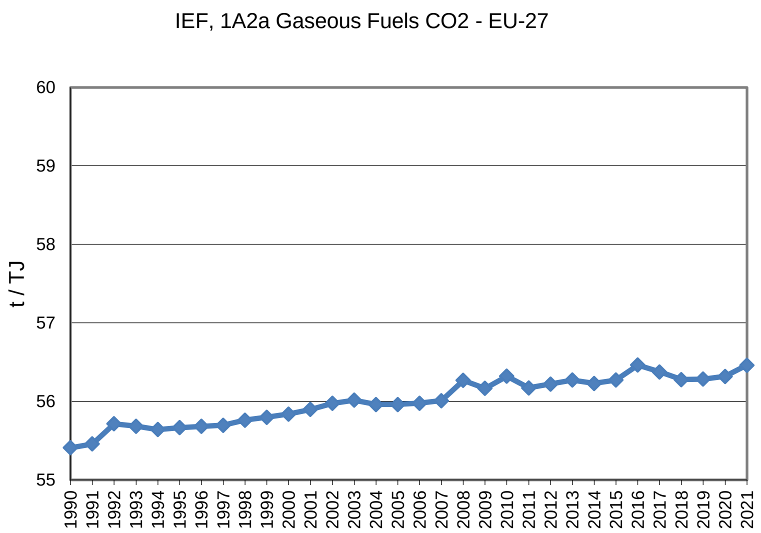
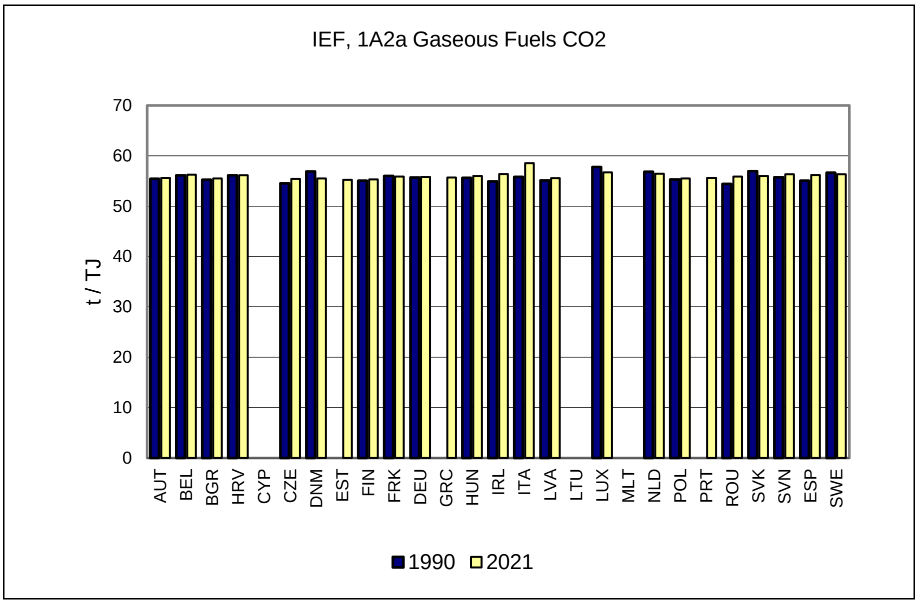


Figure *3.39* shows comparison of implied emission factors (CO_2 IEFs) used by countries for emission estimates in 1990 and 2021. No significant differences between CO_2 IEF used by EU are not occurring as also no significant differences between CO_2 IEF used in 1990 and 2021 are occurring.

Figure 3.39: 1.A.2.a Iron and Steel, Gaseous fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



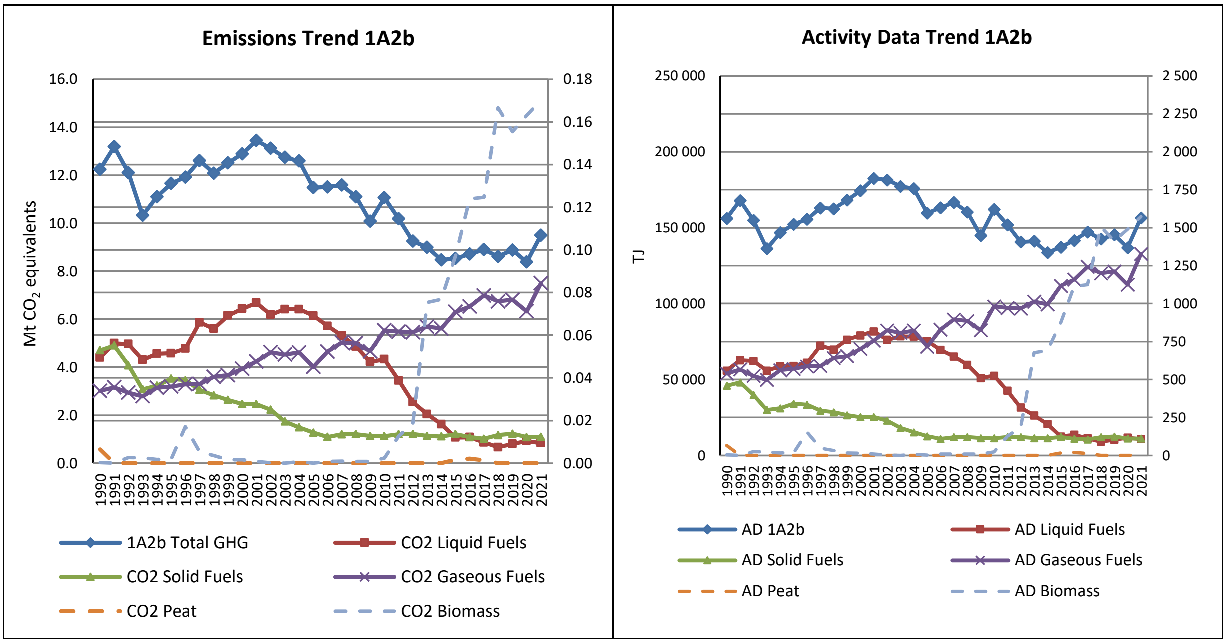
3.2.2.2 Non-Ferrous Metals (1.A.2.b)

This chapter provides information about European emission trend, Member States contribution to the overall emission trend, activity data and emission factors used for emission estimates by countries for category 1.A.2.b Non-Ferrous Metals.

Total CO_2 emissions from 1.A.2.b amounted to 9 431 kt CO_2 eq. in 2021. The trend of total emissions for 1990 to 2021 from category 1.A.2.b is depicted in Figure 3.40. Total CO_2 emissions decreased by 23% since 1990 and increased by 13% between 2020 and 2021. Total CO_2 emissions from 1.A.2.b Non-Ferrous Metals accounted for 2% of 1.A.2. source category.

Figure **3.40** shows the emission trend within the category 1.A.2.b, which is dominated by CO_2 emissions from gaseous fuels in 2021. The share of liquid fuels on CO_2 emissions from 1.A.2.b decreased from 36% in 1990 to 9% in 2021. The share of solid fuels on CO_2 emissions from 1.A.2.b decreased from 39% in 1990 to 12% in 2021. The share of gaseous fuels on CO_2 emissions from 1.A.2.b increased from 25% in 1990 to 79% in 2021.

Figure 3.40: 1.A.2.b Non-ferrous Metals: CO_2 emissions and activity data trends



Data displayed as dashed line refers to the secondary axis.

Detailed data related to the EU submissions are depicted in Table.3.25. Denmark, Lithuania, Malta and Portugal report emissions as 'NO' (not occurring) or 'IE' (included elsewhere). For Portugal, emissions from non-ferrous metals are included in 1.A.2.g Other. Ten Member States reported increase of CO_2 emissions compared to level of emissions in 1990. The highest increase of CO_2 emissions was reported by Romania (408%), with a 4.4% share on total EU emissions in 2021.

Table.3.25: 1.A.2.b Non-ferrous Metals: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	132	268	294	3.1%	162	123%	26	10%	T1,T2	CS,D
Belgium	629	402.70	418	4.4%	-211	-33%	15	4%	T1	D
Bulgaria	299	249	246	2.6%	-53	-18%	-3	-1%	T1,T2	CS,D
Croatia	17	26	30	0.3%	13	77%	5	19%	T1	D
Cyprus	5	3	3	0.0%	-2	-44%	-1	-17%	T1	D
Czechia	102	142	282	3.0%	180	176%	139	98%	T2	CS,D
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	1	0	0.0%	0	∞	-1	-60%	T2	CS
Finland	338	100	81	0.9%	-257	-76%	-19	-19%	T3	CS,D
France	2 472	885	903	9.6%	-1 569	-63%	18	2%	T2,T3	CS,PS
Germany	1 377	157	117	1.2%	-1 260	-92%	-40	-26%	CS	CS
Greece	582	335	674	7.1%	92	16%	339	101%	T2	CS,PS
Hungary	297	152	165	1.7%	-133	-45%	12	8%	T2	CS
Ireland	809	1 323	1 322	14.0%	513	63%	-1	0%	T1,T2,T3	CS,D
Italy	735	1 036	968	10.3%	232	32%	-69	-7%	T2	CS
Latvia	NO	1	1	0.0%	1	∞	0	55%	T2	CS
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	28	43	49	0.5%	20	71%	6	13%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	214	127	150	1.6%	-63	-30%	23	18%	T2	CS
Poland	1 053	1 069	1 095	11.6%	42	4%	26	2%	T1,T2	CS,D
Portugal	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Romania	81	354	413	4.4%	332	408%	59	17%	T1,T2,T3	CS,D,PS
Slovakia	1 256	95	114	1.2%	-1 142	-91%	19	19%	T2	CS
Slovenia	440	117	138	1.5%	-301	-69%	21	18%	T1,T2	CS,D
Spain	1 192	1 354	1 851	19.6%	659	55%	497	37%	T1,T2,T3	CS,D,PS
Sweden	129	107	117	1.2%	-12	-9%	10	10%	T2	CS
EU-27	**12 187**	**8 347**	**9 431**	**100%**	**-2 756**	**-23%**	**1 083**	**13%**	**-**	**-**

Malta and Portugal include emissions under 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

1.A.2.b Non-Ferrous Metals - Liquid Fuels (CO_2)

CO_2 emissions from the use of liquid fuels in category 1.A.2.b amounted 837 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 81% and compared to 2020 by 10%. Category has 0.2% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 78% compared to 1990. The category was not identified as a key category for this submission but it was identified in previous submissions and thus the description of the category is still included in the reporting.

Detailed data related to the EU submissions are depicted in *Table 3.26*. Czechia, Denmark, Estonia, Hungary, Latvia, Lithuania, Luxemburg, Malta and Netherlands report emissions as 'NO' (not occurring). Portugal reports emissions as 'IE' (included elsewhere). Five Member States use Tier 1 methodology for emission estimates (approximately 87% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.b – Liquid Fuels (CO_2)). All Member States reported lower level of emissions in 2021 than in 1990 (except Italy).

Table 3.26: 1.A.2.b Non-ferrous Metals, liquid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	35	8	9	1.1%	-26	-73%	1	14%	T2	CS
Belgium	220	37.20	38	4.6%	-182	-83%	1	3%	T1	D
Bulgaria	199	40	48	5.7%	-151	-76%	8	19%	T1	D
Croatia	17	3	3	0.4%	-14	-82%	0	11%	T1	D
Cyprus	5	3	3	0.3%	-2	-44%	-1	-17%	T1	D
Czechia	3	NO	NO	-	-3	-100%	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	174	71	60	7.1%	-115	-66%	-11	-16%	T3	CS
France	773	243	239	28.5%	-534	-69%	-4	-2%	T2,T3	CS,PS
Germany	144	108	69	8.2%	-75	-52%	-39	-36%	CS	CS
Greece	582	20	19	2.3%	-563	-97%	-1	-4%	T2	PS
Hungary	202	NO	NO	-	-202	-100%	-	-	NA	NA
Ireland	766	16	12	1.4%	-754	-98%	-4	-24%	T1,T3	CS,D
Italy	18	34	30	3.5%	12	67%	-5	-13%	T2	CS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	15	NO	NO	-	-15	-100%	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	62	36	26	3.1%	-36	-58%	-10	-27%	T1,T2	CS,D
Portugal	IE	IE	IE	-	-	-	-	-	NA	NA
Romania	IE	1	4	0.5%	4	∞	3	365%	T1,T2	CS,D
Slovakia	23	3	3	0.3%	-20	-88%	0	-9%	T2	CS
Slovenia	120	3	3	0.4%	-117	-97%	0	5%	T1	D
Spain	931	211	171	20.4%	-759	-82%	-40	-19%	T1,T2,T3	CS,D,PS
Sweden	110	91	100	11.9%	-10	-9%	9	10%	T2	CS
EU-27	**4 401**	**928**	**837**	**100%**	**-3 563**	**-81%**	**-91**	**-10%**	**-**	**-**

Portugal includes emissions under 1.A.2.g. Romania includes emissions under 1.A.2.a from 1990 to 2017 (except 2007). Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.41 shows CO_2 emissions trend as well as the share of the Member States with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to France (28.5%), Spain (20.4%), Sweden (12%), Germany (8%) and Finland (7%) which together represent 76% share of EU emissions.

Figure 3.41: 1.A.2.b Non-ferrous Metals, liquid fuels: Emission trend and share for CO_2

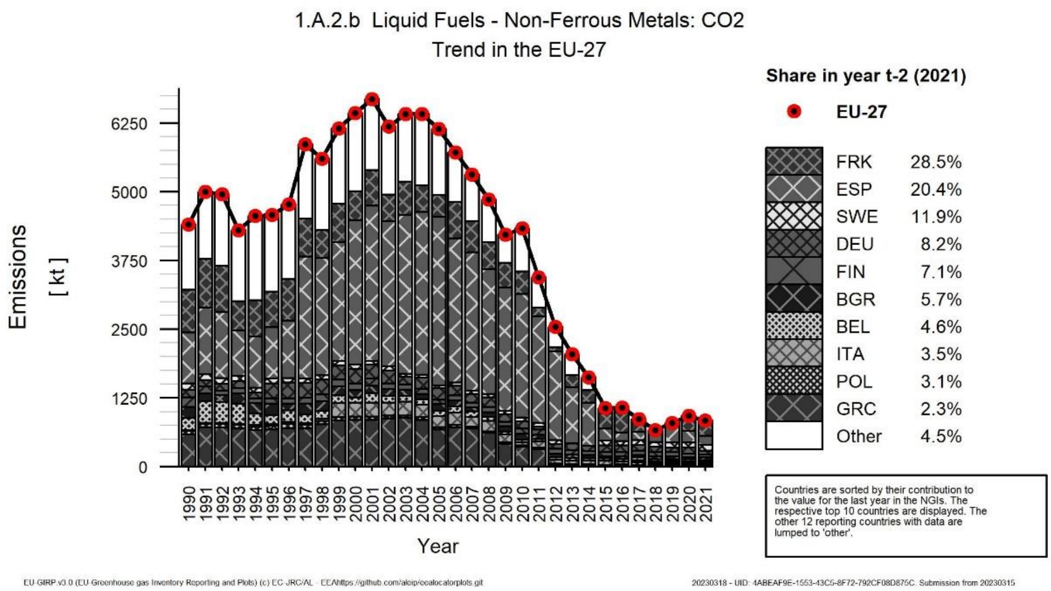


Figure 3.42 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that CO_2 IEF fluctuated at the beginning of the time series and since 2013 shows major fluctuations. The peak in the 2015 implied emission factor, as presented in the figure below, occurs because Sweden reported activity data as confidential. Huge drop of IEF in 2018 was caused by massive decrease of fuel consumption in France from 1 896 to 419 TJ. CO_2 IEF equalled to 77.87 t/TJ in 2021.

Figure 3.42: 1.A.2.b Non-ferrous Metals, liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)

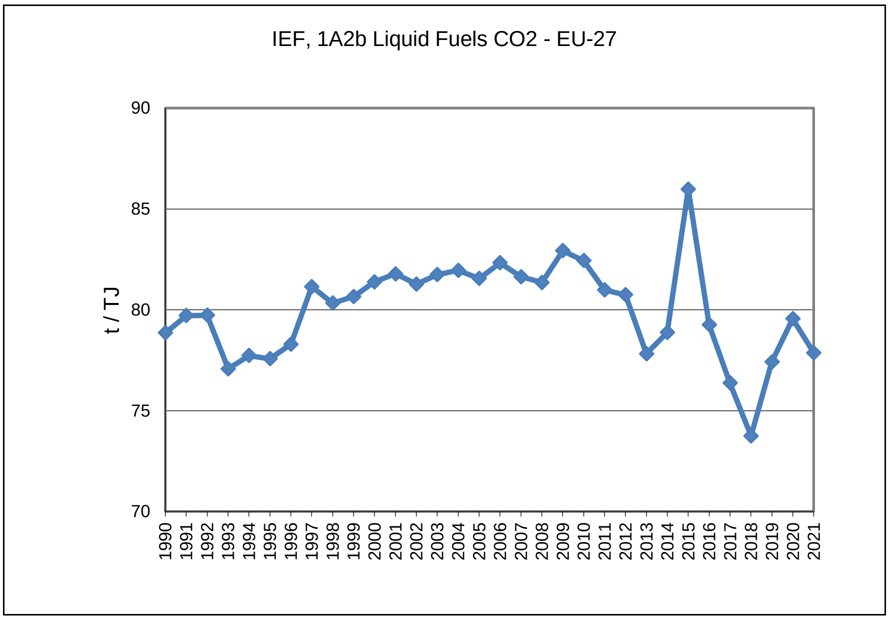
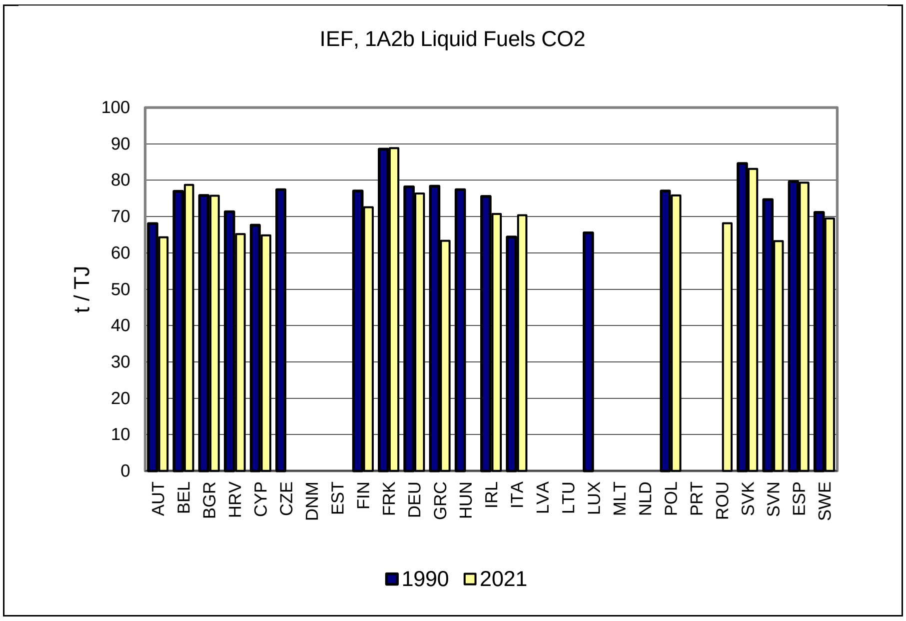


Figure 3.43 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. Particularly higher implied CO_2 emission factors are due to the use of petroleum coke, which has significantly higher carbon content than liquid oil products.

Figure 3.43: 1.A.2.b Non-ferrous Metals, liquid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.b Non-Ferrous Metals - Solid Fuels (CO_2)

CO_2 emissions from the use of solid fuels in category 1.A.2.b amounted 1 097 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 77% and compared to 2020 increased by 1%. Category has 0.2% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 76% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.27. Eleven member states report emissions as 'NO' (not occurring). Greece, Portugal and Romania report emissions as 'IE' (included elsewhere). Belgium uses Tier 1 methodology for emission estimates, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 92% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.b – Solid Fuels (CO_2)). All Member States reported lower level of emissions in 2021 than in 1990 (except Bulgaria with a 7% share on total EU emissions in subcategory 1.A.2.b solid fuels in 2021).

Table 3.27: 1.A.2.b Non-ferrous Metals, solid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	22	13	10	0.9%	-12	-56%	-3	-26%	T2	CS
Belgium	147	94	91	8.3%	-57	-38%	-3	-3%	T1	D
Bulgaria	76	93	77	7.1%	1	1%	-15	-16%	T1,T2	CS,D
Croatia	0	NO	NO	-	0	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	46	15	17	1.5%	-29	-63%	2	12%	T2	CS,D
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	155	26	18	1.6%	-137	-88%	-8	-31%	T3	CS
France	954	2	2	0.2%	-952	-100%	0	16%	T2,T3	CS,PS
Germany	1 233	49	48	4.4%	-1 185	-96%	-1	-2%	CS	CS
Greece	IE	IE	IE	-	-	-	-	-	NA	NA
Hungary	9	NO	NO	-	-9	-100%	-	-	NA	NA
Ireland	4	NO	NO	-	-4	-100%	-	-	NA	NA
Italy	152	61	47	4.3%	-105	-69%	-15	-24%	T2	CS
Latvia	NO	NO	0	0.0%	0	∞	0	∞	T2	CS
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	0	NO	NO	-	0	-100%	-	-	NA	NA
Poland	673	608	626	57.1%	-47	-7%	18	3%	T1,T2	CS,D
Portugal	IE	IE	IE	-	-	-	-	-	NA	NA
Romania	81	IE	IE	-	-81	-100%	-	-	NA	NA
Slovakia	798	24	25	2.2%	-774	-97%	0	1%	T2	CS
Slovenia	154	5	5	0.5%	-150	-97%	0	0%	T1,T2	CS,D
Spain	188	98	132	12.0%	-56	-30%	33	34%	T1,T2	CS,D
Sweden	8	NO	NO	-	-8	-100%	-	-	NA	NA
EU-27	**4 702**	**1 088**	**1 097**	**100%**	**-3 605**	**-77%**	**9**	**1%**	**-**	**-**

Portugal includes emissions under 1.A.2.g. From 1991, Romania includes emissions under 1.A.2.a.
Greece includes emissions in the Industrial processes sector (as non-energy use of fuels).
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.44 shows CO_2 emissions trend as well as the share of countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest share on total CO_2 emissions (above the average share calculated for EU) has Poland (57%), Spain (12%) and Belgium (8%) which together have 77% share on EU emissions.

Figure 3.44: 1.A.2.b Non-ferrous Metals, solid fuels: Emission trend and share for CO_2

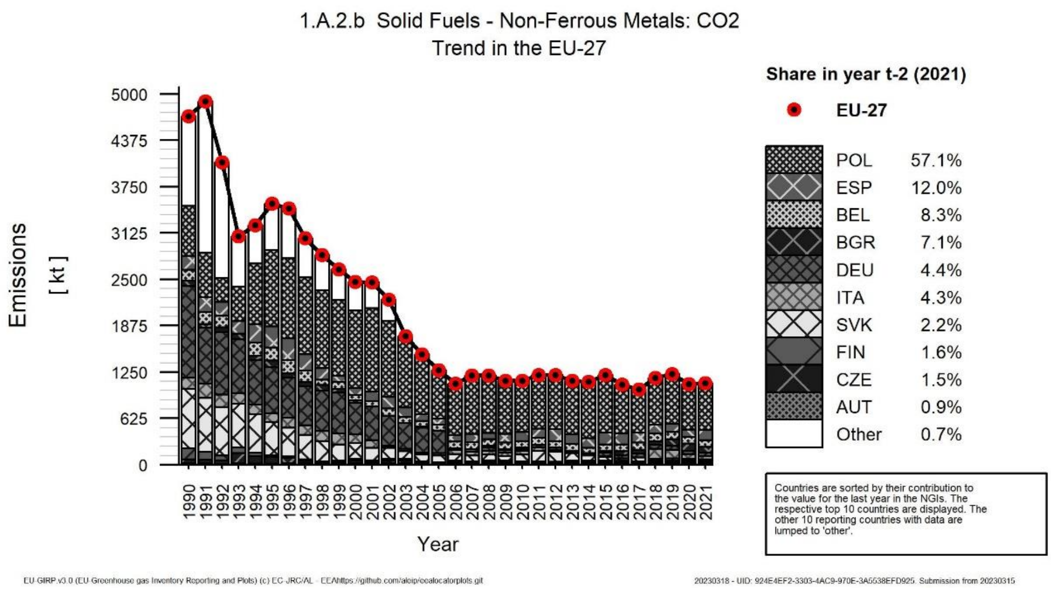


Figure 3.45 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. Since the beginning of the time series, the CO_2 IEF had relatively decreasing trend. CO_2 IEF equalled to 98.53 t/TJ in 2021.

Figure 3.45: 1.A.2.b Non-ferrous Metals, solid fuels: Implied Emission Factors for CO_2 (in t/TJ)

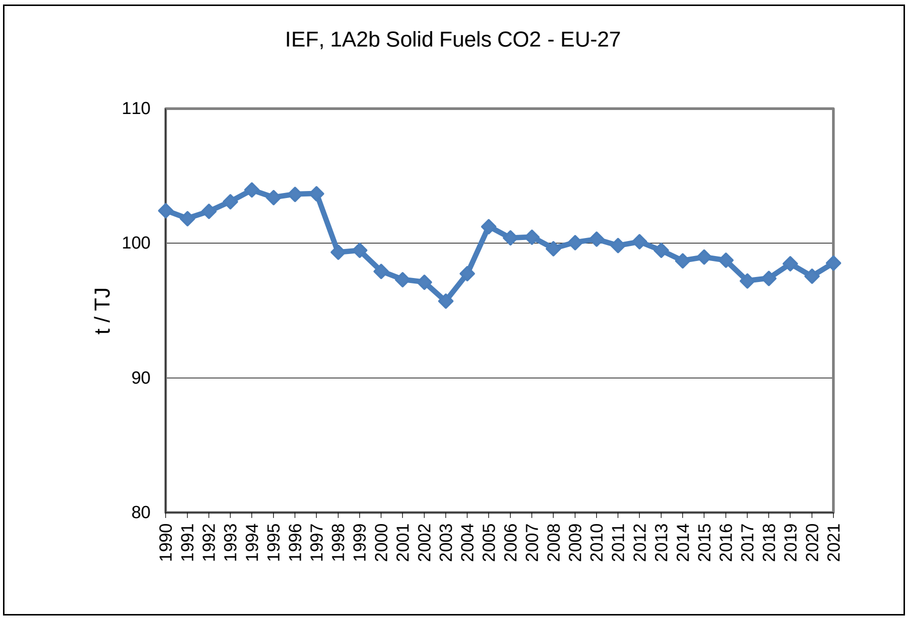
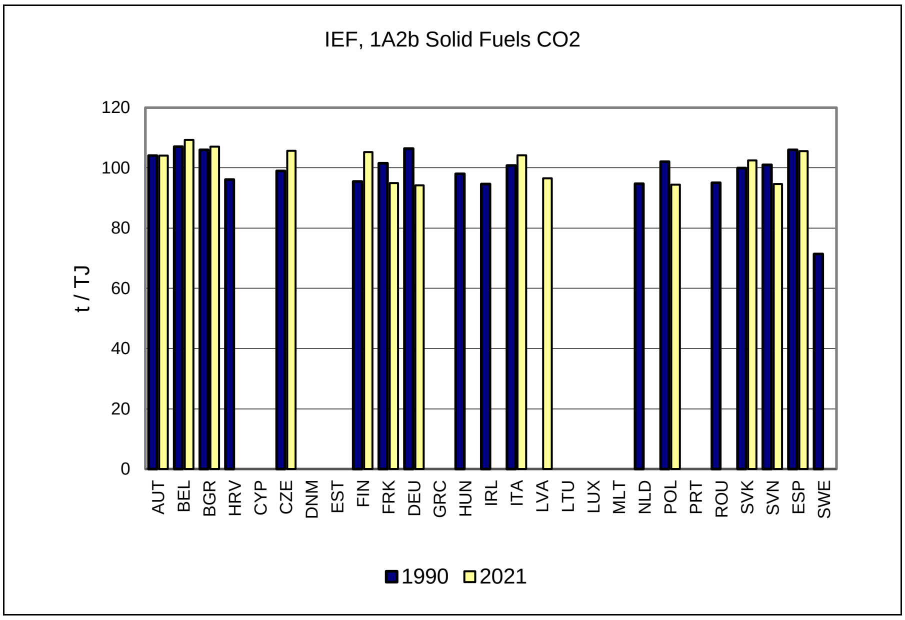


Figure 3.46 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021.

Figure 3.46: 1.A.2.b Non-ferrous Metals, solid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.b Non-Ferrous Metals - Gaseous Fuels (CO_2)

CO_2 emissions from the use of gaseous fuels in category 1.A.2.b amounted 7 496 kt in 2021 for EU. CO_2 emissions increased compared to year 1990 by 149% and compared to year 2020 increased by 18%. This category represents 1.7% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption increased by 146% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.28. Cyprus, Denmark, Lithuania and Malta report emissions as 'NO' (not occurring). Germany and Portugal report emissions as 'IE' (included elsewhere). For Germany, emissions from gaseous fuels from this category are reported in 1.A.2.g Other. Two Member States use for emission estimates Tier 1 methodology, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 96% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.b – Gaseous Fuels (CO_2)). Four countries reported lower level of emissions in 2021 than in 1990. Most rapid increase of emissions was reported by Ireland (3296%); Ireland has also the highest share on total CO_2 emissions from 1.A.2.b – Gaseous Fuels (CO_2).

Table 3.28: 1.A.2.b Non-ferrous Metals, Gaseous fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27	Change 1990-2021		Change 2020-2021		Method	Emission factor
	1990	2020	2021	Emissions in 2021	kt CO2	%	kt CO2	%		Informa-tion
Austria	75	246	275	3.7%	200	266%	29	12%	T2	CS
Belgium	261	272	289	3.9%	28	11%	17	6%	T1	D
Bulgaria	23	116	120	1.6%	97	413%	4	4%	T2	CS
Croatia	NO	23	27	0.4%	27	∞	4	20%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	53	127	265	3.5%	212	399%	138	108%	T2	CS
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	1	0	0.0%	0	∞	-1	-60%	T2	CS
Finland	NO	3	3	0.0%	3	∞	0	14%	T3	CS
France	745	640	662	8.8%	-83	-11%	22	3%	T2,T3	CS,PS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	NO	315	655	8.7%	655	∞	339	108%	T2	CS
Hungary	86	152	165	2.2%	78	90%	12	8%	T2	CS
Ireland	39	1 307	1 310	17.5%	1 271	3296%	3	0%	T2	CS
Italy	566	941	891	11.9%	326	58%	-49	-5%	T2	CS
Latvia	NO	1	1	0.0%	1	∞	0	43%	T2	CS
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	13	43	49	0.7%	35	264%	6	13%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	213	127	150	2.0%	-63	-30%	23	18%	T2	CS
Poland	254	425	443	5.9%	188	74%	18	4%	T2	CS
Portugal	IE	IE	IE	-	-	-	-	-	NA	NA
Romania	IE	353	409	5.5%	409	∞	56	16%	T2,T3	CS,PS
Slovakia	435	68	86	1.2%	-348	-80%	18	27%	T2	CS
Slovenia	165	109	130	1.7%	-34	-21%	21	19%	T2	CS
Spain	73	1 044	1 548	20.7%	1 475	2014%	504	48%	T2,T3	CS,PS
Sweden	10	16	17	0.2%	7	64%	1	7%	T2	CS
EU-27	**3 013**	**6 330**	**7 496**	**100%**	**4 483**	**149%**	**1 166**	**18%**	**-**	**-**

Portugal includes emissions under 1.A.2.g. From 1990 to 2017, Romania includes emissions under 1.A.2.a. Germany reported emissions under 1.A.2.g (unspecified industrial power plants) because of confidential data.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.47 shows CO_2 emissions trend as well as the share of countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest share on total CO_2 emissions (above the average share calculated for EU) has Spain (21%), Ireland (17%), Italy (12%), Hungary and France (both with 9%), Poland (6%) and Romania (5%) which together have 79% share on EU emissions.

Figure 3.47: 1.A.2.b Non-ferrous Metals, Gaseous fuels: Emission trend and share for CO_2

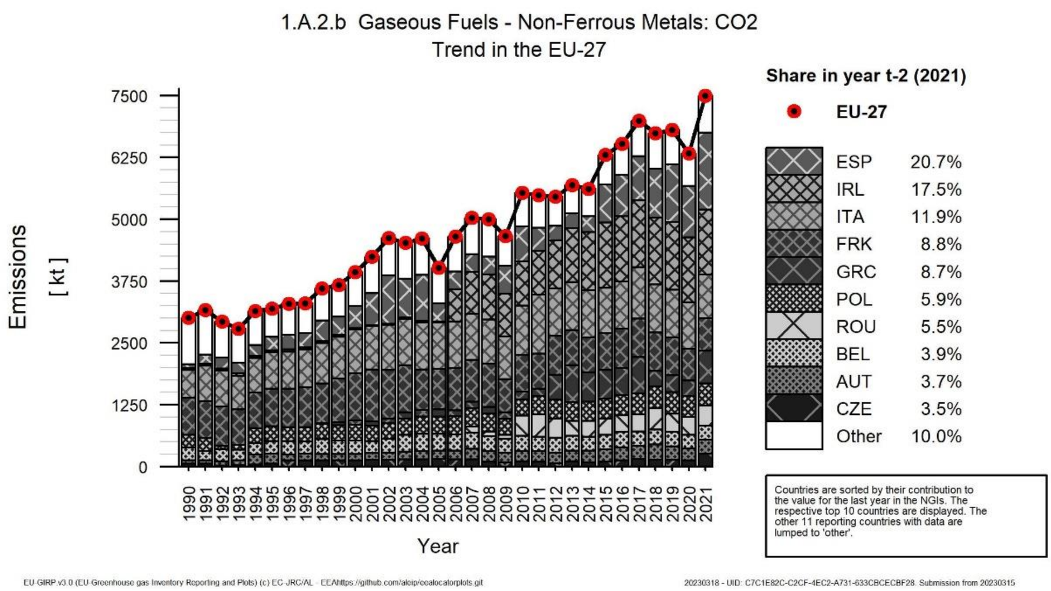


Figure 3.48 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that CO_2 IEF has stable trend for the period 1990-2017 bud since 2018 the trend has slightly changed. CO_2 IEF equalled to 56.47 t/TJ in 2021.

Figure 3.48: 1.A.2.b Non-ferrous Metals, Gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)

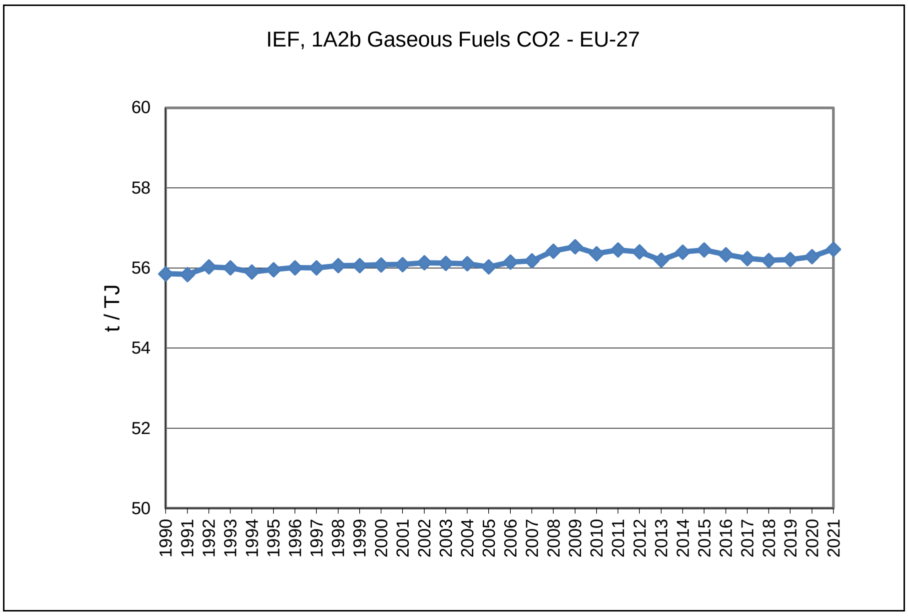
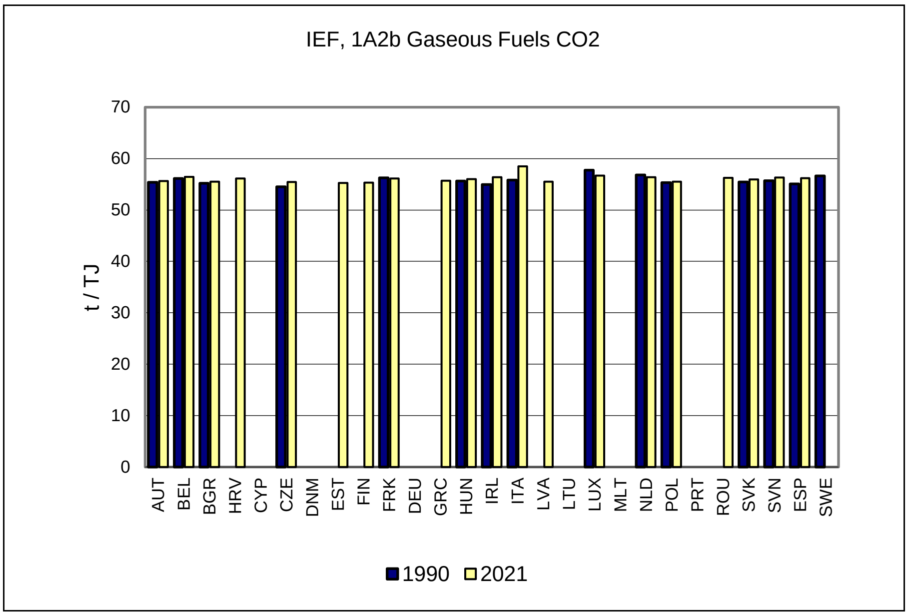


Figure 3.49 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021 No significant differences between CO_2 IEF used by EU are occurring and also no significant differences between CO_2 IEF used in 1990 and 2021 are occurring.

Figure 3.49: 1.A.2.b Non-ferrous Metals, Gaseous fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



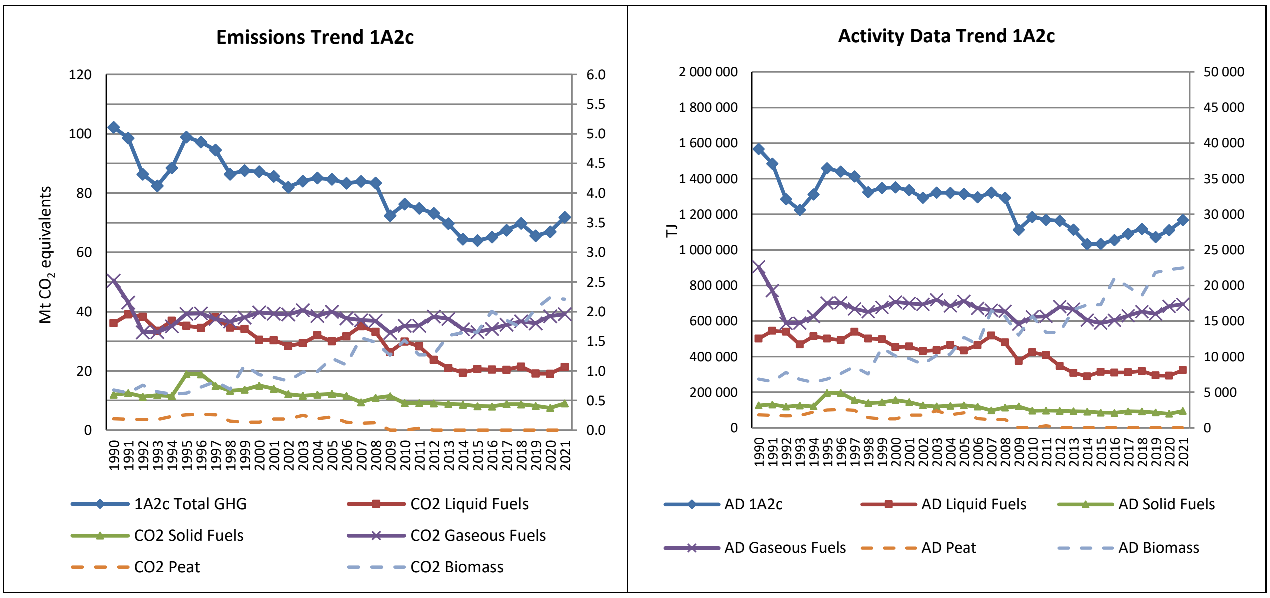
3.2.2.3 Chemicals (1.A.2.c)

This chapter provides information about European emission trend contribution to the overall emission trend, activity data and emission factors used for emission estimates by countries for category 1.A.2.c Chemicals.

Total CO_2 emissions from 1.A.2.c amounted to 71 147 kt CO_2 eq. in 2021. The trend of total CO_2 emissions for 1990 to 2021 from category 1.A.2.c is depicted in Figure 3.50. CO_2 emissions decreased by 30% since 1990 and increased by 7% between 2020 and 2021. CO_2 emissions from 1.A.2.c Chemicals accounted for 16% of 1.A.2. source category.

Figure **3.50** shows the emission trend within the category 1.A.2.c, which is dominated by CO_2 emissions from gaseous fuels in 2021. The share of liquid fuels on CO_2 emissions from 1.A.2.c decreased from 35% in 1990 to 30% in 2021. The share of solid fuels on CO_2 emissions from 1.A.2.c slightly increased from 12% in 1990 to 13% in 2021. The share of gaseous fuels on CO_2 emissions from 1.A.2.c increased from 50% in 1990 to 55% in 2021.

Figure 3.50: 1.A.2.c Chemicals: Total and CO_2 emission and activity trends



Data displayed as dashed line refers to the secondary axis.

Detailed data related to the EU submissions are depicted in Table 3.29. Malta and Germany report emissions as ‘NO’ (not occurring) or ‘IE’ (included elsewhere). For Germany, emissions from this category are reported in 1.A.2.g Other. Six Member States reported increase of CO_2 emissions compared to level of emissions in 1990. The highest increase of CO_2 emissions was reported by Cyprus (but it should be noted that the share of Cyprus emissions on total EU emissions is minor compared to for example Poland and Spain which reported significant increase of emissions and have also high share on total EU emissions).

Table 3.29: 1.A.2.c Chemicals: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27	Change 1990-2021		Change 2020-2021		Method	Emission factor
	1990	2020	2021	Emissions in 2021	kt CO2	%	kt CO2	%		Informa-tion
Austria	847	1 426	1 582	2.2%	735	87%	156	11%	T1,T2	CS,D
Belgium	5 098	3 783	4 134	5.8%	-964	-19%	350	9%	T1,T3	D,PS
Bulgaria	966	1 327	1 556	2.2%	590	61%	228	17%	T1,T2	CS,D
Croatia	738	336	234	0.3%	-504	-68%	-102	-30%	T1	D
Cyprus	2	8	7	0.0%	5	206%	-1	-13%	T1	D
Czechia	2 996	2 027	3 251	4.6%	254	8%	1 224	60%	T1,T2	CS,D
Denmark	337	208	220	0.3%	-117	-35%	12	6%	T1,T2,T3	CS,D
Estonia	390	11	15	0.0%	-375	-96%	4	36%	T1,T2	CS,D
Finland	1 191	704	729	1.0%	-463	-39%	25	3%	T3	CS,D
France	14 760	10 414	10 728	15.1%	-4 032	-27%	313	3%	T2,T3	CS,PS
Germany	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Greece	808	618	645	0.9%	-163	-20%	27	4%	T2	CS
Hungary	1 531	382	396	0.6%	-1 134	-74%	14	4%	T1,T2,T3	CS,D,PS
Ireland	410	405	396	0.6%	-14	-3%	-9	-2%	T2	CS
Italy	21 428	8 672	11 301	15.9%	-10 127	-47%	2 628	30%	T2	CS
Latvia	294	24	30	0.0%	-263	-90%	6	26%	T2	CS
Lithuania	397	276	280	0.4%	-117	-29%	5	2%	T2	CS
Luxembourg	170	111	128	0.2%	-42	-25%	17	15%	T1,T3	CS,D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	17 275	14 722	14 583	20.5%	-2 693	-16%	-140	-1%	T2	CS,D
Poland	4 003	6 613	6 845	9.6%	2 842	71%	232	4%	T1,T2	CS,D
Portugal	1 412	1 232	1 198	1.7%	-214	-15%	-34	-3%	T1,T3	D,PS
Romania	17 864	3 602	3 032	4.3%	-14 832	-83%	-571	-16%	T1,T2,T3	CS,D,PS
Slovakia	2 652	473	476	0.7%	-2 176	-82%	3	1%	T2	CS
Slovenia	211	65	73	0.1%	-138	-65%	8	12%	T1,T2	CS,D
Spain	5 354	8 426	8 867	12.5%	3 513	66%	441	5%	T1,T2	CS,D,PS
Sweden	683	468	443	0.6%	-239	-35%	-25	-5%	T2	CS
EU-27	**101 814**	**66 334**	**71 147**	**100%**	**-30 667**	**-30%**	**4 813**	**7%**	**-**	**-**

Emissions of Germany and Malta are included in 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

1.A.2.c Chemicals - Liquid Fuels (CO_2)

CO_2 emissions from the use of liquid fuels in category 1.A.2.c amounted 21 347 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 41% and compared to 2020 increased by 12%. Category has 5% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 35% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.30. Malta reports emissions as 'NO' (not occurring). Germany reports emissions as 'IE' (include elsewhere) and reports them in 1.A.2.g Other. Seven Member States use for emission estimates Tier 1 methodology, the rest of Member States use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 93% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.c – Liquid Fuels (CO_2)). Bulgaria, Cyprus, Czechia, Netherlands and Poland reported higher level of emissions in 2021 than in 1990.

Table 3.30: 1.A.2.c Chemicals, Liquid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	97	75	39	0.2%	-58	-60%	-36	-48%	T2	CS
Belgium	1 852	228	259	1.2%	-1 593	-86%	31	13%	T1	D
Bulgaria	855	834	965	4.5%	110	13%	131	16%	T1	D
Croatia	291	6	7	0.0%	-284	-97%	1	15%	T1	D
Cyprus	2	8	7	0.0%	5	206%	-1	-13%	T1	D
Czechia	175	280	324	1.5%	149	85%	44	16%	T1	D
Denmark	220	7	15	0.1%	-205	-93%	8	116%	T1,T2	CS,D
Estonia	229	4	3	0.0%	-226	-99%	-1	-26%	T1,T2	CS,D
Finland	677	600	616	2.9%	-61	-9%	17	3%	T3	CS
France	5 469	2 508	2 380	11.1%	-3 090	-56%	-128	-5%	T2,T3	CS,PS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	639	37	79	0.4%	-560	-88%	42	114%	T2	CS
Hungary	380	3	3	0.0%	-377	-99%	0	0%	T1	D
Ireland	131	50	53	0.2%	-78	-59%	4	7%	T2	CS
Italy	13 125	3 399	5 697	26.7%	-7 428	-57%	2 298	68%	T2	CS
Latvia	270	10	11	0.1%	-259	-96%	1	6%	T2	CS
Lithuania	69	4	5	0.0%	-64	-93%	1	21%	T2	CS
Luxembourg	112	0	0	0.0%	-112	-100%	0	30%	T1,T3	CS,D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	6 493	7 679	7 572	35.5%	1 080	17%	-106	-1%	T2	CS,D
Poland	308	1 167	1 198	5.6%	890	289%	31	3%	T1,T2	CS,D
Portugal	1 373	704	726	3.4%	-647	-47%	22	3%	T1,T3	D,PS
Romania	NO	970	935	4.4%	935	∞	-35	-4%	T1,T2,T3	CS,D,PS
Slovakia	51	2	1	0.0%	-50	-97%	0	-23%	T2	CS
Slovenia	32	9	9	0.0%	-23	-71%	0	2%	T1	D
Spain	2 844	113	118	0.6%	-2 726	-96%	6	5%	T1,T2	CS,D
Sweden	424	352	323	1.5%	-101	-24%	-29	-8%	T2	CS
EU-27	**36 118**	**19 049**	**21 347**	**100%**	**-14 772**	**-41%**	**2 297**	**12%**	**-**	**-**

From 1990 to 2000 Croatia includes emissions under 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.51 shows CO_2 emissions trend as well as the share of countries with the highest contribution to the total CO_2 emissions. It can be seen, that the highest share on total CO_2 emissions (above the average share calculated for EU) has Netherlands (36%), Italy (27%), France (11%), Poland (6%), Bulgaria (5%) and Romania (4%) which together have 88% share on EU emissions.

Figure 3.51: 1.A.2.c Chemicals, Liquid fuels: Emission trend and share for CO_2

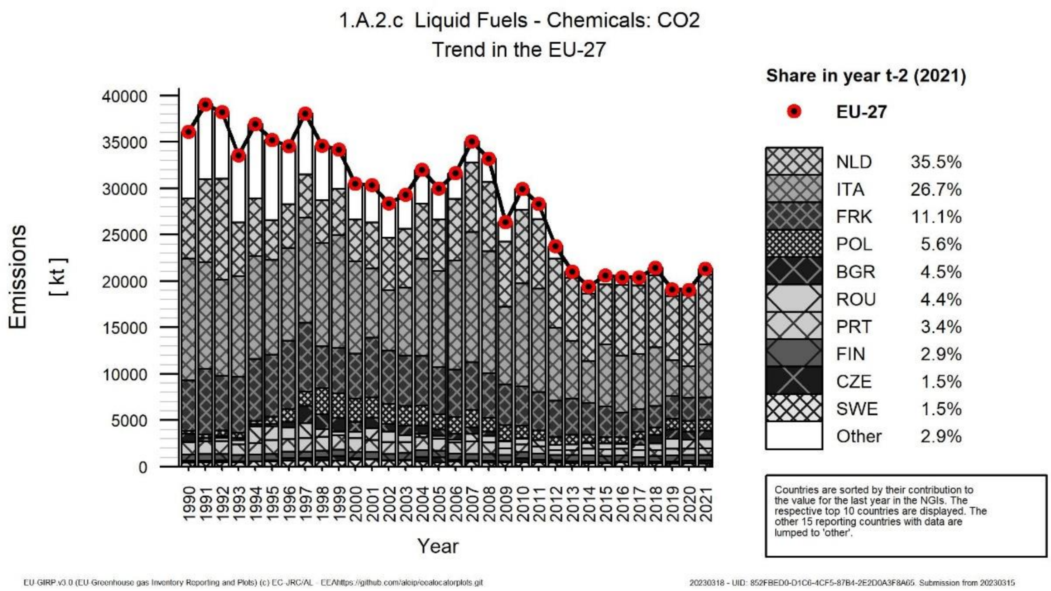


Figure 3.52 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that CO_2 IEF fluctuates over the time period with decreasing trend. CO_2 IEF equaled to 65.76 t/TJ in 2021. The main reason for the declining trend of the IEF is the growing weight of the Netherlands (with a lower IEF) and the decreasing weight of Italy (with a higher IEF) in total EU emissions.

Figure 3.52: 1.A.2.c Chemicals, Liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)

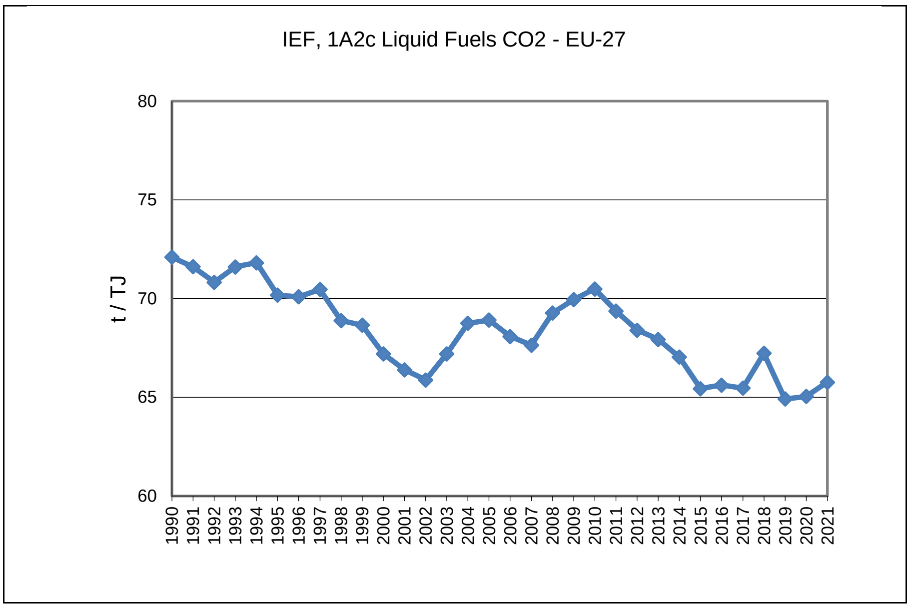
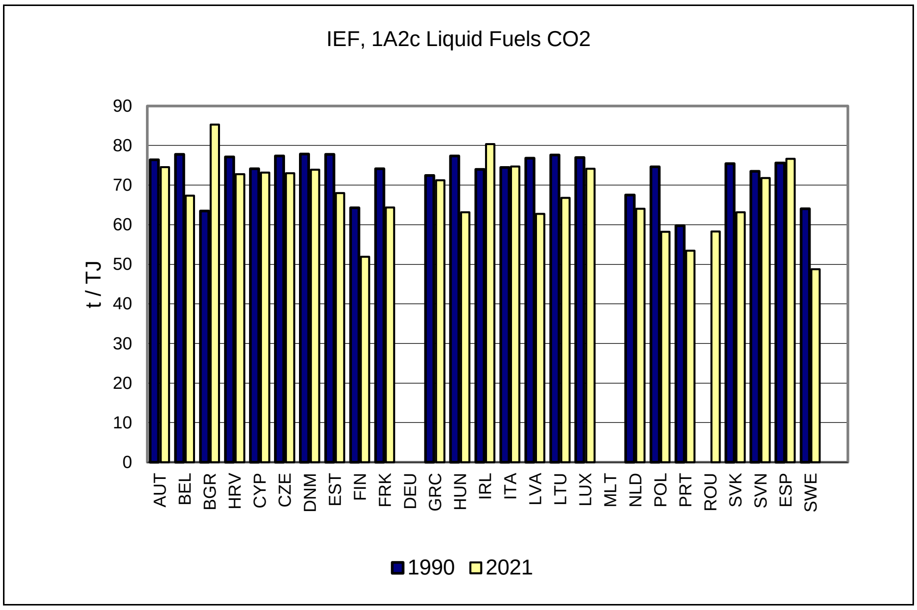


Figure 3.53 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. The main reason for the differences of IEFs across countries is differences in the fuel mix. Bulgaria has a bit higher IEF compared to other countries which is caused by high share of petroleum coke.

Figure 3.53: 1.A.2.c Chemicals, Liquid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.c Chemicals - Solid Fuels (CO_2)

CO_2 emissions from the use of solid fuels in category 1.A.2.c amounted 9 021 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 25% and compared to 2020 increased by 20%. Category has 2% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 25% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.31. Sixteen Member States report emissions as 'NO' (not occurring). Germany reports emissions as 'IE' (include elsewhere) and reports them in 1.A.2.g Other. Belgium uses for emission estimates Tier 1 methodology, the rest of Member States use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 99.97% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.c – Solid Fuels (CO_2)). Bulgaria and Poland reported higher level of emissions in 2021 than in 1990. Poland has the highest share on total EU emissions.

Table 3.31: 1.A.2.c Chemicals, Solid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	106	38	30	0.3%	-76	-72%	-8	-21%	T2	CS
Belgium	688	4	3	0.0%	-685	-100%	-1	-27%	T1	D
Bulgaria	80	215	301	3.3%	221	275%	87	40%	NA	NA
Croatia	101	NO	NO	-	-101	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	2 487	967	2 108	23.4%	-380	-15%	1 141	118%	T2	CS,D
Denmark	6	NO	NO	-	-6	-100%	-	-	NA	NA
Estonia	5	NO	NO	-	-5	-100%	-	-	NA	NA
Finland	214	NO	NO	-	-214	-100%	-	-	NA	NA
France	2 149	1 192	1 352	15.0%	-796	-37%	161	13%	T2,T3	CS,PS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	169	NO	NO	-	-169	-100%	-	-	NA	NA
Hungary	96	NO	NO	-	-96	-100%	-	-	NA	NA
Ireland	72	NO	NO	-	-72	-100%	-	-	NA	NA
Italy	640	NO	NO	-	-640	-100%	-	-	NA	NA
Latvia	NO	0	1	0.0%	1	∞	1	700%	T2	CS
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	1 087	NO	NO	-	-1 087	-100%	-	-	NA	NA
Poland	1 012	4 454	4 595	50.9%	3 583	354%	142	3%	T1,T2	CS,D
Portugal	39	NO	NO	-	-39	-100%	-	-	NA	NA
Romania	644	NO	NO	-	-644	-100%	-	-	NA	NA
Slovakia	1 584	49	9	0.1%	-1 574	-99%	-40	-81%	T2	CS
Slovenia	1	NO	NO	-	-1	-100%	-	-	NA	NA
Spain	691	580	621	6.9%	-70	-10%	41	7%	T1,T2	CS,D,PS
Sweden	101	C	C	-	-101	-100%	-	-	T2	CS
EU-27	**11 871**	**7 498**	**9 021**	**100%**	**-2 850**	**-24%**	**1 523**	**20%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.
EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.

Figure 3.54 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Poland (51%), Czechia (23%) and France (15%) which together represent 89% share on EU emissions.

Figure 3.54: 1.A.2.c Chemicals, Solid fuels: Emission trend and share for CO_2

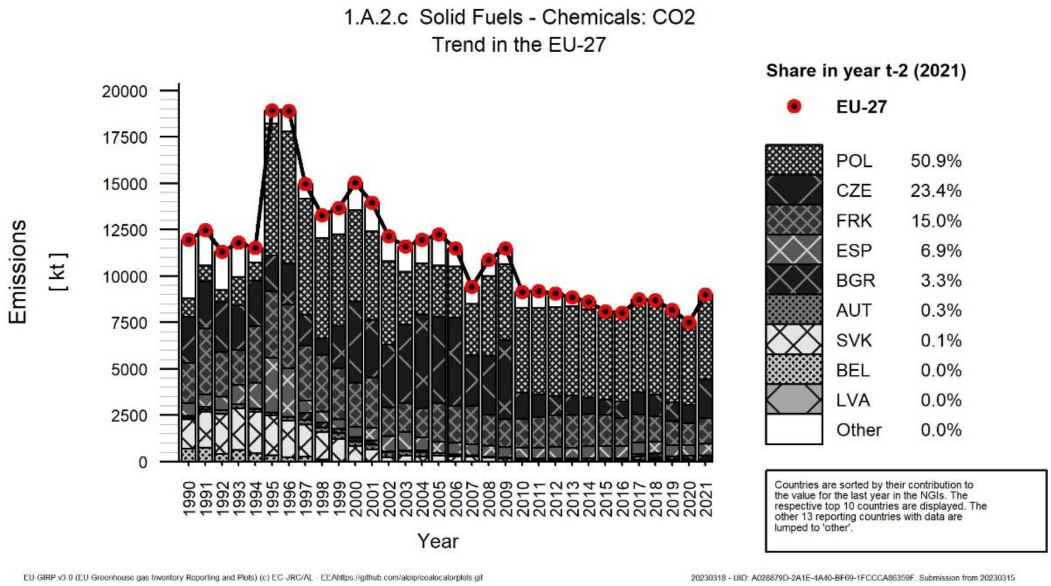


Figure 3.55 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that since 2010, the CO_2 IEF fluctuates only slightly. CO_2 IEF equalled to 95.08 t/TJ in 2021.

Figure 3.55: 1.A.2.c Chemicals, Solid fuels: Implied Emission Factors for CO_2 (in t/TJ)

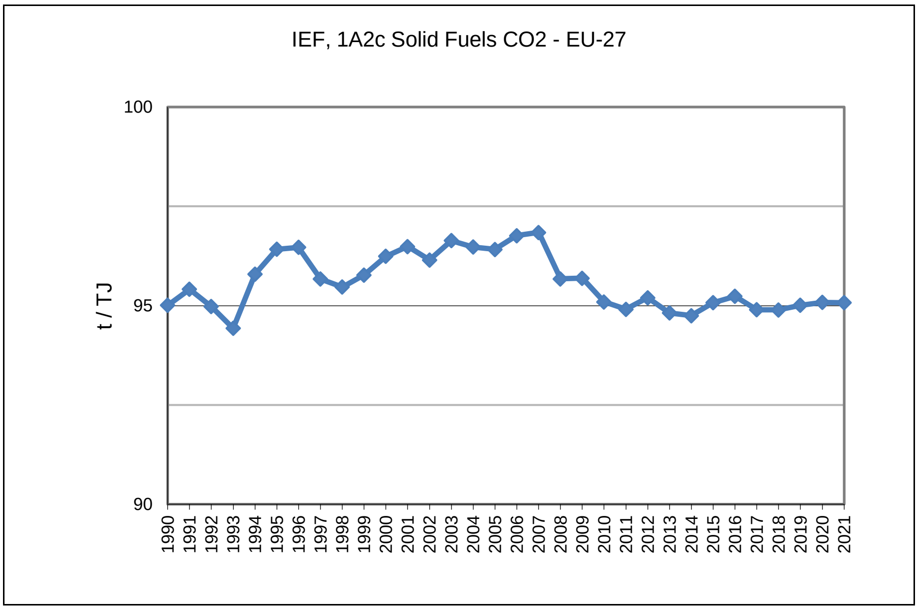
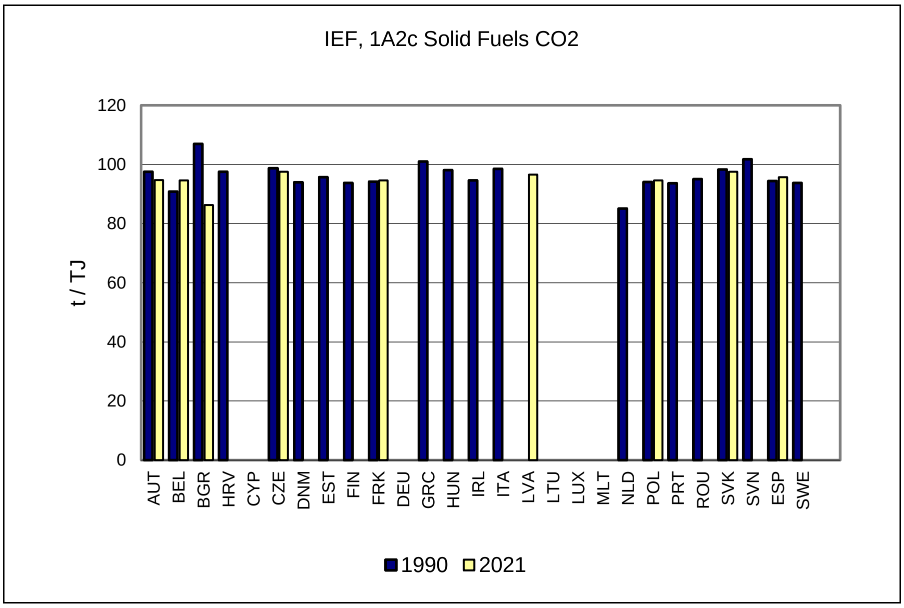


Figure 3.56 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021.

Figure 3.56: 1.A.2.c Chemicals, Solid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.c Chemicals – Gaseous Fuels (CO_2)

CO_2 emissions from the use of gaseous fuels in category 1.A.2.c amounted 39 145 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 22% and compared to 2020 CO_2 emissions increased by 2%. This category represents 9% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 23% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.32. Cyprus and Malta report emissions as 'NO' (not occurring). Germany reports emissions as 'IE' (include elsewhere) and reports them in 1.A.2.g Other. Croatia uses for emission estimates Tier 1 methodology, the rest of Member States use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 99% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.c –Gaseous Fuels (CO_2)). Nine Member States reported higher level of emissions in 2021 than in 1990. Noticeable higher level of emissions in 2021 compared to 1990 was reported by Bulgaria (858%) and Spain (347%).

Table 3.32: 1.A.2.c Chemicals, gaseous fuels: Member States contributions to CO_2

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	519	1 131	1 220	3.1%	701	135%	88	8%	T2	CS
Belgium	2 559	3 544	3 865	9.9%	1 306	51%	321	9%	T1,T3	D,PS
Bulgaria	30	279	289	0.7%	259	858%	11	4%	T2	CS
Croatia	346	330	227	0.6%	-119	-34%	-103	-31%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	334	780	819	2.1%	485	145%	39	5%	T2	CS
Denmark	110	201	205	0.5%	95	86%	4	2%	T3	CS
Estonia	156	7	12	0.0%	-144	-92%	5	68%	T2	CS
Finland	99	98	91	0.2%	-8	-8%	-7	-7%	T3	CS
France	6 657	5 677	5 827	14.9%	-830	-12%	150	3%	T2,T3	CS,PS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	NO	581	566	1.4%	566	∞	-15	-3%	T2	CS
Hungary	1 055	376	388	1.0%	-667	-63%	12	3%	T2	CS
Ireland	207	356	343	0.9%	135	65%	-13	-4%	T2	CS
Italy	7 663	5 273	5 604	14.3%	-2 060	-27%	330	6%	T2	CS
Latvia	24	13	18	0.0%	-5	-22%	5	37%	T2	CS
Lithuania	328	272	276	0.7%	-53	-16%	4	1%	T2	CS
Luxembourg	57	111	128	0.3%	70	122%	17	15%	T3	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	9 695	7 043	7 010	17.9%	-2 685	-28%	-33	0%	T2	CS
Poland	293	945	1 048	2.7%	755	258%	103	11%	T2	CS
Portugal	NO	527	472	1.2%	472	∞	-55	-11%	T1,T3	D,PS
Romania	17 220	2 631	2 091	5.3%	-15 129	-88%	-541	-21%	T2,T3	CS,PS
Slovakia	989	412	456	1.2%	-533	-54%	44	11%	T2	CS
Slovenia	177	56	64	0.2%	-113	-64%	7	13%	T2	CS
Spain	1 819	7 733	8 128	20.8%	6 308	347%	395	5%	T2	CS
Sweden	155	67	C	-	-155	-100%	-67	-100%	T2	CS
EU-27	**50 337**	**38 376**	**39 145**	**100%**	**-11 192**	**-22%**	**769**	**2%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.57 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Spain (21%), Netherlands (18%), France (15%), Italy (14%), Belgium (10%) and Romania (5%) which together represent 83% share on EU emissions.

Figure 3.57: 1.A.2.c Chemicals, Gaseous fuels: Emission trend and share for CO_2

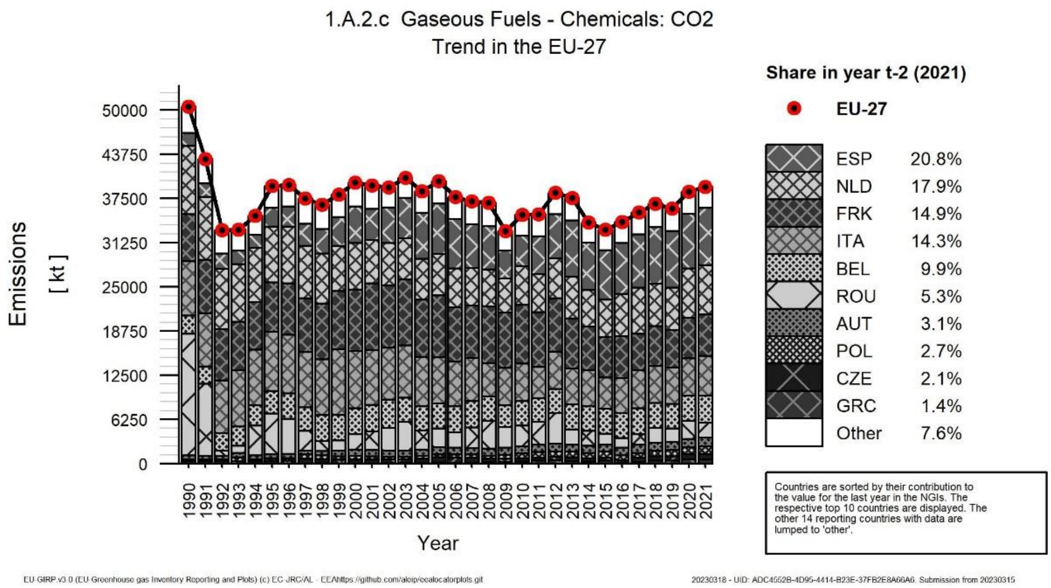


Figure 3.58 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. CO_2 IEF shows stable trend for the whole time series. CO_2 IEF equaled to 56.49 t/TJ in 2021.

Figure 3.58: 1.A.2.c Chemicals, Gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)

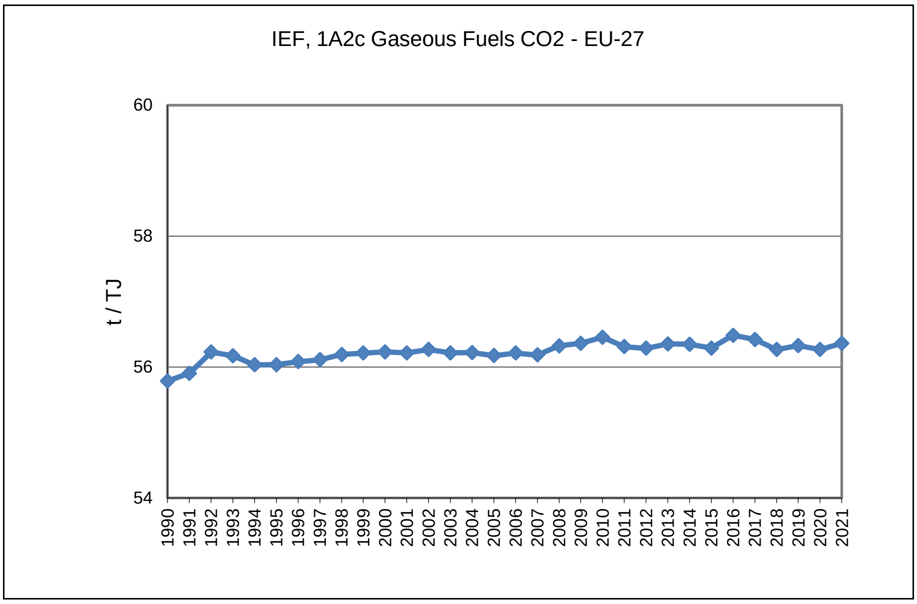
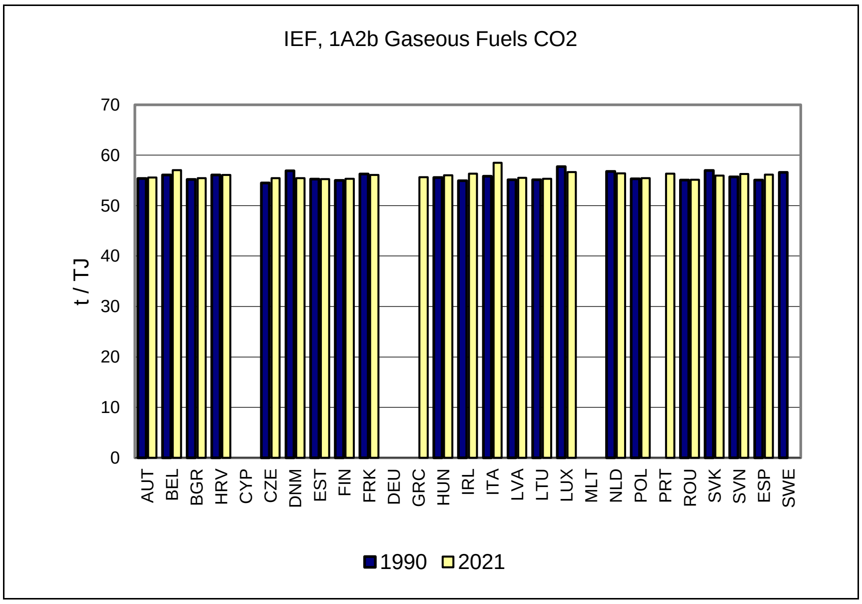


Figure 3.59 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. No significant differences between CO_2 IEF used by EU are occurring as also no significant differences between CO_2 IEF used in 1990 and 2021 are occurring.

Figure 3.59: 1.A.2.c Chemicals, Gaseous fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



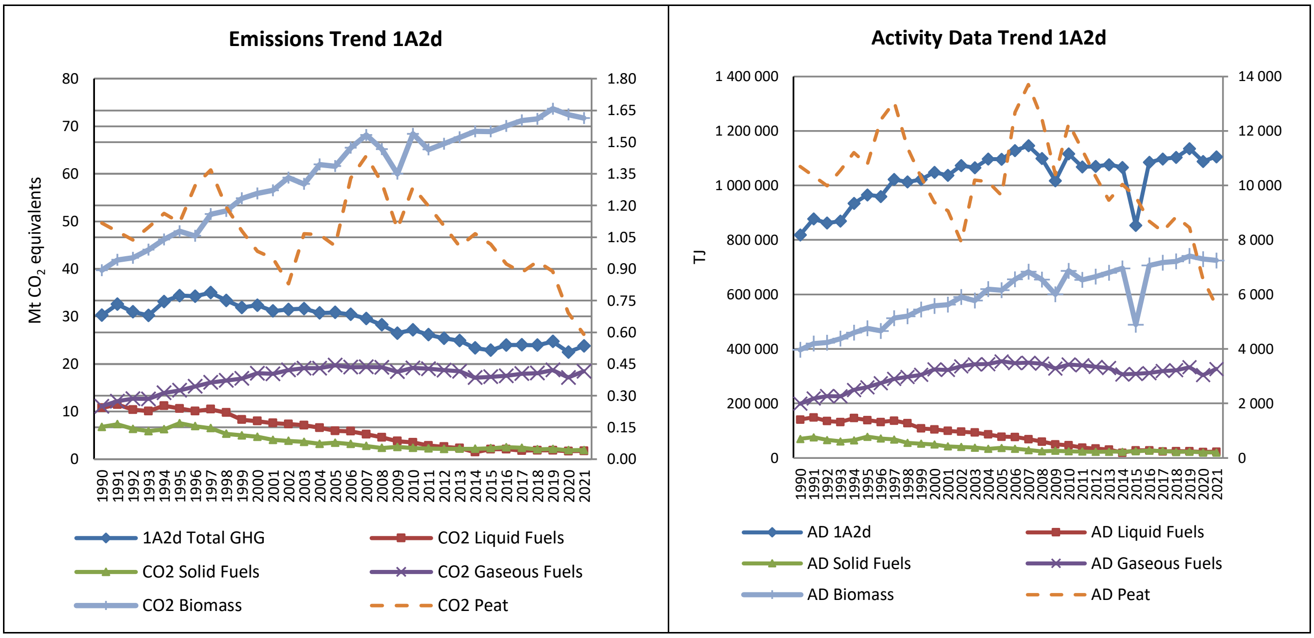
3.2.2.4 Pulp, Paper and Print (1.A.2.d)

This chapter provides information about European emission trend and Member States contribution to the overall emission trend, activity data and emission factors used for emission estimates by countries for category 1.A.2.d Pulp, Paper and Print.

Total CO_2 emissions from 1.A.2.d amounted to 23 096 kt CO_2 eq. in 2021. The trend of total emissions for 1990 to 2021 from category 1.A.2.d is depicted in Figure **3.60**. Total CO_2 emissions decreased by 23% since 1990 and increased by 6% between 2020 and 2021. CO_2 emissions from 1.A.2.d Pulp, Paper and Print accounted for 5% of 1.A.2. source category.

Figure **3.60** shows the emission trend within the category 1.A.2.d, which is dominated by CO_2 emissions from gaseous fuels in 2021. The share of liquid fuels on CO_2 emissions from 1.A.2.d decreased from 36% in 1990 to 7% in 2021. The share of solid fuels on CO_2 emissions from 1.A.2.d decreased from 23% in 1990 to 8% in 2021. The share of gaseous fuels on CO_2 emissions from 1.A.2.d increased from 37% in 1990 to 80% in 2021. This sector includes a high amount of biomass consumption which is also gradually increasing since 1990. The activity data shows a strong switch from liquid and solid fuels to gaseous fuels and biomass.

Figure 3.60: 1.A.2.d Pulp, Paper and Print: Total and CO_2 emission and activity trends



Data displayed as dashed line refers to the secondary axis.

Note that total CO_2 emissions in the figure on the left side do not include CO_2 from biomass whereas total activity data in the figure on the right side includes AD biomass.

Detailed data related to the EU submissions are depicted in Table 3.33. Malta reports emissions as 'NO' (not occurring). Seven Member States report increase of CO_2 emissions compared to level of emissions in 1990. The most significant increase of CO_2 emissions was reported by Bulgaria, Germany, Hungary and Poland (which together represent 8% share on total EU emissions).

Table 3.33: 1.A.2.d Pulp, Paper and Print: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	2 208	1 800	1 811	7.8%	-397	-18%	11	1%	T1,T2	CS,D
Belgium	644	549	563	2.4%	-81	-13%	14	2%	T1,T3	D,PS
Bulgaria	16	95	110	0.5%	95	609%	16	17%	T1,T2	CS,D
Croatia	303	115	121	0.5%	-182	-60%	6	5%	T1	D
Cyprus	5	3	3	0.0%	-1	-28%	0	12%	T1	D
Czechia	2 285	472	779	3.4%	-1 507	-66%	306	65%	T1,T2	CS,D
Denmark	343	56	59	0.3%	-284	-83%	3	5%	T1,T2,T3	CS,D
Estonia	145	63	56	0.2%	-89	-61%	-7	-10%	T1,T2	CS,D
Finland	5 330	2 185	2 206	9.6%	-3 123	-59%	21	1%	T3	CS,D
France	4 449	2 254	2 441	10.6%	-2 008	-45%	187	8%	T2	CS
Germany	4	8	11	0.0%	7	196%	3	38%	CS	CS
Greece	306	84	86	0.4%	-220	-72%	2	3%	T2	CS
Hungary	74	417	380	1.6%	306	415%	-36	-9%	T1,T2,T3	CS,D,PS
Ireland	28	18	17	0.1%	-11	-40%	0	-3%	T2	CS
Italy	3 108	4 665	5 308	23.0%	2 200	71%	643	14%	T2	CS
Latvia	168	5	6	0.0%	-163	-97%	1	24%	T2	CS
Lithuania	255	32	30	0.1%	-225	-88%	-2	-5%	T2	CS
Luxembourg	NO,IE	0	1	0.0%	1	∞	0	32%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	1 668	848	919	4.0%	-750	-45%	70	8%	T2	CS
Poland	284	1 335	1 436	6.2%	1 151	405%	101	8%	T1,T2	CS,D
Portugal	754	1 235	968	4.2%	214	28%	-267	-22%	T1	D
Romania	NO	205	347	1.5%	347	∞	142	69%	T1,T2,T3	CS,D,PS
Slovakia	2 329	390	296	1.3%	-2 033	-87%	-94	-24%	T2	CS
Slovenia	381	276	244	1.1%	-137	-36%	-33	-12%	T1,T2,T3	CS,D,PS
Spain	2 600	4 088	4 239	18.4%	1 638	63%	150	4%	T1,T2,T3	CS,D,PS
Sweden	2 156	616	660	2.9%	-1 496	-69%	43	7%	T2	CS
EU-27	**29 844**	**21 816**	**23 096**	**100%**	**-6 748**	**-23%**	**1 281**	**6%**	**-**	**-**

Emissions of Luxembourg from 1990 to 1999 are included in 1.A.2.g. Emissions of Malta are reported in 1.A.2.g. Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

1.A.2.d Pulp, Paper and Print – Liquid Fuels (CO_2)

CO_2 emissions from the use of liquid fuels in category 1.A.2.d amounted 1 710 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 84% and compared to 2020 increased by 4%. Category has 0.4% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 84% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.34. Luxembourg, Malta and Netherlands report emissions as 'NO' (not occurring). Germany reports emissions as 'IE' (include elsewhere) and reports them in 1.A.2.g Other. Six Member States use Tier 1 methodology for emission estimates, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 92% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.d – Liquid Fuels (CO_2)). All Member States reported lower level of emissions in 2021 than in 1990 (except of Poland, which has 9% share on total EU emissions in 2021).

Table 3.34: 1.A.2.d Pulp, Paper and Print, Liquid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	853	13	20	1.2%	-833	-98%	6	48%	T2	CS
Belgium	235	8	5	0.3%	-230	-98%	-3	-41%	T1,T3	D,PS
Bulgaria	16	1	1	0.1%	-14	-91%	0	8%	NA	NA
Croatia	58	2	3	0.2%	-56	-95%	0	13%	T1	D
Cyprus	5	3	3	0.2%	-1	-28%	0	12%	T1	D
Czechia	461	11	10	0.6%	-450	-98%	0	-1%	T1	CS,D
Denmark	94	5	6	0.4%	-88	-93%	2	41%	T1,T2	CS,D
Estonia	145	1	1	0.0%	-145	-100%	0	5%	T1,T2	CS,D
Finland	1 138	398	369	21.6%	-768	-68%	-29	-7%	T3	CS
France	1 352	107	211	12.4%	-1 141	-84%	105	98%	T2	CS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	302	51	50	2.9%	-252	-83%	-1	-1%	T2	CS
Hungary	19	3	3	0.2%	-16	-84%	0	0%	T1	D
Ireland	28	2	2	0.1%	-27	-93%	0	4%	T2	CS
Italy	1 017	15	27	1.6%	-989	-97%	12	78%	T2	CS
Latvia	16	0	0	0.0%	-15	-98%	0	25%	T2	CS
Lithuania	69	1	1	0.1%	-67	-98%	0	35%	T2	CS
Luxembourg	IE	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	2	NO	NO	-	-2	-100%	-	-	NA	NA
Poland	106	114	150	8.8%	44	42%	36	31%	T1,T2	CS,D
Portugal	754	239	113	6.6%	-641	-85%	-126	-53%	T1	D
Romania	NO	1	2	0.1%	2	∞	0	26%	T1,T2	CS,D
Slovakia	985	3	3	0.1%	-982	-100%	0	-6%	T2	CS
Slovenia	98	1	3	0.2%	-95	-97%	2	206%	T1	D
Spain	1 247	155	170	9.9%	-1 077	-86%	15	10%	T1,T2,T3	CS,D,PS
Sweden	1 786	513	555	32.5%	-1 230	-69%	43	8%	T2	CS
EU-27	**10 783**	**1 647**	**1 710**	**100%**	**-9 074**	**-84%**	**63**	**4%**	**-**	**-**

Emissions of Germany are included in 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.61 shows CO_2 emissions trend as well as the share of countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Sweden (32%), Finland (22%), France (12%), Spain (10%), Poland (9%) and Portugal (7%) which together represent 92% share on EU emissions.

Figure 3.61: 1.A.2.d Pulp, Paper and Print, Liquid fuels: Emission trend and share for CO_2

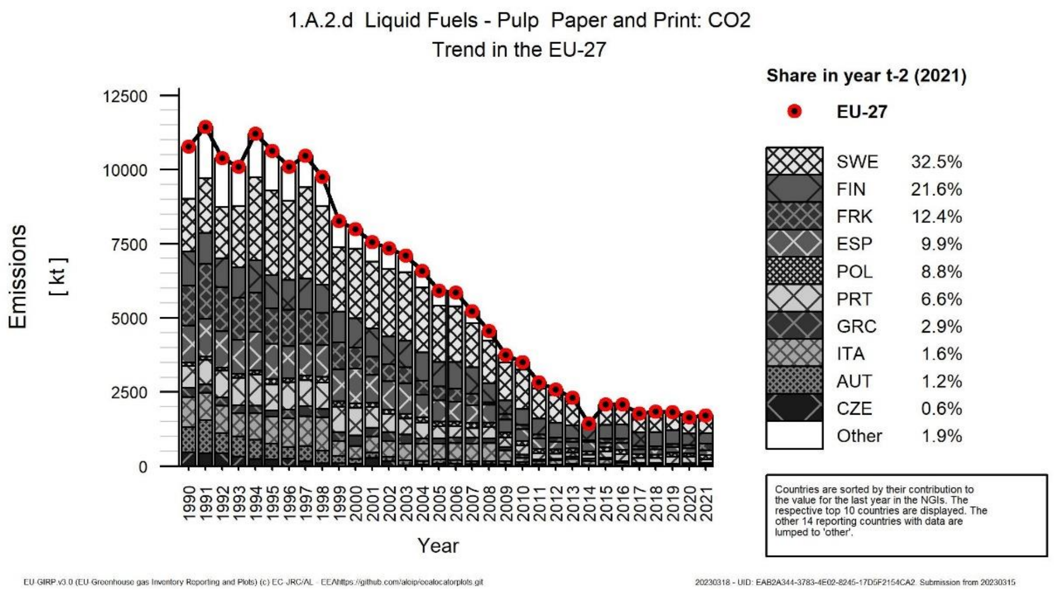


Figure.3.62 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that CO_2 IEF is decreasing during whole time period, which is caused by increasing consumption of Liquified Petroleum Gas with lower CO_2 IEF and decreasing consumption of Heavy Fuel Oil with higher CO_2 IEF. Peak in 2014 IEF was caused by SWE which reported data as C but it is reflected in EU IEF estimation for that year. CO_2 IEF equaled to 74.82 t/TJ in 2021.

Figure.3.62: 1.A.2.d Pulp, Paper and Print, Liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)

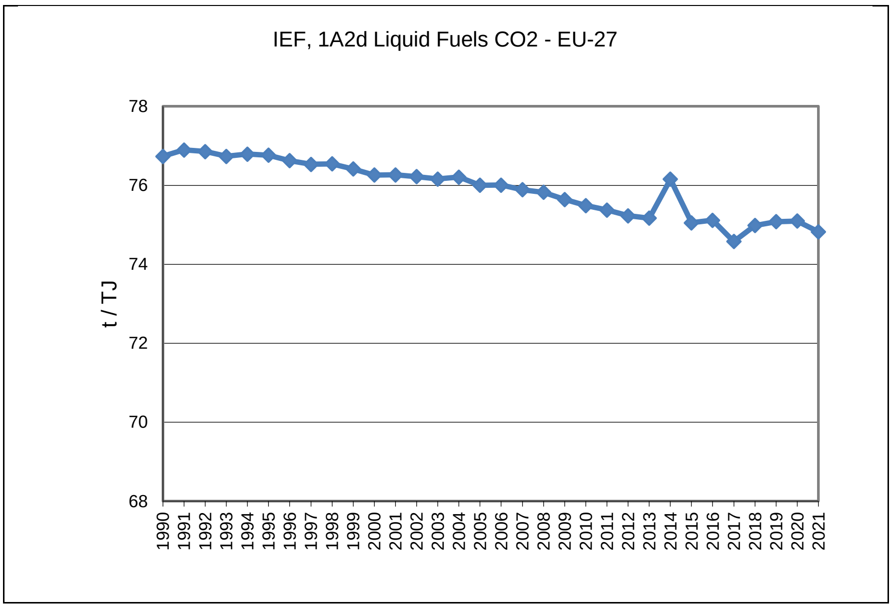
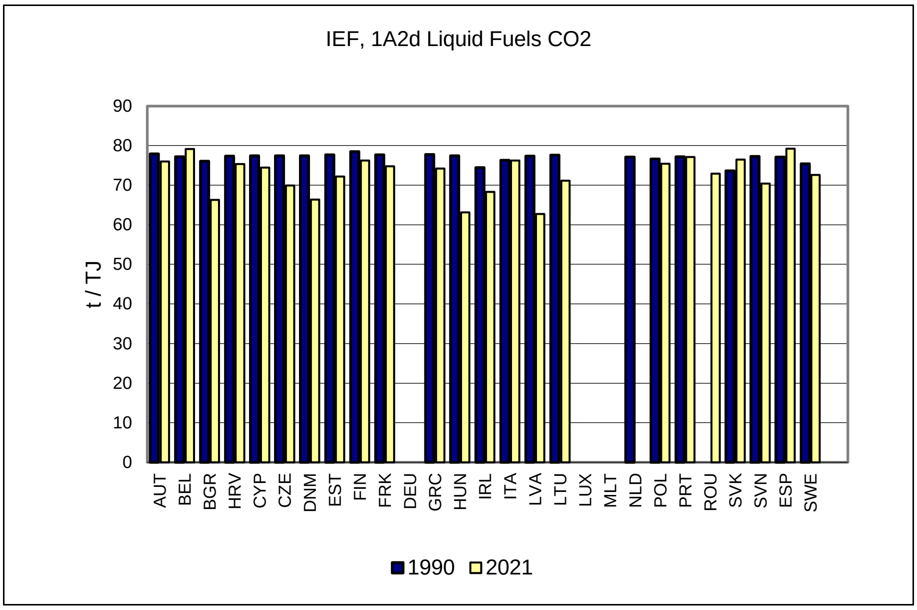


Figure.3.63 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. No major differences between countries CO_2 IEF occur.

Figure.3.63: 1.A.2.d Pulp, Paper and Print, Liquid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.d Pulp, Paper and Print - Solid Fuels (CO_2)

CO_2 emissions from the use of solid fuels in category 1.A.2.d amounted 1 882 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 72% and almost without the change between current and previous year submission. This category represents 0.4% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 71% compared to 1990.

Detailed data related to the EU submissions are depicted in Table **3.35**. Fifteen Member States report emissions as 'NO' (not occurring). Germany reports emissions as 'IE' (include elsewhere) and reports them in 1.A.2.g Other. Belgium uses for emission estimates Tier 1 methodology, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 96% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.d – Solid Fuels (CO_2)). All Member States reported lower level of emissions in 2021 than in 1990 (except for Hungary and Poland which together have 43% share on EU emissions).

Table 3.35: 1.A.2.d Pulp, Paper and Print, solid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	398	298	210	11.1%	-189	-47%	-88	-30%	T2	CS
Belgium	128	95	73	3.9%	-55	-43%	-22	-23%	T1	D
Bulgaria	NO	4	11	0.6%	11	∞	7	174%	T1,T2	CS,D
Croatia	68	NO	NO	-	-68	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	1 646	169	361	19.2%	-1 285	-78%	192	114%	T2	CS,D
Denmark	125	NO	NO	-	-125	-100%	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	1 318	164	224	11.9%	-1 094	-83%	60	37%	T3	CS
France	1 034	51	57	3.0%	-977	-95%	6	12%	T2	CS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	4	NO	NO	-	-4	-100%	-	-	NA	NA
Hungary	6	189	130	6.9%	125	2239%	-59	-31%	T3	PS
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	6	NO	NO	-	-6	-100%	-	-	NA	NA
Latvia	3	NO	NO	-	-3	-100%	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	8	NO	NO	-	-8	-100%	-	-	NA	NA
Poland	173	628	681	36.2%	508	294%	53	8%	T1,T2	CS,D
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	1 142	205	102	5.4%	-1 040	-91%	-102	-50%	T2	CS
Slovenia	172	64	27	1.4%	-145	-84%	-37	-58%	T3	PS
Spain	277	NO	NO	-	-277	-100%	-	-	NA	NA
Sweden	265	13	7	0.4%	-258	-97%	-6	-49%	T2	CS
EU-27	**6 770**	**1 879**	**1 882**	**100%**	**-4 888**	**-72%**	**3**	**0%**	**-**	**-**

Emissions of Germany are included in 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.64 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Poland (36%), Czechia (19%), Finland (12%) and Austria (11%) which together represent 78% share on EU emissions.

Figure 3.64: 1.A.2.d Pulp, Paper and Print, Solid fuels: Emission trend and share for CO_2

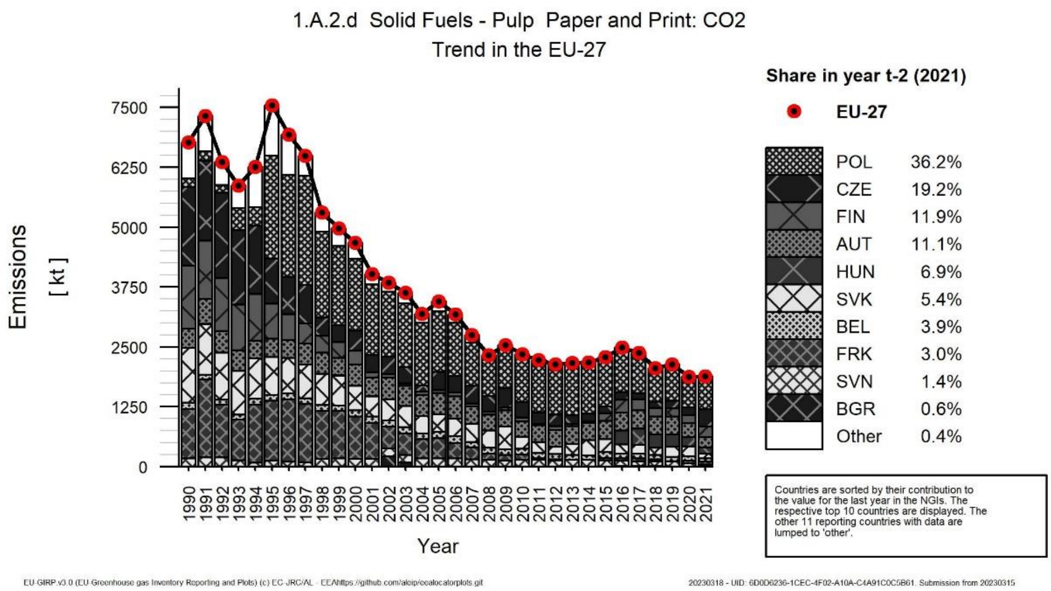


Figure 3.65 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. CO_2 IEF equalled to 93.81 t/TJ in 2021.

Figure 3.65: 1.A.2.d Pulp, Paper and Print, Solid fuels: Implied Emission Factors for CO_2 (in t/TJ)

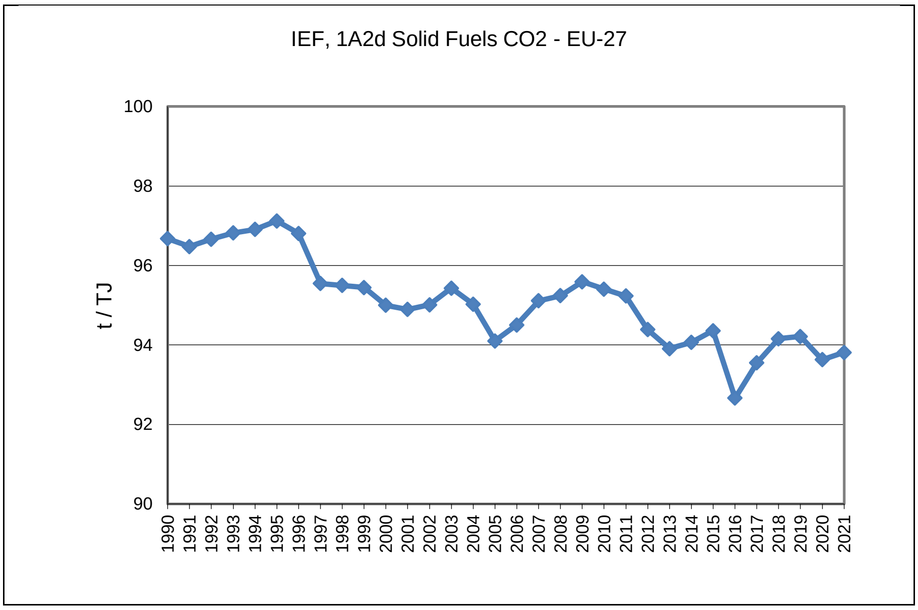
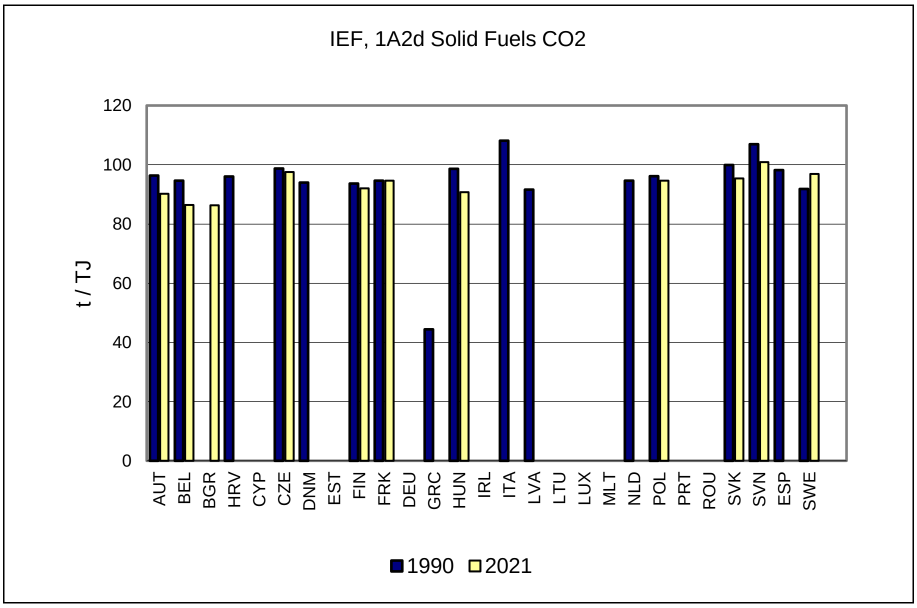


Figure 3.66 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021.

Figure 3.66: 1.A.2.d Pulp, Paper and Print, Solid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.d Pulp, Paper and Print - Gaseous Fuels (CO_2)

CO_2 emissions from the use of gaseous fuels in category 1.A.2.d amounted 18 452 kt in 2021 for EU. CO_2 emissions increased compared to year 1990 by 66% and compared to 2020 by 8%. This category has 4% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption increased by 64% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.36. Cyprus and Malta report emissions as 'NO' (not occurring). Germany reports emissions as 'IE' (include elsewhere) and reports them in 1.A.2.g Other. Belgium, Croatia and Portugal use Tier 1 methodology for emission estimates, the rest of Member States use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 93% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.d – Gaseous Fuels (CO_2)). Seven Member States reported lower level of emissions in 2021 than in 1990, the rest of Member States reported increase of emissions compared to 1990. Most rapid increase of emissions compared to 1990 was reported by Poland, Spain, Hungary, Italy and Czechia (which together have 57% share on total EU emissions).

Table 3.36: 1.A.2.d Pulp, Paper and Print, Gaseous fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	943	1 480	1 580	8.6%	637	68%	100	7%	T2	CS
Belgium	282	328	353	1.9%	72	25%	25	8%	T1	D
Bulgaria	NO	89	97	0.5%	97	∞	8	9%	T2	CS
Croatia	177	113	119	0.6%	-58	-33%	6	5%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	179	293	407	2.2%	229	128%	115	39%	T2	CS
Denmark	124	51	52	0.3%	-72	-58%	1	2%	T3	CS
Estonia	NO	62	56	0.3%	56	∞	-7	-11%	T2	CS
Finland	1 757	856	934	5.1%	-823	-47%	78	9%	T3	CS
France	2 063	2 077	2 146	11.6%	83	4%	69	3%	T2	CS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	NO	34	36	0.2%	36	∞	3	8%	T2	CS
Hungary	50	127	149	0.8%	99	200%	21	17%	T2	CS
Ireland	NO	16	15	0.1%	15	∞	-1	-4%	T2	CS
Italy	2 085	4 649	5 280	28.6%	3 196	153%	631	14%	T2	CS
Latvia	150	4	5	0.0%	-145	-96%	1	24%	T2	CS
Lithuania	187	31	29	0.2%	-158	-85%	-2	-6%	T2	CS
Luxembourg	IE	0	1	0.0%	1	∞	0	32%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	1 659	848	919	5.0%	-740	-45%	70	8%	T2	CS
Poland	6	517	547	3.0%	541	9704%	30	6%	T2	CS
Portugal	NO	996	855	4.6%	855	∞	-141	-14%	T1	D
Romania	NO	190	330	1.8%	330	∞	140	74%	T2,T3	CS,PS
Slovakia	203	183	191	1.0%	-11	-6%	8	4%	T2	CS
Slovenia	110	209	213	1.2%	103	93%	4	2%	T2	CS
Spain	1 077	3 934	4 069	22.1%	2 992	278%	135	3%	T2,T3	CS,PS
Sweden	66	58	68	0.4%	2	4%	10	17%	T2	CS
EU-27	**11 115**	**17 146**	**18 452**	**100%**	**7 337**	**66%**	**1 306**	**8%**	**-**	**-**

Emissions of Germany are included in 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.67 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest share on total CO_2 emissions (above the average share calculated for EU) correspond to Italy (29%), Spain (22%), France (11%), Austria (9%) and Finland, Netherlands and Portugal (5%) which together have 86% share on EU emissions.

Figure 3.67: 1.A.2.d Pulp, Paper and Print, Gaseous fuels: Emission trend and share for CO_2

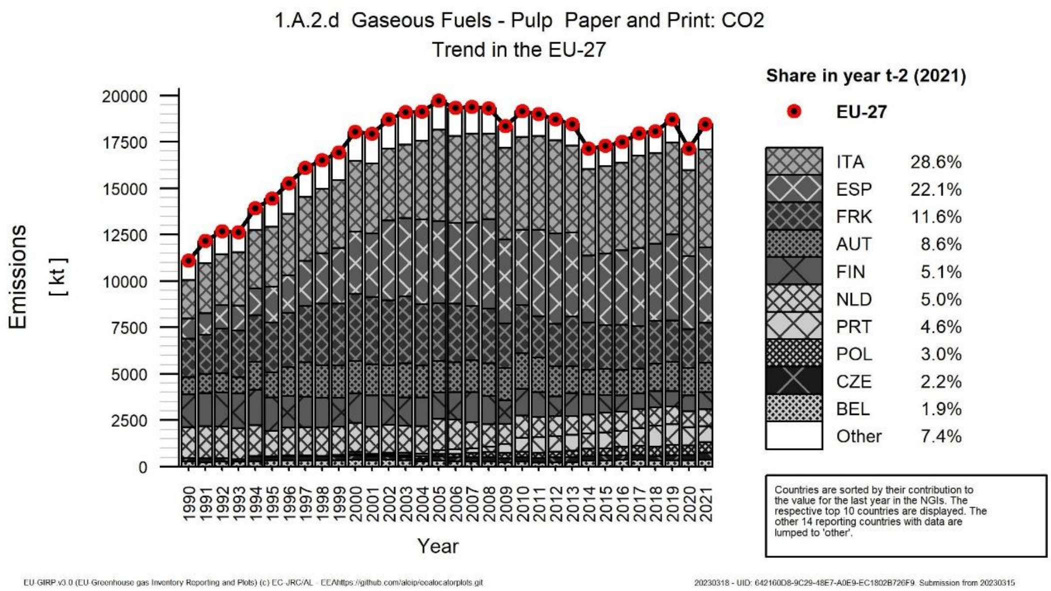


Figure 3.68 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. CO_2 IEF shows relatively stable slightly increasing trend without major fluctuations for whole time series. The main reason for increasing trend of the CO_2 IEF is the growing share of Italy and Spain on total EU emissions; their CO_2 IEFs have been slightly growing since 1990. CO_2 IEF equalled to 56.87 t/TJ in 2021.

Figure 3.68: 1.A.2.d Pulp, Paper and Print, Gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)

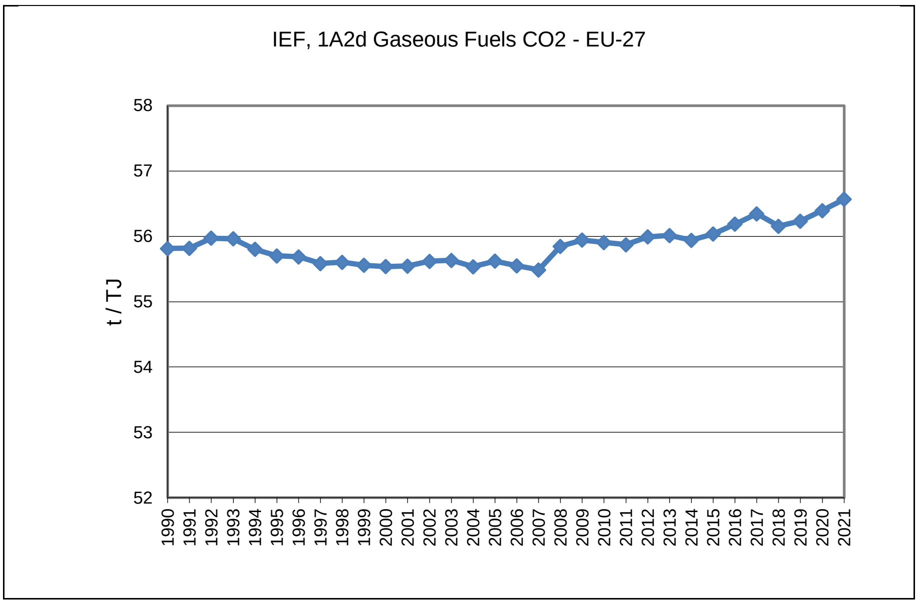
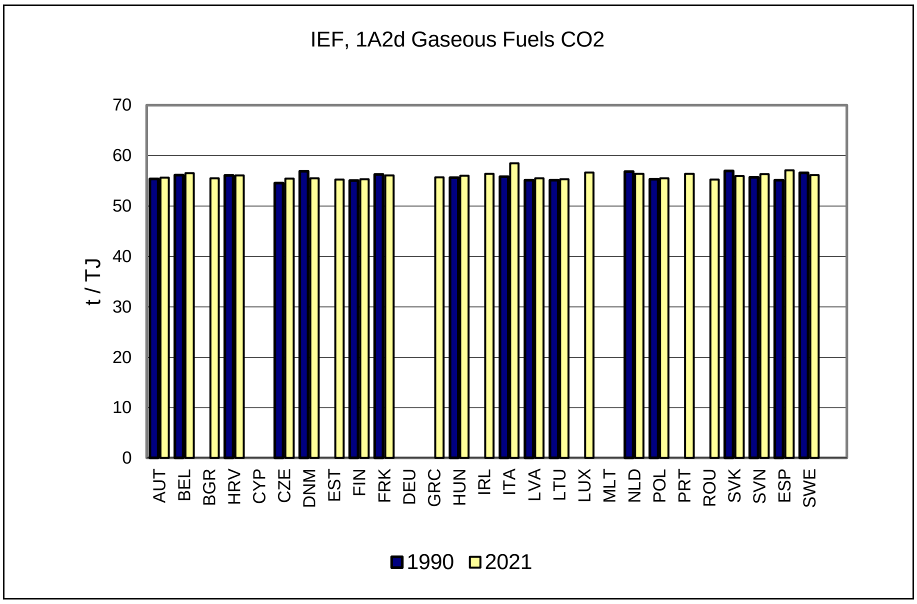


Figure 3.69 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. It can be seen that no major differences between CO_2 IEF used by countries occur, also no major differences between 1990 and 2021 CO_2 IEFs occur.

Figure 3.69: 1.A.2.d Pulp, Paper and Print, Gaseous fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



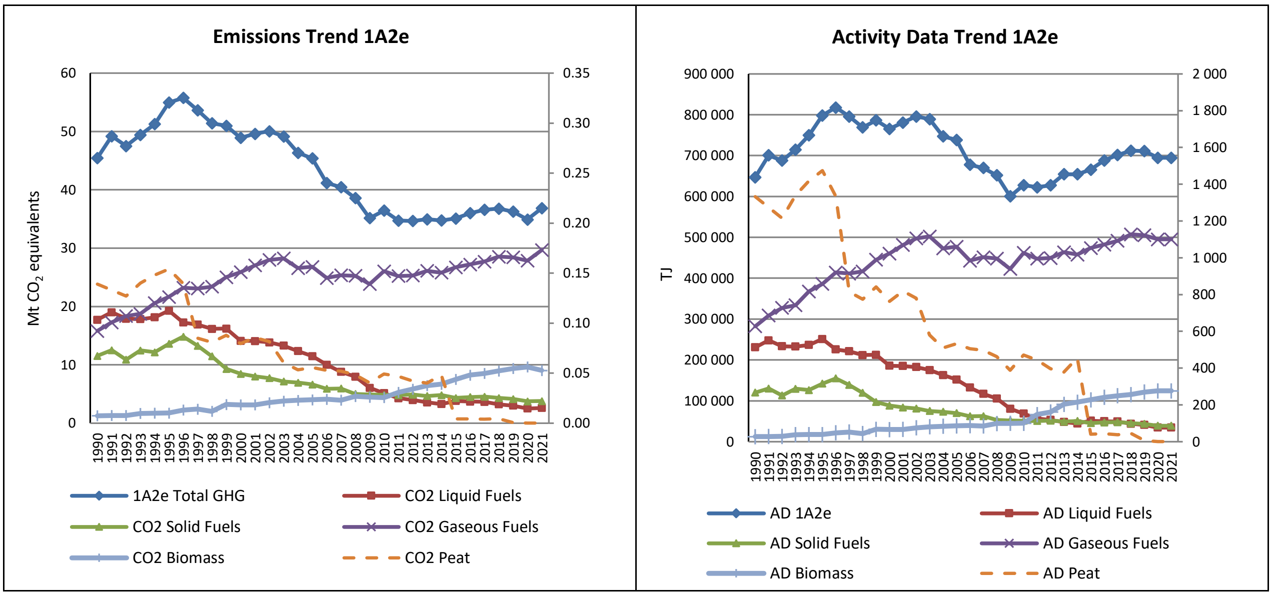
3.2.2.5 Food Processing, Beverages and Tobacco (1.A.2.e)

This chapter provides information about European emission trend, Member States contribution to the overall emission trend, activity data and emission factors used for emission estimates by countries for category 1.A.2.e Food Processing, Beverages and Tobacco.

Total CO_2 emissions from 1.A.2.e amounted to 36 143 kt CO_2 eq. in 2021. The trend of total CO_2 emissions for 1990 to 2021 from category 1.A.2.e is depicted in Figure 3.70. Total CO_2 emissions decreased by 20% since 1990 and increased by 6% between 2020 and 2021. CO_2 emissions from 1.A.2.e Food Processing, Beverages and Tobacco accounted for 8% of 1.A.2. source category.

Figure 3.70 shows the emission trend within the category 1.A.2.e, which is dominated by CO_2 emissions from gaseous fuels in 2021. The share of liquid fuels on CO_2 emissions from 1.A.2.e decreased from 39% in 1990 to 7% in 2021. The share of solid fuels on CO_2 emissions from 1.A.2.e decreased from 26% in 1990 to 10% in 2021. The share of gaseous fuels on CO_2 emissions from 1.A.2.e increased from 35% in 1990 to 82% in 2021.

Figure 3.70: 1.A.2.e Food Processing, Beverages and Tobacco: Total and CO_2 emission and activity trends



Data displayed as dashed line refers to the secondary axis.

Detailed data related to the EU submissions are depicted in Table 3.37. Malta reports emissions as 'NO' (not occurring). Five Member States reported increase of CO_2 emissions compared to level of emissions in 1990. The highest increase of CO_2 emissions was reported by Romania which represent 3% share on total EU emissions.

Table 3.37: 1.A.2.e Food Processing, Beverages and Tobacco: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	870	790	794	2.2%	-75	-9%	5	1%	T1,T2	CS,D
Belgium	3 023	2 295	2 463	6.8%	-560	-19%	168	7%	T1,T3	D,PS
Bulgaria	454	223	318	0.9%	-136	-30%	95	43%	T1,T2	CS,D
Croatia	729	295	242	0.7%	-487	-67%	-53	-18%	T1	D
Cyprus	73	62	64	0.2%	-9	-12%	2	3%	T1	D
Czechia	2 988	995	1 181	3.3%	-1 807	-60%	186	19%	T1,T2	CS,D
Denmark	1 651	901	907	2.5%	-744	-45%	6	1%	T1,T2,T3	CS,D
Estonia	695	98	82	0.2%	-613	-88%	-16	-16%	T1,T2	CS,D
Finland	828	125	102	0.3%	-726	-88%	-23	-18%	T3	CS,D
France	8 524	7 621	8 232	22.8%	-292	-3%	611	8%	T2	CS
Germany	2 016	161	150	0.4%	-1 866	-93%	-11	-7%	CS	CS
Greece	917	555	611	1.7%	-305	-33%	56	10%	T1,T2	CS,D
Hungary	2 029	841	868	2.4%	-1 161	-57%	27	3%	T1,T2	CS,D
Ireland	1 017	1 090	1 069	3.0%	51	5%	-22	-2%	T1,T2	CS,D
Italy	3 891	3 472	3 815	10.6%	-76	-2%	343	10%	T2	CS
Latvia	840	88	93	0.3%	-747	-89%	6	6%	T1,T2	CS,D
Lithuania	676	242	236	0.7%	-441	-65%	-7	-3%	T2	CS
Luxembourg	5	12	14	0.0%	8	155%	1	12%	T1,T2,T3	CS,D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	4 009	3 451	3 529	9.8%	-480	-12%	79	2%	T2	CS
Poland	3 715	4 177	4 149	11.5%	434	12%	-28	-1%	T1,T2	CS,D
Portugal	830	740	706	2.0%	-125	-15%	-34	-5%	T1	CR,D
Romania	132	925	936	2.6%	804	611%	11	1%	T1,T2,T3	CS,D,PS
Slovakia	1 140	342	321	0.9%	-819	-72%	-21	-6%	T2	CS
Slovenia	221	91	95	0.3%	-126	-57%	4	4%	T1,T2	CS,D
Spain	2 998	4 356	4 901	13.6%	1 903	63%	545	13%	T1,T2	CS,D
Sweden	945	274	264	0.7%	-682	-72%	-11	-4%	T2	CS
EU-27	**45 218**	**34 222**	**36 143**	**100%**	**-9 074**	**-20%**	**1 921**	**6%**	**-**	**-**

Emissions of Malta are included in 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels (CO_2)

CO_2 emissions from the use of liquid fuels in category 1.A.2.e amounted 2 593 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 85% and compared to 2020 increased by 3%. This category represents 0.6% share of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 84% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.38. Malta reports emissions as 'NO' (not occurring). Nine Member States use for emission estimates Tier 1 methodology, the rest of Member States use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 69% of countries emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.e – Liquid Fuels (CO_2)). All countries reported lower level of emissions in 2021 than in 1990 (except for Luxembourg which has 0.1% share on EU emissions).

Table 3.38: 1.A.2.e Food Processing, Beverages and Tobacco, liquid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	345	29	38	1.5%	-307	-89%	9	30%	T2	CS
Belgium	1 689	44	44	1.8%	-1 644	-97%	1	2%	T1	D
Bulgaria	409	25	23	0.9%	-387	-94%	-2	-10%	T1	D
Croatia	342	44	45	1.8%	-298	-87%	1	2%	T1	D
Cyprus	73	62	64	2.6%	-9	-12%	2	3%	T1	D
Czechia	472	21	27	1.1%	-445	-94%	5	24%	T1	CS,D
Denmark	786	202	195	7.8%	-590	-75%	-6	-3%	T1,T2	CS,D
Estonia	695	28	22	0.9%	-673	-97%	-6	-21%	T1,T2	CS,D
Finland	365	68	51	2.0%	-314	-86%	-17	-25%	T3	CS
France	2 995	194	387	15.5%	-2 608	-87%	193	99%	T2	CS
Germany	908	14	9	0.3%	-899	-99%	-5	-36%	CS	CS
Greece	863	443	457	18.3%	-406	-47%	14	3%	T2	CS
Hungary	616	32	26	1.0%	-589	-96%	-6	-18%	T1	D
Ireland	433	191	189	7.5%	-244	-56%	-2	-1%	T1,T2	CS,D
Italy	1 424	50	13	0.5%	-1 411	-99%	-37	-75%	T2	CS
Latvia	565	9	6	0.3%	-559	-99%	-3	-31%	T2	CS
Lithuania	174	36	32	1.3%	-142	-82%	-4	-11%	T2	CS
Luxembourg	2	3	3	0.1%	1	78%	0	-5%	T1,T3	CS,D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	165	0	0	0.0%	-164	-100%	0	-12%	NA	NA
Poland	232	175	171	6.8%	-61	-26%	-4	-2%	T1,T2	CS,D
Portugal	829	171	151	6.0%	-678	-82%	-20	-12%	T1	CR,D
Romania	NO	114	119	4.7%	119	∞	5	5%	T1,T2,T3	CS,D,PS
Slovakia	359	1	1	0.0%	-358	-100%	0	-13%	T2	CS
Slovenia	146	19	17	0.7%	-129	-89%	-2	-12%	T1	D
Spain	2 244	539	413	16.5%	-1 831	-82%	-126	-23%	T1	D
Sweden	596	C	92	3.7%	-505	-85%	92	∞	T2	CS
EU-27	**17 129**	**2 513**	**2 502**	**100%**	**-14 627**	**-85%**	**-11**	**0%**	**-**	**-**

EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.71 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Greece (18%), Spain (16%), France (15%), Denmark (8%), Ireland (7%), Poland (7%), Portugal (6%) and Romania (5%) which together represent 80% share on EU emissions.

Figure 3.71: 1.A.2.e Food Processing, Beverages and Tobacco, Liquid fuels: Emission trend and share for CO_2

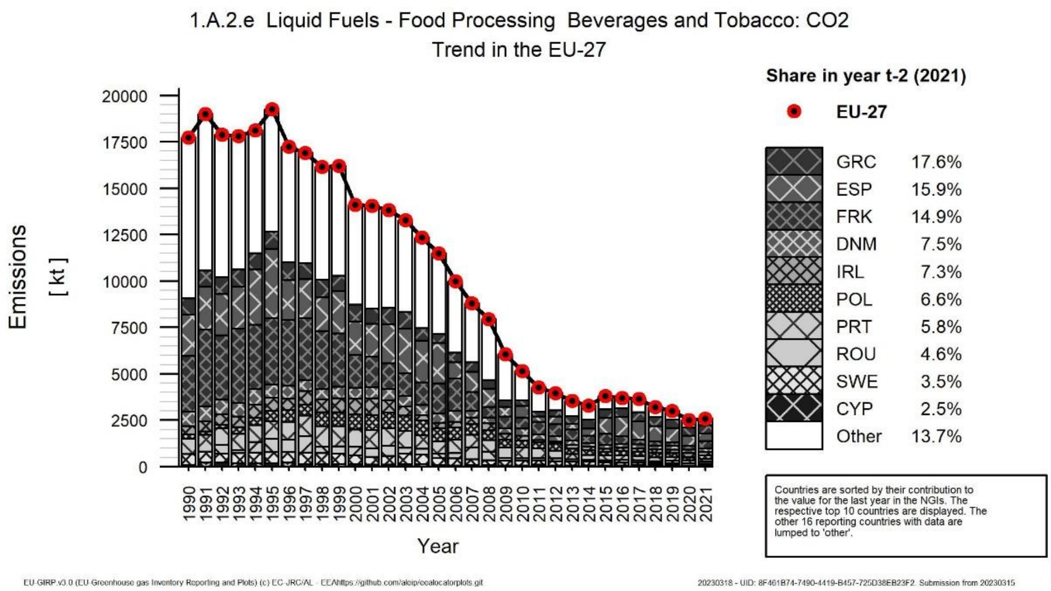


Figure 3.72 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that whole time series CO_2 IEF has decreasing trend with minor fluctuation between 2014 and 2018. CO_2 IEF equalled to 72.16 t/TJ in 2021.

Figure 3.72: 1.A.2.e Food Processing, Beverages and Tobacco, Liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)

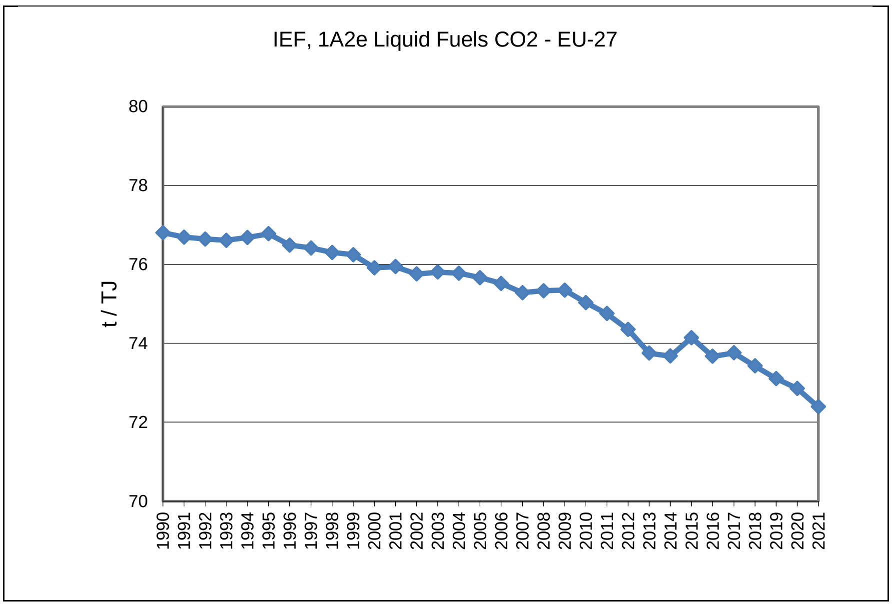
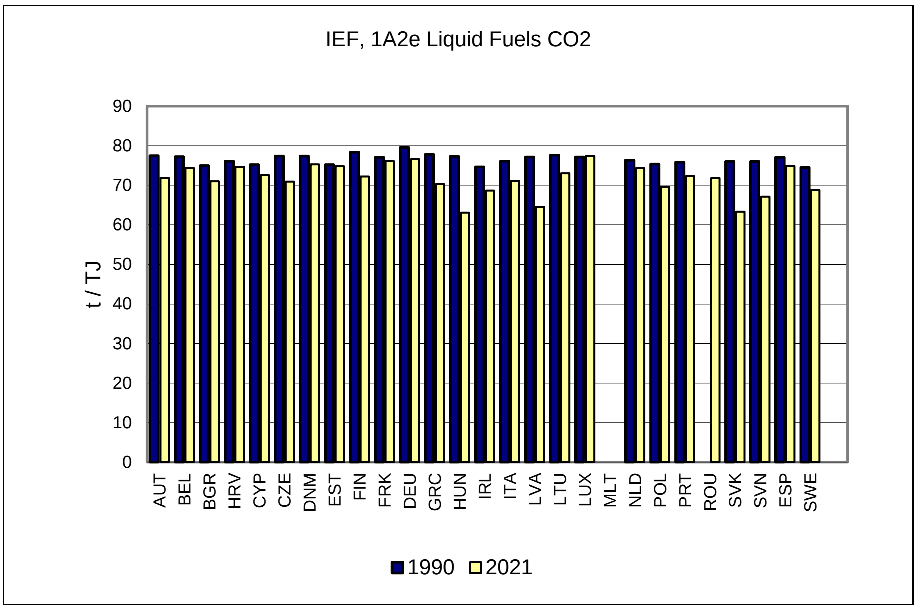


Figure 3.73 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. It can be seen that no major differences between CO_2 IEF used by countries occur. Also, no major differences between CO_2 IEF calculated in 1990 and 2021 occur.

Figure 3.73: 1.A.2.e Food Processing, Beverages and Tobacco, Liquid fuels: Implied Emissions for CO_2 by Member States (in t/TJ)



1.A.2.e Food Processing Beverages and Tobacco - Solid Fuels (CO_2)

CO_2 emissions from the use of solid fuels in category 1.A.2.e amounted 3 785 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 67% and compared to 2020 increased by 1%. This category represents 0.9% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 67% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.39. Eight Member States report emissions as 'NO' (not occurring). Belgium, Croatia and Denmark use for emission estimates Tier 1 methodology, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 95% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.e – Solid Fuels (CO_2)). All countries reported lower level of emissions in 2021 than in 1990.

Table 3.39: 1.A.2.e Food Processing, Beverages and Tobacco, Solid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	18	12	13	0.4%	-5	-26%	1	13%	T2	CS
Belgium	651	88	42	1.1%	-608	-93%	-46	-52%	T1	D
Bulgaria	33	4	4	0.1%	-29	-88%	0	13%	T1,T2	CS,D
Croatia	207	32	6	0.2%	-201	-97%	-26	-82%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	1 789	180	310	8.2%	-1 479	-83%	131	73%	T2	CS,D
Denmark	399	116	124	3.3%	-275	-69%	8	7%	T1	D
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	257	36	19	0.5%	-237	-92%	-17	-46%	T3	CS
France	2 083	798	917	24.2%	-1 166	-56%	118	15%	T2	CS
Germany	1 108	147	141	3.7%	-967	-87%	-6	-4%	CS	CS
Greece	54	NO	NO	-	-54	-100%	-	-	NA	NA
Hungary	185	6	6	0.2%	-179	-97%	0	0%	T1,T2	CS,D
Ireland	292	NO	NO	-	-292	-100%	-	-	NA	NA
Italy	87	NO	5	0.1%	-82	-95%	5	∞	NA	NA
Latvia	100	2	1	0.0%	-99	-99%	-1	-35%	T2	CS
Lithuania	33	10	8	0.2%	-25	-76%	-3	-24%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	227	71	79	2.1%	-148	-65%	8	12%	T2	CS
Poland	3 374	2 101	1 998	52.8%	-1 376	-41%	-102	-5%	T1,T2	CS,D
Portugal	1	NO	NO	-	-1	-100%	-	-	NA	NA
Romania	132	5	5	0.1%	-126	-96%	0	8%	T2,T3	CS,PS
Slovakia	312	47	9	0.2%	-303	-97%	-38	-82%	T2	CS
Slovenia	9	NO	NO	-	-9	-100%	-	-	NA	NA
Spain	94	67	84	2.2%	-10	-10%	17	26%	T1,T2	CS,D
Sweden	91	11	13	0.3%	-78	-86%	1	12%	T2	CS
EU-27	**11 536**	**3 734**	**3 785**	**100%**	**-7 750**	**-67%**	**52**	**1%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.74 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Poland (53%), France (24%) and Czechia (8%) which together represent 85% share on EU emissions.

Figure 3.74: 1.A.2.e Food Processing, Beverages and Tobacco, solid fuels: Emission trend and share for CO_2

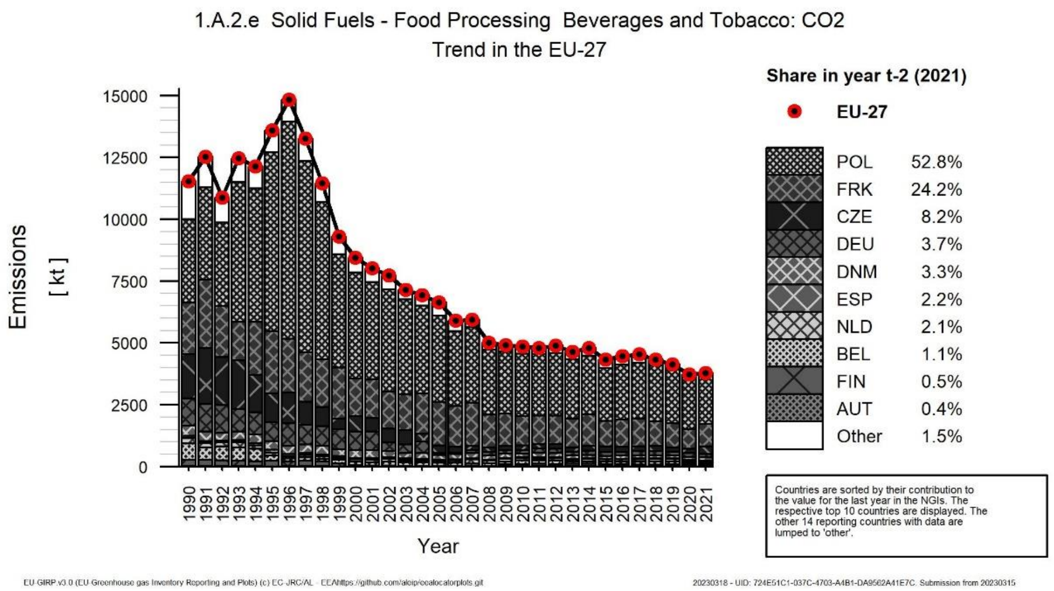


Figure 3.75 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that CO_2 IEF is relatively stable during whole time period with slightly increasing trend since 2006. CO_2 IEF equalled to 95.55 t/TJ in 2021.

Figure 3.75: 1.A.2.e Food Processing, Beverages and Tobacco, Solid fuels: Implied Emission Factors for CO_2 (in t/TJ)

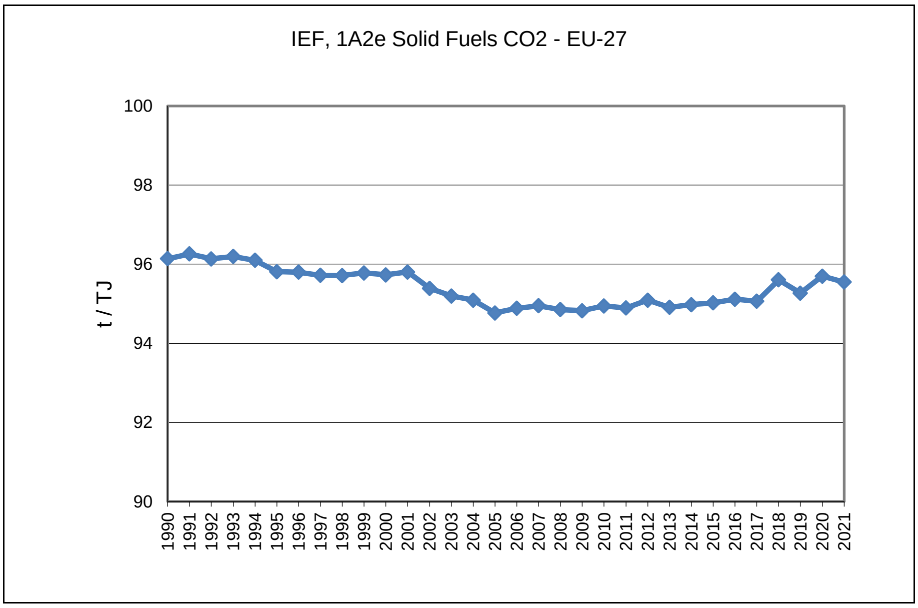
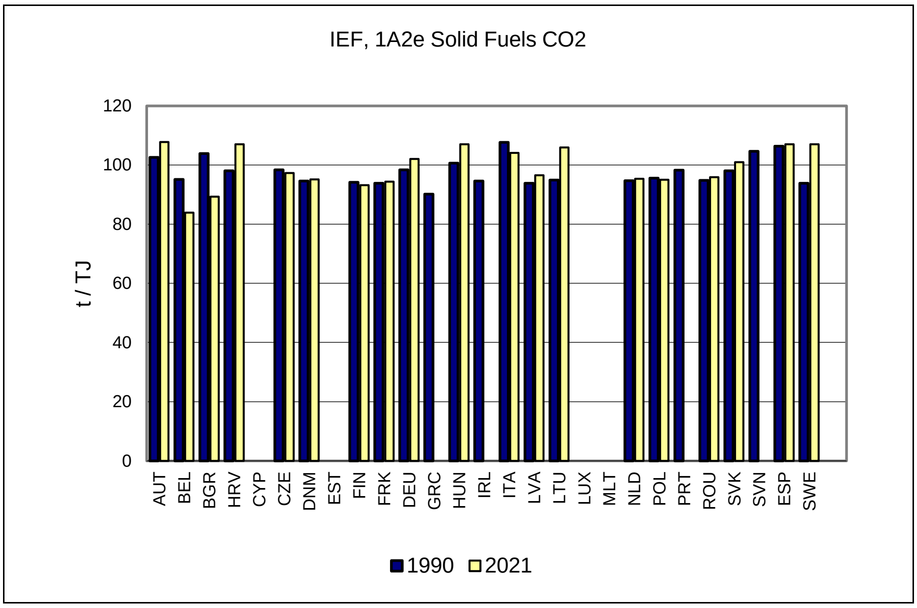


Figure 3.76 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021.

Figure 3.76: 1.A.2.e Food Processing, Beverages and Tobacco, Solid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.e Food Processing Beverages and Tobacco - Gaseous Fuels (CO_2)

CO_2 emissions from the use of gaseous fuels in category 1.A.2.e amounted 29 679 kt in 2021 for EU. CO_2 emissions increased compared to year 1990 by 88% and by 7% compared to 2020. This category represents 7% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption increased by 86% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.40. Cyprus and Malta report emissions as 'NO' (not occurring). For confidentiality reasons Germany reports emissions in 1.A.2.g. Croatia and Portugal use Tier 1 methodology for emission estimates, the rest of Member States use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 97% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.e – Gaseous Fuels (CO_2)). Seven Member States reported lower level of emissions in 2021 than in 1990, the rest of countries reported increase of emissions.

Table 3.40: 1.A.2.e Food Processing, Beverages and Tobacco, gaseous fuels: Member States contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	507	749	743	2.5%	237	47%	-5	-1%	T2	CS
Belgium	684	2 163	2 377	8.0%	1 692	247%	213	10%	T1,T3	D,PS
Bulgaria	11	194	291	1.0%	280	2448%	97	50%	T2	CS
Croatia	180	219	191	0.6%	11	6%	-27	-12%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	727	794	844	2.8%	117	16%	51	6%	T2	CS
Denmark	466	583	588	2.0%	122	26%	4	1%	T3	CS
Estonia	NO	70	60	0.2%	60	∞	-10	-14%	T2	CS
Finland	67	21	31	0.1%	-36	-53%	10	49%	T3	CS
France	3 446	6 628	6 870	23.1%	3 424	99%	241	4%	T2	CS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	NO	112	154	0.5%	154	∞	42	38%	T2	CS
Hungary	1 228	803	835	2.8%	-393	-32%	32	4%	T2	CS
Ireland	293	900	880	3.0%	587	200%	-19	-2%	T2	CS
Italy	2 380	3 422	3 797	12.8%	1 417	60%	375	11%	T2	CS
Latvia	175	77	86	0.3%	-89	-51%	9	12%	T2	CS
Lithuania	469	196	196	0.7%	-273	-58%	0	0%	T2	CS
Luxembourg	4	9	11	0.0%	7	188%	2	17%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	3 617	3 379	3 450	11.6%	-167	-5%	71	2%	T2	CS
Poland	109	1 901	1 980	6.7%	1 871	1716%	78	4%	T2	CS
Portugal	NO	569	555	1.9%	555	∞	-14	-3%	T1	D
Romania	NO	782	786	2.6%	786	∞	4	0%	T2,T3	CS,PS
Slovakia	470	294	312	1.1%	-158	-34%	18	6%	T2	CS
Slovenia	66	72	78	0.3%	13	19%	6	8%	T2	CS
Spain	660	3 750	4 404	14.8%	3 744	567%	654	17%	T2	CS
Sweden	254	171	159	0.5%	-94	-37%	-11	-7%	T2	CS
EU-27	**15 813**	**27 859**	**29 679**	**100%**	**13 866**	**88%**	**1 820**	**7%**	**-**	**-**

Emissions of Germany included in 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.77 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to France (23%), Spain (15%), Italy (13%), Netherland (12%), Belgium (8%) and Poland (7%) which together represent 77% share on EU emissions.

Figure 3.77: 1.A.2.e Food Processing, Beverages and Tobacco, Gaseous fuels: Emission trend and share for CO_2

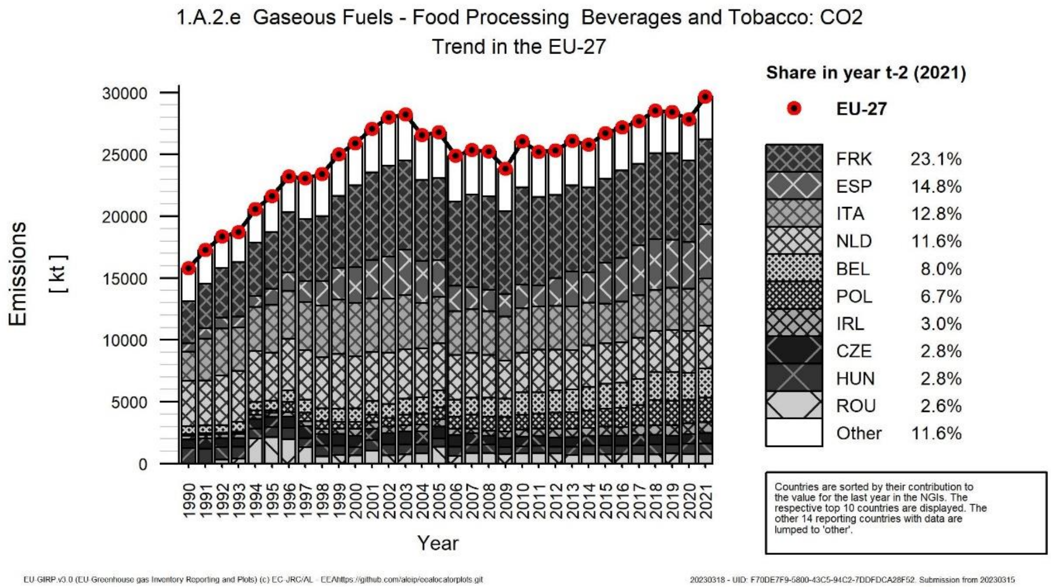


Figure 3.78 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021 which is stable during whole time period. CO_2 IEF equalled to 56.39 t/TJ in 2021.

Figure 3.78: 1.A.2.e Food Processing, Beverages and Tobacco, Gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)

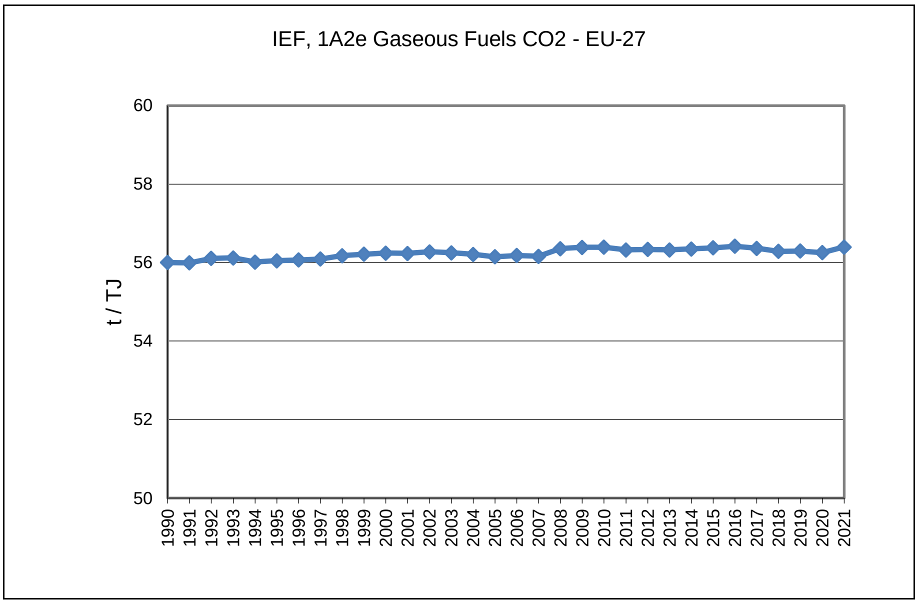
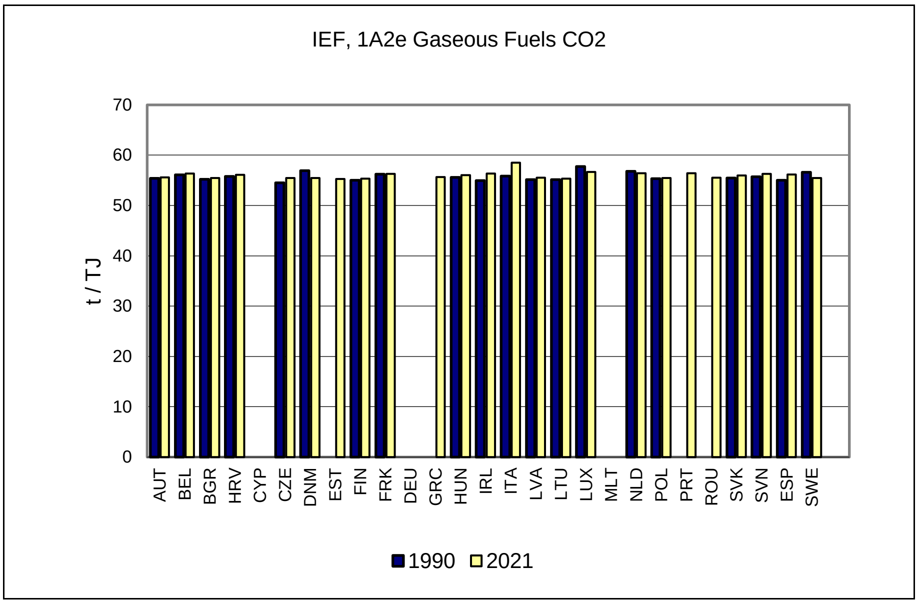


Figure 3.79 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. It can be seen that no major differences between CO_2 IEF used by countries occur, also no major differences between CO_2 IEF calculated by countries for 1990 and 2021 occur.

Figure 3.79: 1.A.2.e Food Processing, Beverages and Tobacco, Gaseous fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



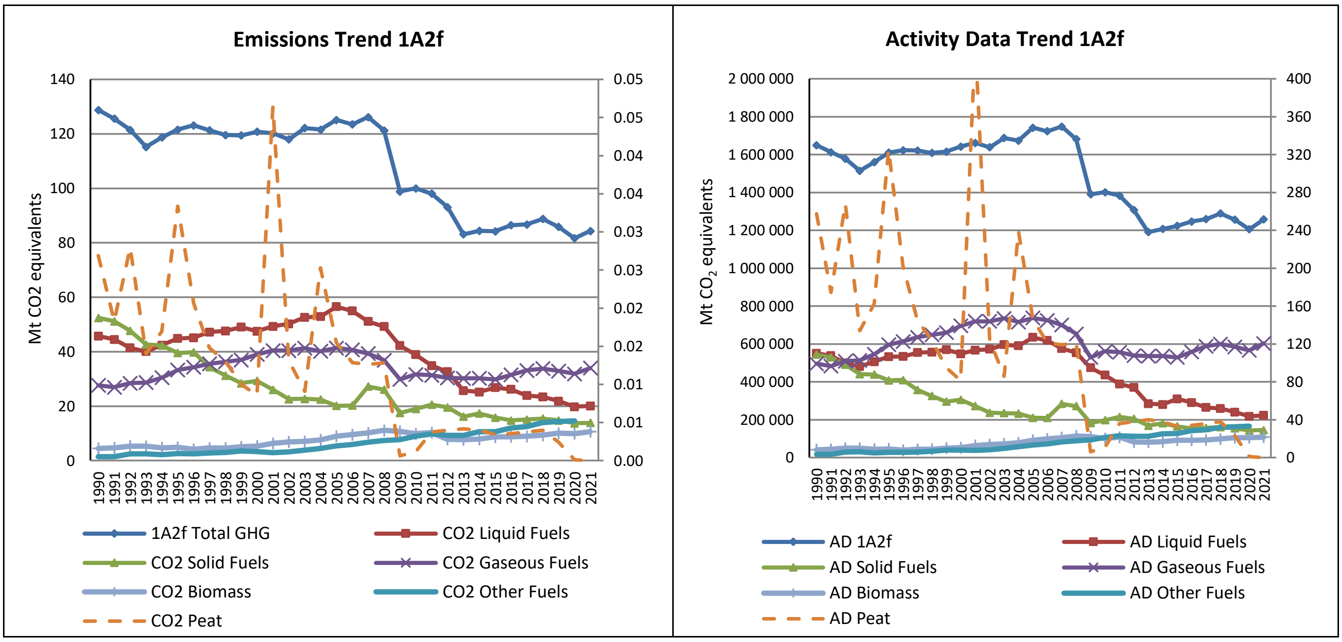
3.2.2.6 Non-metallic Minerals (1.A.2.f)

This chapter provides information about European emission trend, Member States contribution to the overall emission trend, activity data and emission factors used for emission estimates by countries for category 1.A.2.f Non-metallic Minerals.

Total CO_2 emissions from 1.A.2.f amounted to 83 196 kt CO_2 eq. in 2021. The trend of total emissions for 1990 to 2021 from category 1.A.2.f is depicted in Figure 3.80. Total CO_2 emissions decreased by 35% since 1990 and increased by 3% between 2020 and 2021. The sharp decline in 2009 is due to the economic crisis and sharp decline in building activity. CO_2 emissions from 1.A.2.f Non-metallic Minerals accounted for 19% of 1.A.2. source category.

Figure 3.80 shows the emission trend within the category 1.A.2.f, which is dominated by CO_2 emissions from gaseous fuels in 2021. The share of liquid fuels on CO_2 emissions from 1.A.2.f decreased from 36% in 1990 to 24% in 2021. The share of solid fuels on CO_2 emissions from 1.A.2.f decreased from 41% in 1990 to 17% in 2021. The share of gaseous fuels on CO_2 emissions from 1.A.2.f increased from 22% in 1990 to 41% in 2021.

Figure 3.80: 1.A.2.f Non-metallic Minerals: Activity data and CO_2 emission trends



Data displayed as dashed line refers to the secondary axis.

Detailed data related to the EU submissions are depicted in Table.3.41. Malta reports emissions as 'NO' (not occurring). Six Member States reported increase of CO_2 emissions compared to level of emissions in 1990. The highest increase of CO_2 emission was reported by Romania (1316%) which represents almost 5% share on total EU emissions.

Table.3.41: 1.A.2.f Non-metallic Minerals: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 669	1 654	1 682	2.0%	13	1%	27	2%	T1,T2	CS,D
Belgium	5 525	3 070	3 137	3.8%	-2 388	-43%	68	2%	T1,T3	D,PS
Bulgaria	2 646	1 007	1 024	1.2%	-1 622	-61%	17	2%	T1,T2	CS,D
Croatia	1 924	1 257	1 362	1.6%	-562	-29%	105	8%	T1	D
Cyprus	380	419	386	0.5%	7	2%	-33	-8%	CS,T1	CS,D
Czechia	4 527	2 629	2 671	3.2%	-1 857	-41%	42	2%	T1,T2	CS,D
Denmark	1 346	1 539	1 465	1.8%	119	9%	-74	-5%	T1,T2,T3	CS,D,PS
Estonia	1 053	114	85	0.1%	-968	-92%	-29	-25%	T1,T2,T3	CS,D,PS
Finland	1 368	568	584	0.7%	-784	-57%	16	3%	T3	CS,D
France	15 223	8 927	9 552	11.5%	-5 671	-37%	626	7%	T2,T3	CS,PS
Germany	18 507	12 560	12 150	14.6%	-6 358	-34%	-411	-3%	CS	CS
Greece	6 278	2 719	2 647	3.2%	-3 632	-58%	-72	-3%	T1,T2	CS,D,PS
Hungary	2 341	1 094	1 143	1.4%	-1 198	-51%	49	4%	T1,T2,T3	CS,D,PS
Ireland	819	1 058	1 218	1.5%	399	49%	160	15%	T1,T2,T3	CS,D,PS
Italy	21 045	10 348	11 194	13.5%	-9 851	-47%	846	8%	T2	CS
Latvia	599	292	264	0.3%	-335	-56%	-28	-10%	T1,T2	CS,D,PS
Lithuania	3 210	414	484	0.6%	-2 726	-85%	70	17%	T2	CS,OTH
Luxembourg	537	357	334	0.4%	-202	-38%	-22	-6%	T1,T2,T3	CS,D,PS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	2 298	1 193	1 216	1.5%	-1 081	-47%	24	2%	T2	CS
Poland	10 340	8 977	9 201	11.1%	-1 139	-11%	223	2%	T1,T2	CS,D
Portugal	3 289	2 605	2 509	3.0%	-780	-24%	-96	-4%	T1,T3	D,PS
Romania	285	3 631	4 036	4.9%	3 751	1316%	405	11%	T1,T2,T3	CS,D,PS
Slovakia	3 408	1 408	1 424	1.7%	-1 984	-58%	16	1%	T2	CS
Slovenia	297	435	456	0.5%	159	53%	21	5%	T1,T2,T3	CS,D,PS
Spain	16 573	11 226	11 908	14.3%	-4 665	-28%	683	6%	T1,T2	CS,D,PS
Sweden	1 832	1 126	1 064	1.3%	-768	-42%	-61	-5%	T1,T2	CS
EU-27	**127 319**	**80 624**	**83 196**	**100%**	**-44 123**	**-35%**	**2 572**	**3%**	**-**	**-**

Malta includes emissions under 1.A.2.g.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

1.A.2.f Non-metallic Minerals - Liquid Fuels (CO_2)

CO_2 emissions from the use of liquid fuels in category 1.A.2.f amounted 20 068 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 56% and compared to 2020 increased by 2%. Category has 4.6% share on total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 60% compared to 1990. One of the reasons for the decline is increase in the use of waste as a fuel.

Detailed data related to the EU submissions are depicted in Table **3.42**. Sweden reports emissions as 'C' (confidential) since 2016 in order to comply with the Public Access to Information and Secrecy Act of the Swedish law. This decision was made based on the results of the internal review. Malta reports emissions as 'NO' (not occurring). Four Member States use Tier 1 methodology for emission estimates, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 96% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.f – Liquid Fuels (CO_2)). Four Member States reported higher level of emissions in 2021 than in 1990.

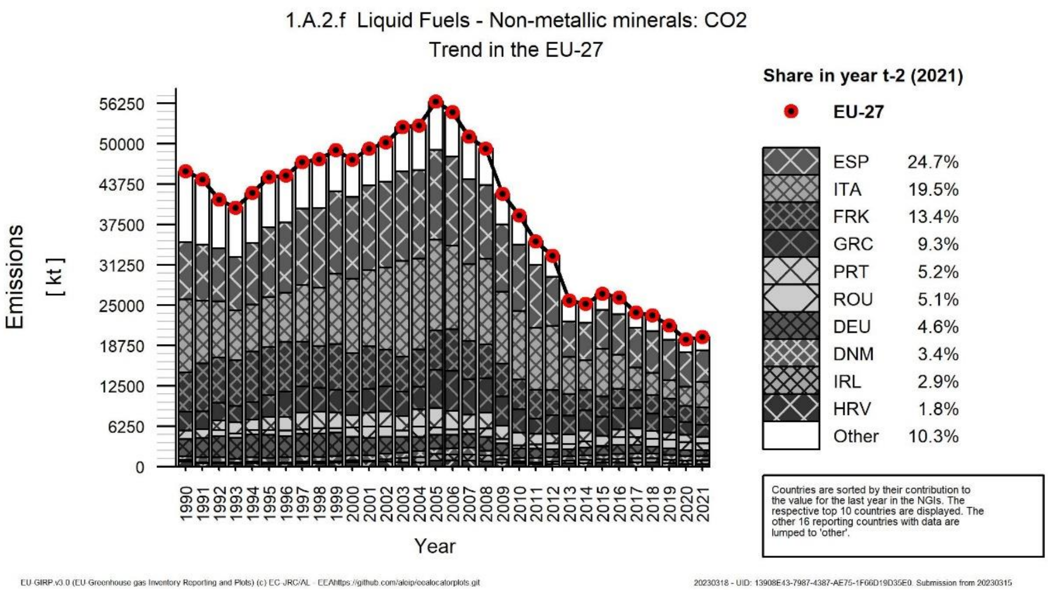
Table 3.42: 1.A.2.f Non-metallic Minerals , liquid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	508	79	147	0.7%	-361	-71%	68	87%	T2	CS
Belgium	1 509	324	278	1.4%	-1 231	-82%	-47	-14%	T1,T3	D,PS
Bulgaria	666	242	97	0.5%	-569	-85%	-145	-60%	T1	D
Croatia	745	354	352	1.8%	-392	-53%	-1	0%	T1	D
Cyprus	148	215	97	0.5%	-51	-35%	-118	-55%	CS	CS
Czechia	1 029	44	39	0.2%	-991	-96%	-5	-11%	T1	CS,D
Denmark	535	774	684	3.5%	149	28%	-90	-12%	T1,T2	CS,D
Estonia	448	0	0	0.0%	-448	-100%	0	0%	T1,T2	CS,D
Finland	437	263	268	1.4%	-169	-39%	4	2%	T3	CS
France	6 081	2 482	2 687	13.6%	-3 395	-56%	205	8%	T2,T3	CS,PS
Germany	2 663	903	918	4.6%	-1 745	-66%	15	2%	CS	CS
Greece	2 914	1 968	1 859	9.4%	-1 055	-36%	-109	-6%	T2	PS
Hungary	453	294	202	1.0%	-251	-55%	-92	-31%	T1,T2	CS,D
Ireland	312	521	588	3.0%	276	88%	67	13%	T1,T2	CS,D
Italy	11 359	2 974	3 905	19.7%	-7 454	-66%	931	31%	T2	CS
Latvia	267	6	0	0.0%	-267	-100%	-6	-99%	T2	CS
Lithuania	2 750	10	12	0.1%	-2 738	-100%	2	22%	T2	CS
Luxembourg	23	3	4	0.0%	-19	-84%	1	34%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	468	0	0	0.0%	-468	-100%	0	67%	T2	CS
Poland	394	242	245	1.2%	-149	-38%	3	1%	T1,T2	CS,D
Portugal	1 319	1 176	1 040	5.2%	-279	-21%	-137	-12%	T1,T3	D,PS
Romania	NO	1 216	1 028	5.2%	1 028	∞	-188	-15%	T1,T2,T3	CS,D,PS
Slovakia	1 219	219	272	1.4%	-947	-78%	53	24%	T2	CS
Slovenia	63	135	142	0.7%	79	125%	7	5%	T1,T2	D,PS
Spain	8 821	5 315	4 949	25.0%	-3 872	-44%	-366	-7%	T1,T2	CS,D
Sweden	625	C	256	1.3%	-369	-59%	256	∞	T1	CS
EU-27	**45 133**	**19 760**	**19 812**	**100%**	**-25 321**	**-56%**	**52**	**0%**	**-**	**-**

EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure.3.81 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest share on total CO_2 emissions (above the average share calculated for EU) has Spain (25%), Italy (19%), France (13%), Greece (9%), Romania (5%), Portugal (5%) and Germany (5%) which together have 82% share on EU emissions.

Figure.3.81: 1.A.2.f Non-metallic Minerals, liquid fuels: Emission trend and share for CO_2



Note: This figure does include Sweden.

Figure.3.82 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that CO_2 IEF increased significantly compared to CO_2 IEF calculated for 1990. The high CO_2 IEF in recent years is caused mainly due to the increased consumption of petrol coke in cement kilns. Between the years 2012 to 2017 strong fluctuation of EU CO_2 IEF. CO_2 IEF equalled to 89.97 t/TJ in 2021.

Figure.3.82: 1.A.2.f Non-metallic Minerals, liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)

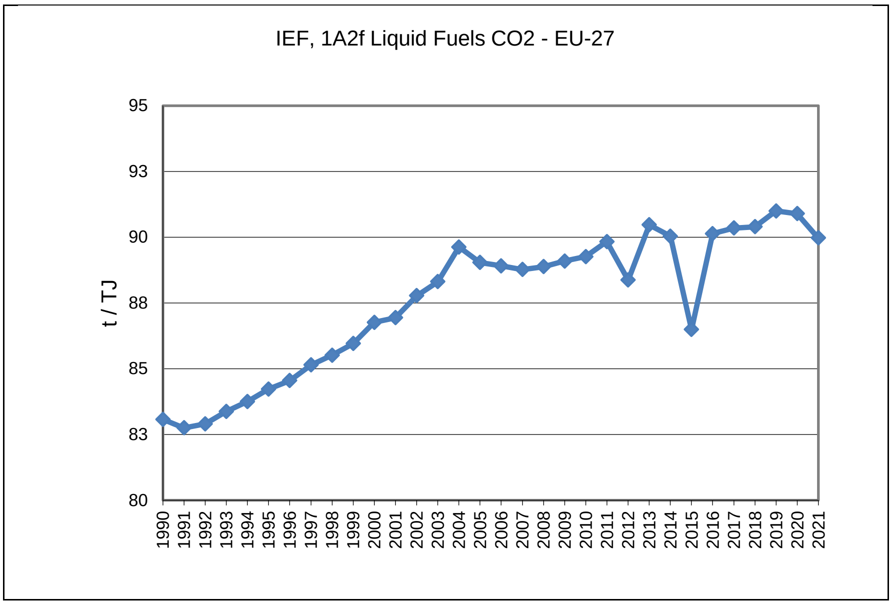
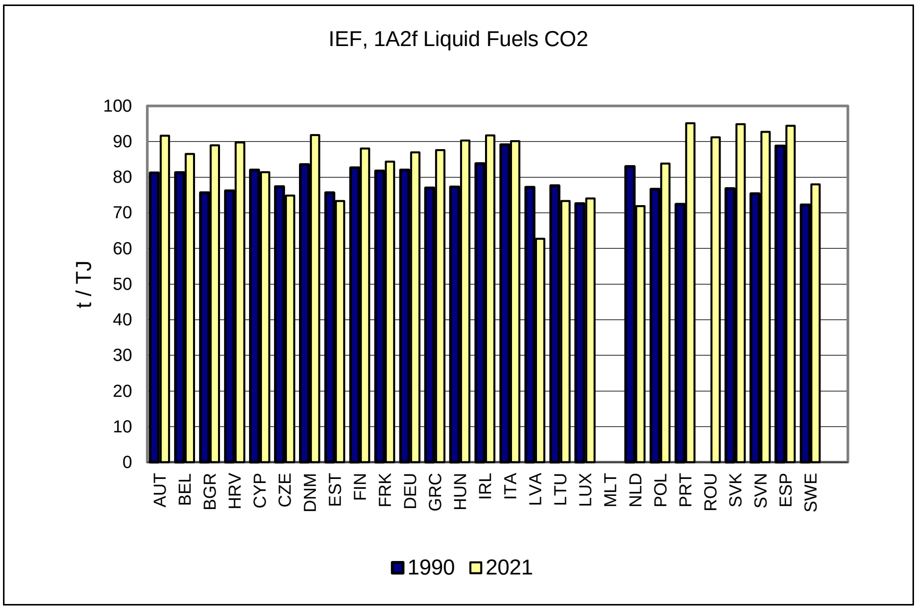


Figure 3.83 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. The CO_2 IEF is in many cases higher in 2021 than in 1990 which reflects reasons for relatively high CO_2 IEF mentioned above.

Figure 3.83: 1.A.2.f Non-metallic Minerals, liquid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.f Non-metallic Minerals - Solid Fuels (CO_2)

CO_2 emissions from the use of solid fuels in category 1.A.2.f amounted 13 887 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 74% and compared to 2020 increased by 1%. This category represents 3.2% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption decreased by 73% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.43. Malta and Estonia report emissions as 'NO' (not occurring). Sweden reports emissions as 'C' (confidential). Croatia and Luxembourg use for emission estimates Tier 1 methodology, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 96% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.f – Solid Fuels (CO_2)). Latvia, Lithuania and Romania reported higher level of emissions in 2021 than in 1990 (it should be noted that the share of their emissions on total EU emissions is together only 11%).

Table 3.43: 1.A.2.f Non-metallic Minerals, solid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	535	311	253	1.8%	-282	-53%	-57	-18%	T2	CS
Belgium	2 466	1 207	1 270	9.1%	-1 196	-49%	63	5%	T1,T3	D,PS
Bulgaria	295	107	198	1.4%	-97	-33%	92	86%	T1,T2	CS,D
Croatia	535	388	419	3.0%	-116	-22%	30	8%	T1	D
Cyprus	232	56	159	1.1%	-73	-31%	103	184%	CS	CS
Czechia	2 209	592	569	4.1%	-1 640	-74%	-23	-4%	T2	CS,D
Denmark	574	319	384	2.8%	-190	-33%	65	20%	T1,T3	D,PS
Estonia	595	25	NO	-	-595	-100%	-25	-100%	NA	NA
Finland	806	191	204	1.5%	-602	-75%	13	7%	T3	CS
France	4 971	899	1 034	7.4%	-3 938	-79%	135	15%	T2,T3	CS,PS
Germany	12 053	4 209	3 527	25.4%	-8 527	-71%	-683	-16%	CS	CS
Greece	3 364	306	357	2.6%	-3 007	-89%	52	17%	T2	PS
Hungary	230	105	93	0.7%	-137	-59%	-11	-11%	T1,T2	D,PS
Ireland	375	301	354	2.5%	-21	-6%	53	17%	T2	CS
Italy	3 690	642	267	1.9%	-3 423	-93%	-375	-58%	T2	CS
Latvia	16	76	48	0.3%	32	203%	-27	-36%	T2	CS
Lithuania	60	348	413	3.0%	353	592%	65	19%	T2	CS
Luxembourg	312	129	139	1.0%	-173	-55%	11	8%	T1	D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	346	116	129	0.9%	-217	-63%	13	11%	T2	CS
Poland	8 576	1 994	2 069	14.9%	-6 507	-76%	75	4%	T1,T2	CS,D
Portugal	1 958	18	33	0.2%	-1 925	-98%	15	84%	T1,T3	D,PS
Romania	285	747	1 164	8.4%	879	309%	418	56%	T2,T3	CS,PS
Slovakia	1 474	475	460	3.3%	-1 014	-69%	-15	-3%	T2	CS
Slovenia	113	47	51	0.4%	-63	-55%	4	8%	T1,T3	D,PS
Spain	5 221	118	292	2.1%	-4 929	-94%	173	146%	T1,T2	CS,D
Sweden	1 142	C	C	-	-1 142	-100%	-	-	T2	CS
EU-27	**51 292**	**13 725**	**13 887**	**100%**	**-37 405**	**-73%**	**162**	**1%**	**-**	**-**

EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.
Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 3.84 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Germany (25%), Poland (15%), Belgium (9%), Romania (8%), and France (7%) which together represent 65% share on EU emissions.

Figure 3.84: 1.A.2.f Non-metallic Minerals, solid fuels: Emission trend and share for CO_2

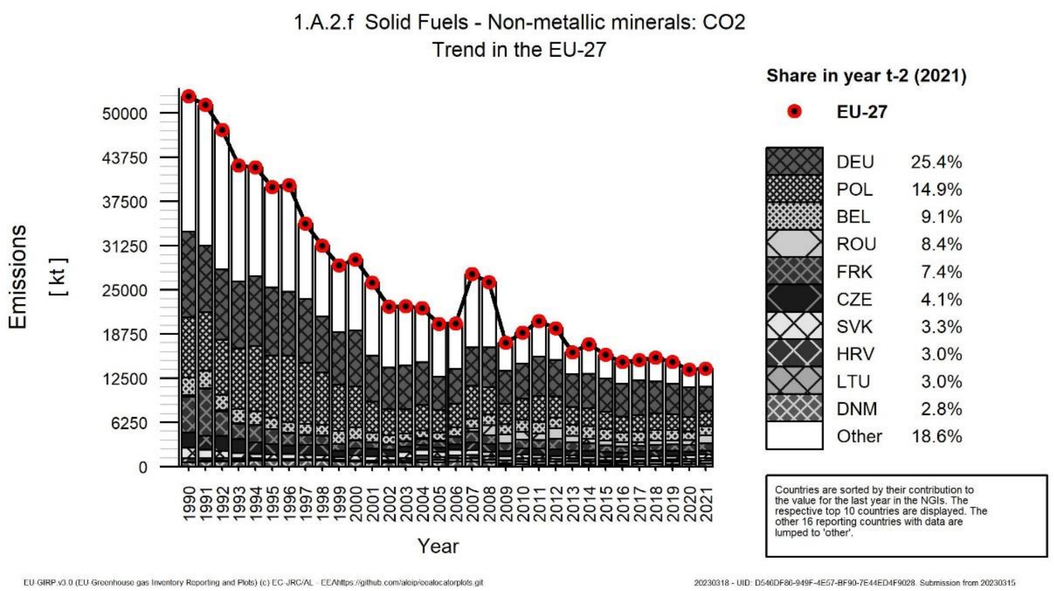


Figure 3.85 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. The IEF has slightly decreasing trend with minor fluctuations. CO_2 IEF equalled to 95.86 t/TJ in 2021.

Figure 3.85: 1.A.2.f Non-metallic Minerals, solid fuels: Implied Emission Factors for CO_2 (in t/TJ)

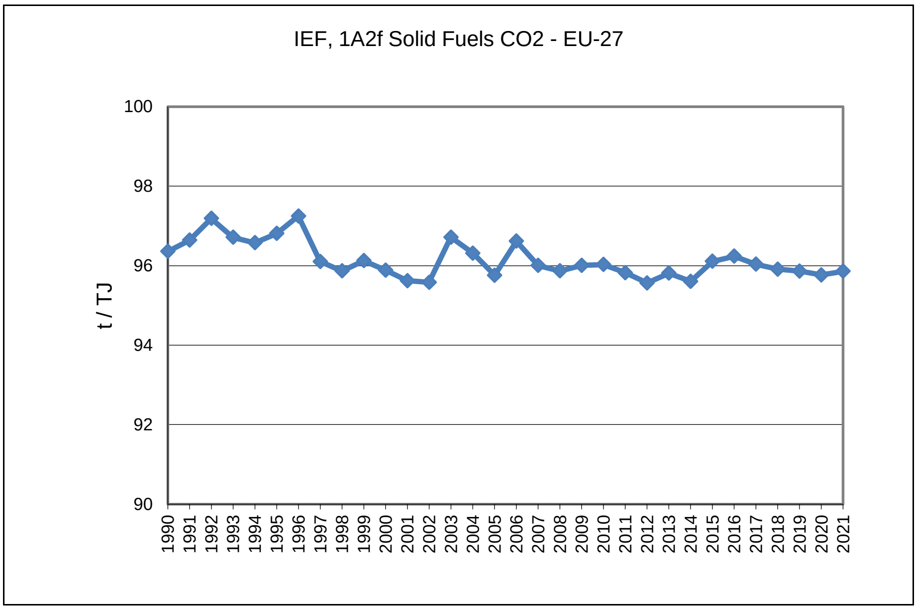
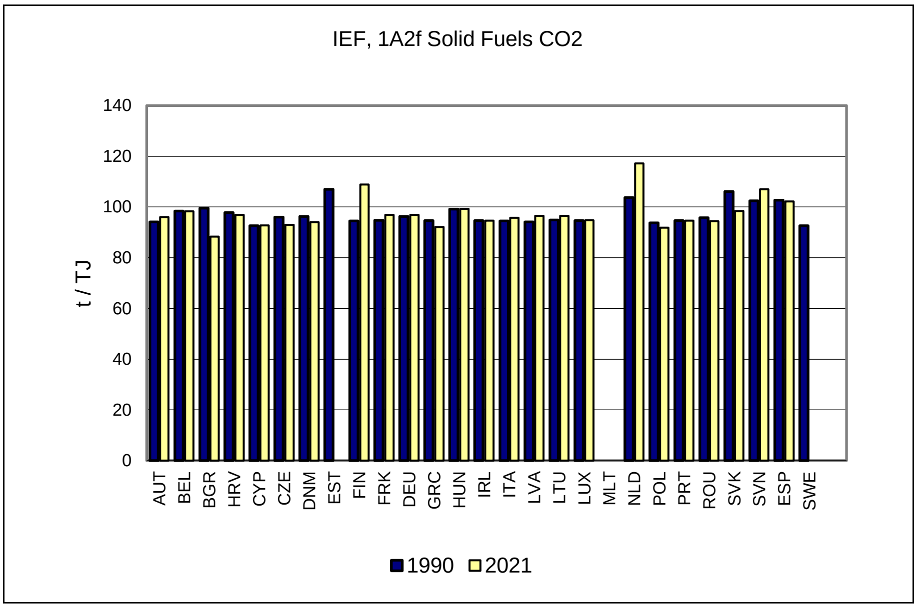


Figure 3.86 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. It can be seen that no major differences between CO_2 IEF used by countries occur, also no major differences between CO_2 IEF calculated by countries for 1990 and 2021 occur. Except for Netherlands where strong increase in 2019 IEF is caused by change in fuel composition; lignite consumption decreased by 92% and this resulted in bigger share of cokes with IEF 120 t/TJ in 2019.

Figure 3.86: 1.A.2.f Non-metallic Minerals, solid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.f Non-metallic Minerals - Gaseous Fuels (CO_2)

CO_2 emissions from the use of gaseous fuels in category 1.A.2.f amounted 34 005 kt in 2021 for EU. CO_2 emissions increased compared to year 1990 by 23% and compared to 2020 by 7%. This category represents 7.8% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption increased by 21% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.44. Cyprus and Malta report emissions as 'NO' (not occurring). Croatia uses Tier 1 methodology for emission estimates, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 99% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.f – Gaseous Fuels (CO_2)). Ten Member States reported higher level of emissions in 2021 than in 1990.

Table 3.44: 1.A.2.f Non-metallic Minerals, gaseous fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	559	699	665	2.0%	106	19%	-34	-5%	T2	CS
Belgium	1 364	1 126	1 204	3.5%	-160	-12%	78	7%	T1,T3	D,PS
Bulgaria	1 684	658	728	2.1%	-956	-57%	70	11%	T2	CS
Croatia	645	282	323	0.9%	-322	-50%	41	15%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	1 289	1 412	1 517	4.5%	228	18%	105	7%	T2	CS
Denmark	237	241	239	0.7%	2	1%	-2	-1%	T3	CS
Estonia	NO	22	33	0.1%	33	∞	11	52%	T2	CS
Finland	126	56	62	0.2%	-64	-51%	6	10%	T3	CS
France	3 830	4 507	4 689	13.8%	859	22%	183	4%	T2,T3	CS,PS
Germany	3 265	4 430	4 550	13.4%	1 284	39%	120	3%	CS	CS
Greece	NO	259	180	0.5%	180	∞	-79	-31%	T2	CS
Hungary	1 658	445	472	1.4%	-1 186	-72%	27	6%	T2	CS
Ireland	132	83	80	0.2%	-53	-40%	-3	-4%	T2	CS
Italy	5 996	6 258	6 614	19.5%	618	10%	356	6%	T2	CS
Latvia	316	71	74	0.2%	-242	-76%	3	5%	T2	CS
Lithuania	382	50	52	0.2%	-331	-86%	2	4%	T2	CS
Luxembourg	201	117	91	0.3%	-110	-55%	-25	-22%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	1 484	1 077	1 087	3.2%	-396	-27%	11	1%	T2	CS
Poland	1 359	2 461	2 874	8.5%	1 515	111%	413	17%	T2	CS
Portugal	0	1 096	1 136	3.3%	1 136	9216805%	40	4%	T1,T3	D,PS
Romania	NO	735	804	2.4%	804	∞	69	9%	T2,T3	CS,PS
Slovakia	542	387	385	1.1%	-157	-29%	-2	0%	T2	CS
Slovenia	116	146	166	0.5%	50	43%	19	13%	T2	CS
Spain	2 411	5 144	5 978	17.6%	3 567	148%	834	16%	T2	CS
Sweden	65	115	C	-	-65	-100%	-115	-100%	T1	CS
EU-27	**27 597**	**31 763**	**34 005**	**100%**	**6 407**	**23%**	**2 242**	**7%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.
EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.

Figure 3.87 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Italy (19%), Spain (18%), France (14%), Germany (13%), Poland (8%) and Czechia (4%) which together represent 77% share on EU emissions.

Figure 3.87: 1.A.2.f Non-metallic Minerals, gaseous fuels: Emission trend and share for CO_2

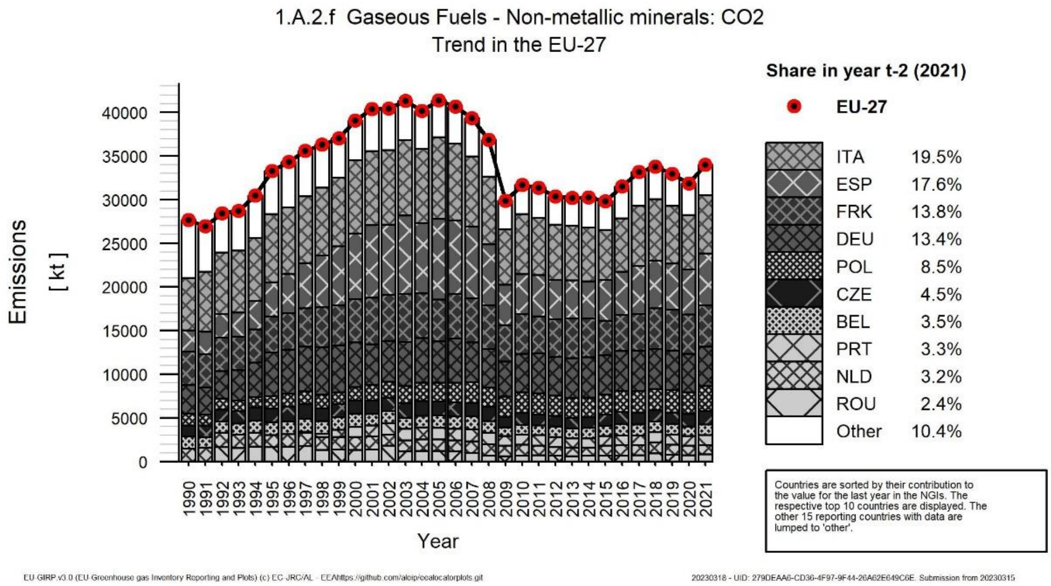


Figure 3.88 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. CO_2 IEF is stable during whole time period with slightly increasing trend. CO_2 IEF equalled to 56.42 t/TJ in 2021.

Figure 3.88: 1.A.2.f Non-metallic Minerals, gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)

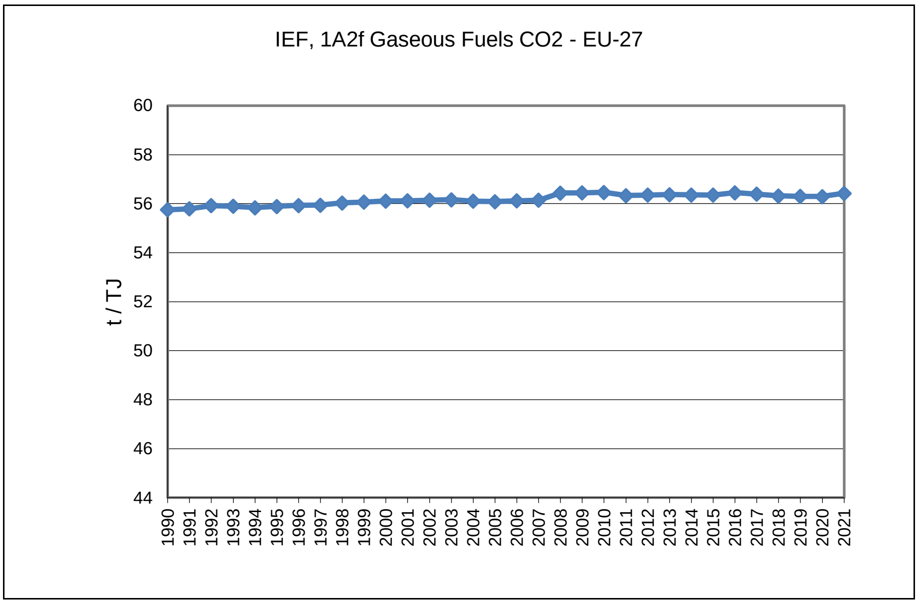
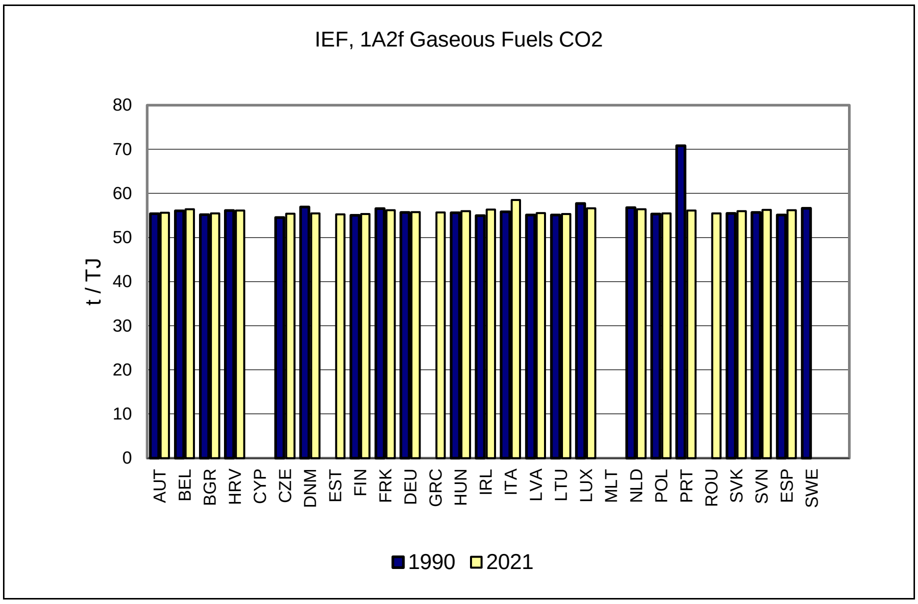


Figure 3.89 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. It can be seen that no major differences between CO_2 IEF used by countries occur, also no major differences between CO_2 IEF calculated by countries for 1990 and 2021 occur.

Figure 3.89: 1.A.2.f Non-metallic Minerals, gaseous fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.f Non-metallic Minerals – Other Fossil Fuels (CO_2)

CO_2 emissions from the use of other fossil fuels in category 1.A.2.f amounted 14 429 kt in 2021 for EU. CO_2 emissions increased compared to year 1990 by 903% and decreased by 1% compared to 2020. This category represents 3.5% of total CO_2 equivalent emissions from category 1.A.2. Fuel consumption increased by 933% compared to 1990.

Detailed data related to the EU submissions are depicted in Table 3.45. Bulgaria, Malta and Netherlands report emissions as 'NO' (not occurring). Three Member States use for emission estimates Tier 1 methodology, the rest of countries use higher tiers or combination of tiers (as it is calculated in chapter 3.2.1 approximately 70% of EU emissions were calculated by using higher Tier methods or combination of methods in category 1.A.2.f – Other Fossil Fuels (CO_2)). All countries reported higher level of emissions in 2021 than in 1990. Most countries report emissions from industrial waste (co-) incineration and particularly incineration of municipal waste (e.g. Spain) under this category, especially from cement kilns. Examples of industrial wastes could be waste tires, waste oil/lubricants, solvents, plastics waste and paper waste.

Table 3.45: 1.A.2.f Non-metallic Minerals, other fossil fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27	Change 1990-2021		Change 2020-2021		Method	Emission factor
	1990	2020	2021	Emissions in 2021	kt CO2	%	kt CO2	%		Informa-tion
Austria	67	566	616	4.3%	549	816%	50	9%	T2	CS
Belgium	186	412	386	2.7%	200	107%	-26	-6%	T1,T3	D,PS
Bulgaria	NO	NO	NO	-	-	-	-	-	NA	NA
Croatia	NO	233	268	1.9%	268	∞	35	15%	T1	D
Cyprus	NO	148	131	0.9%	131	∞	-18	-12%	T1	D
Czechia	NO	581	546	3.8%	546	∞	-36	-6%	T2	CS
Denmark	NO	204	158	1.1%	158	∞	-47	-23%	T2	CS
Estonia	NO	66	51	0.4%	51	∞	-15	-23%	T3	PS
Finland	NO	57	50	0.3%	50	∞	-7	-12%	T3	CS
France	340	1 039	1 143	7.9%	803	236%	103	10%	T2,T3	CS,PS
Germany	526	3 019	3 156	21.9%	2 630	500%	137	5%	CS	CS
Greece	NO	186	251	1.7%	251	∞	65	35%	T2	PS
Hungary	NO	250	376	2.6%	376	∞	126	50%	T3	PS
Ireland	NO	153	196	1.4%	196	∞	44	29%	T3	PS
Italy	NO	474	408	2.8%	408	∞	-66	-14%	T2	CS
Latvia	NO	139	141	1.0%	141	∞	2	1%	T2	PS
Lithuania	NO	6	7	0.1%	7	∞	1	22%	T2	OTH
Luxembourg	NO	108	100	0.7%	100	∞	-8	-8%	T1,T3	D,PS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	10	4 280	4 013	27.8%	4 003	41164%	-267	-6%	T1	D
Portugal	12	314	300	2.1%	288	2359%	-14	-4%	T1,T3	D,PS
Romania	NO	934	1 040	7.2%	1 040	∞	106	11%	T2	CS
Slovakia	173	328	307	2.1%	134	77%	-21	-6%	T2	CS
Slovenia	5	106	97	0.7%	92	1974%	-9	-9%	T1,T3	D,PS
Spain	120	648	689	4.8%	570	477%	41	6%	T2	CS,PS
Sweden	NO	302	C	-	-	-	-302	-100%	T2	CS
EU-27	**1 438**	**14 251**	**14 429**	**100%**	**12 991**	**903%**	**178**	**1%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.

Figure 3.90 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Poland (28%), Germany (22%), France (8%), Romania (7%) and Spain (5%) which together represent 70% share on EU emissions.

Figure 3.90: 1.A.2.f Non-metallic Minerals, other fossil fuels: Emission trend and share for CO_2

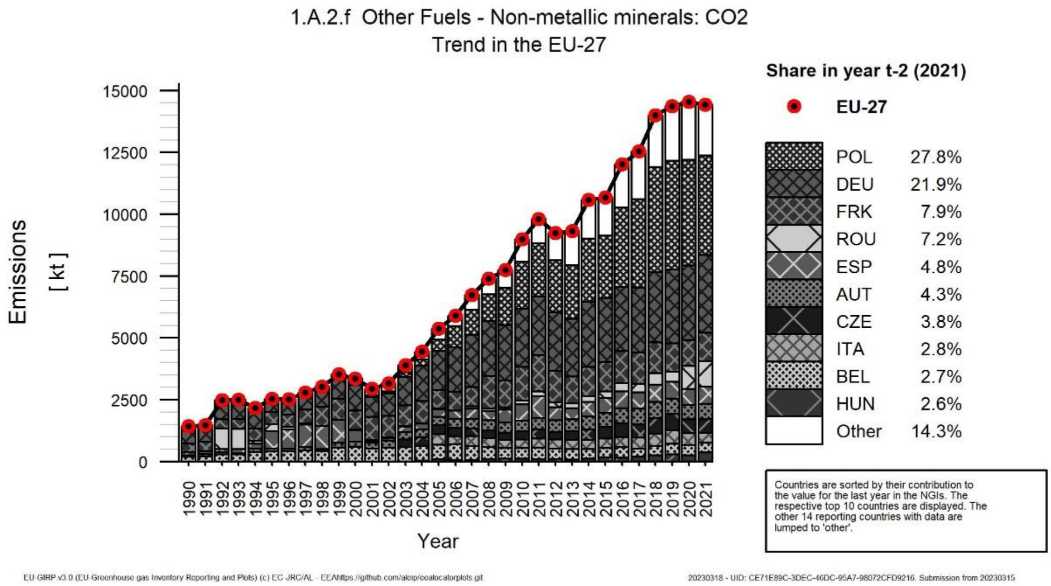


Figure 3.91 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. It can be seen that CO_2 IEF is fluctuating during whole time period, the lowest CO_2 IEF was calculated for 2002. Another low CO_2 IEF is observed for the year 2019. Industrial waste as a fuel that has an EF below the IPCC default EF for industrial waste combusted in manufacturing industries and constructions (2006 IPCC Guidelines, vol.2, chap. 2, table 2.3). The EFs for industrial waste components are typically around 80 t fossil CO_2/TJ fossil energy and for year 2021 the CO_2 IEF equalled to 86.02 t/TJ.

Figure 3.91: 1.A.2.f Non-metallic Minerals, other fossil fuels: Implied Emission Factors for CO_2 (in t/TJ)

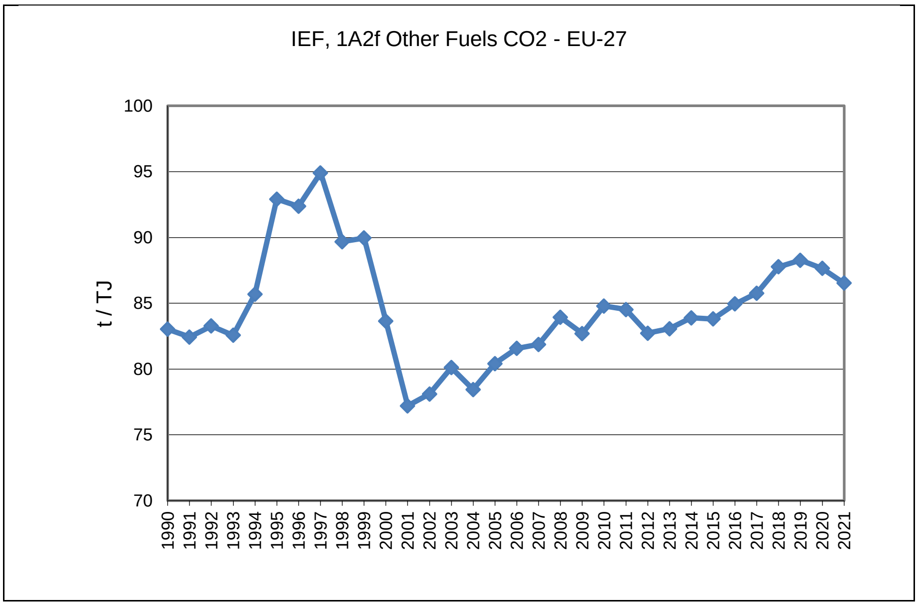
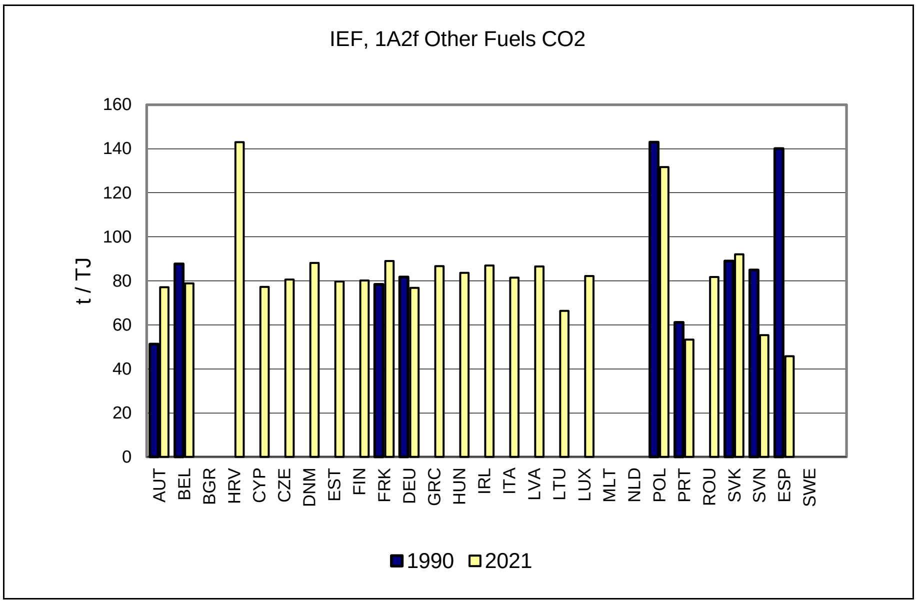


Figure 3.92 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. Croatia and Poland apply the default IPCC CO_2 emission factor (or a factor which is close to it) which is significantly higher than the country specific values used by almost all other countries. The comparatively low implied emission factor reported by almost all countries is mainly due to incineration of industrial waste. Industrial waste as a fuel that has an EF below the IPCC default EF for industrial

waste combusted in manufacturing industries and constructions (2006 IPCC Guidelines, vol.2, chap. 2, table 2.3). The EFs for industrial waste components are typically around 80 t fossil CO_2/TJ fossil energy.

Figure 3.92: 1.A.2.f Non-metallic Minerals, other fossil fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



3.2.2.7 Other (1.A.2.g)

This chapter provides information about European emission trend, Member States contribution to the overall emission trend, activity data and emission factors used for emission estimates by countries for category 1.A.2.g Other.

This category includes emissions from stationary combustion but also may include emissions from mobile sources (e.g. construction machinery). Some countries use this category to report emissions which cannot be allocated to the categories 1.A.2.a to 1.A.2.f due to lack of detailed data, e.g. IEA data provides fuel consumption of Industrial Auto-producers (Electricity, CHP, Heat) for total industry only. This category is dominated by Germany; Germany reports all emissions from power and heat production in industry under this category. Emissions for category 1.A.2.g other (manufacturing industries and construction) include those from stationary combustion, but may also include emissions from mobile sources (e.g. construction machinery), and that some member States use this category to report emissions that cannot be allocated to categories 1.A.2.a–1.A.2.f owing to a lack of detailed data. The following **Table 3.49** presents 1.A.2.g GHG emissions and the share of mobile machinery (off road vehicles) by Member State in year 2021. Greece reports emissions of 1A2g together with category 1A2f. Ireland presumably includes it in the transport sector (1A3). Cyprus, Czechia, Estonia, France, Malta and Slovakia report data from 1.A.2.g.vii together with agricultural mobile sources under the category 1A4cii while Italy and Poland report data under residential or commercial under categories 1A4 or 1A5.

Table 3.46: 1.A.2.g Other: CO_2, CH_4 and N_2O emissions

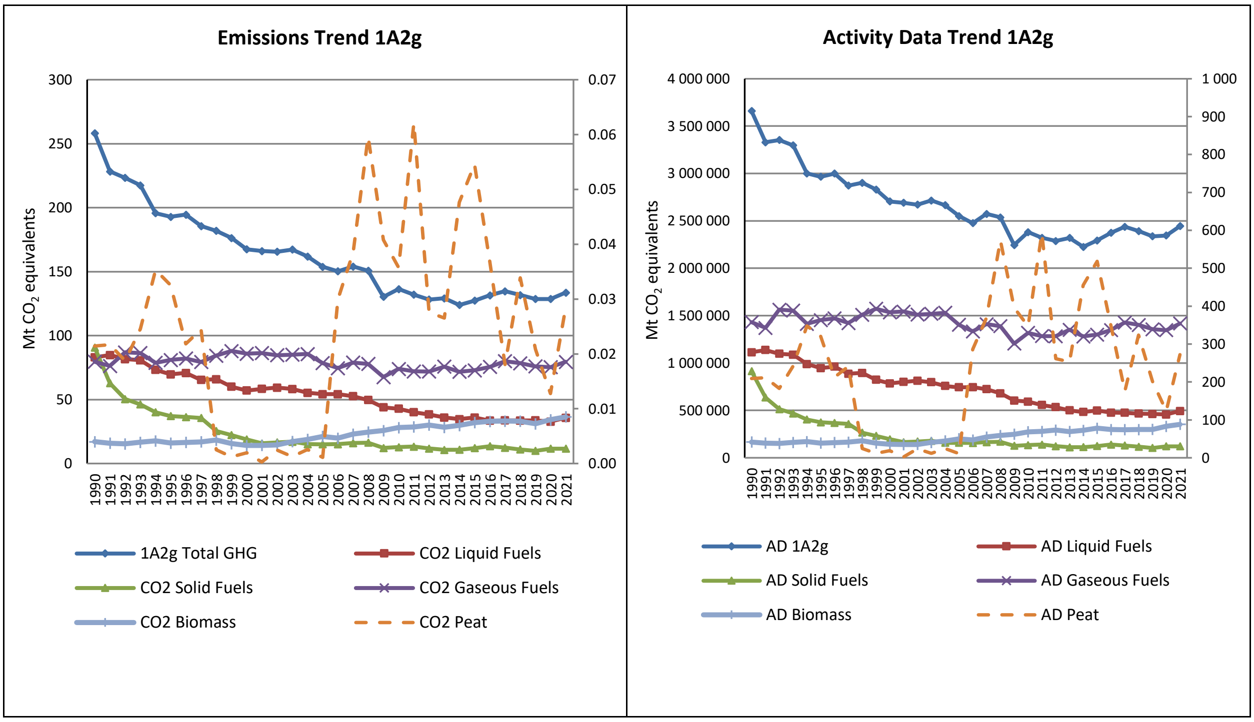
MS		Emissions 2021 in kt CO_2 eq.		
		CO_2	CH_4	N_2O
AUT	g. Other	2854	0.2	0.2
	1.A.2.g.vii Off-road vehicles and other machinery	1349	0.0	0.2
BEL	g. Other	1875	0.3	0.1
	1.A.2.g.vii Off-road vehicles and other machinery	579	0.0	0.0

MS		Emissions 2021 in kt CO_2 eq.		
		CO_2	CH_4	N_2O
BGR	g. Other	1150	0.2	0.1
	1.A.2.g.vii Off-road vehicles and other machinery	88	0.0	0.0
HRV	g. Other	371	0.0	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	371	0.0	0.0
CYP	g. Other	59	0.0	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	NO, IE	NO, IE	NO, IE
CZE	g. Other	2496	0.3	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	NO, IE	NO, IE	NO, IE
DNM	g. Other	989	0.1	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	628	0.0	0.0
EST	g. Other	154	0.0	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	NO, IE	NO, IE	NO, IE
FIN	g. Other	1657	0.5	0.1
	1.A.2.g.vii Off-road vehicles and other machinery	1135	0.1	0.0
FRK	g. Other	7601	1.0	1.2
	1.A.2.g.vii Off-road vehicles and other machinery	NO, IE	NO, IE	NO, IE
DEU	g. Other	74725	8.5	2.0
	1.A.2.g.vii Off-road vehicles and other machinery	3608	0.1	0.1
GRC	g. Other	IE	IE	IE
	1.A.2.g.vii Off-road vehicles and other machinery	IE	IE	IE
HUN	g. Other	2062	0.2	0.1
	1.A.2.g.vii Off-road vehicles and other machinery	795	0.0	0.0
IRL	g. Other	580	0.2	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	NO, IE	NO, IE	NO, IE
ITA	g. Other	10616	0.3	0.7
	1.A.2.g.vii Off-road vehicles and other machinery	NO, IE	NO, IE	NO, IE
LVA	g. Other	210	0.5	0.1
	1.A.2.g.vii Off-road vehicles and other machinery	116	0.0	0.0
LTU	g. Other	227	0.1	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	40	0.0	0.0
LUX	g. Other	337	0.2	0.1
	1.A.2.g.vii Off-road vehicles and other machinery	274	0.0	0.0
MLT	g. Other	54	0.0	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	NO, IE	NO, IE	NO, IE
NLD	g. Other	2918	0.7	0.1
	1.A.2.g.vii Off-road vehicles and other machinery	1630	0.0	0.0
POL	g. Other	3001	1.3	0.2
	1.A.2.g.vii Off-road vehicles and other machinery	NO, IE	NO, IE	NO, IE
PRT	g. Other	1699	0.1	0.1
	1.A.2.g.vii Off-road vehicles and other machinery	172	0.0	0.0
ROU	g. Other	4805	0.3	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	NO	NO	NO
SVK	g. Other	1188	0.1	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	IE	IE	IE
SVN	g. Other	491	0.1	0.0
	1.A.2.g.vii Off-road vehicles and other machinery	95	0.0	0.0
ESP	g. Other	7078	8.5	0.2
	1.A.2.g.vii Off-road vehicles and other machinery	2149	0.0	0.1
SWE	g. Other	2281	0.2	0.2
	1.A.2.g.vii Off-road vehicles and other machinery	1276	0.0	0.1

Total CO_2 emissions from 1.A.2.g amounted to 131 478 kt CO_2 eq. in 2021. The trend of total CO_2 emissions for 1990 to 2021 from category 1.A.2.g is depicted in Figure 3.93. Total CO_2 emissions decreased by 49% since 1990 and increased by 4% between 2020 and 2021. CO_2 emissions from 1.A.2.g Other accounted for 30% of 1.A.2. source category.

Figure 3.93 shows the emission trend within the category 1.A.2.g, which is mainly dominated by CO_2 emissions from gaseous, liquid and solid fuels; the decrease in the early 1990s was mainly due to a decline of solid fuel consumption.

Figure 3.93: 1.A.2.g Other: Activity data and CO_2 emission trends



Data displayed as dashed line refers to the secondary axis.

Detailed data related to the EU submissions are depicted in Table **3.47**. Greece report data as 'IE' (included elsewhere). Five Member States reported increase of CO_2 emissions compared to level of emissions in 1990. The highest increase of CO_2 emission was reported by Luxembourg (250%), but it should be noted that Luxembourg has minor share (approximately 0.3%) on total EUs emissions.

Table 3.47: 1.A.2.g Other: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 974	2 654	2 854	2.2%	880	45%	200	8%	T1,T2,T3	CS,D
Belgium	2 806	1 842	1 875	1.4%	-932	-33%	32	2%	CS,M,T1,T3	CS,D,PS
Bulgaria	10 579	954	1 150	0.9%	-9 429	-89%	196	21%	T1,T2	CS,D
Croatia	435	319	371	0.3%	-63	-15%	53	17%	T1	D
Cyprus	38	59	59	0.0%	21	54%	0	0%	T1	D
Czechia	19 064	2 004	2 496	1.9%	-16 568	-87%	492	25%	T1,T2	CS,D
Denmark	1 853	854	989	0.8%	-865	-47%	135	16%	M,T1,T2,T3	CS,D
Estonia	1 183	221	154	0.1%	-1 028	-87%	-67	-30%	T1,T2	CS,D
Finland	1 639	1 636	1 657	1.3%	18	1%	21	1%	T3	CS,D
France	10 581	7 218	7 601	5.8%	-2 981	-28%	382	5%	T2	CS
Germany	127 015	74 365	74 725	56.8%	-52 290	-41%	360	0%	CS,T1	CS,D
Greece	IE	IE	IE	-	-	-	-	-	NA	NA
Hungary	4 603	1 868	2 062	1.6%	-2 541	-55%	194	10%	T1,T2	CS,D
Ireland	788	596	580	0.4%	-208	-26%	-16	-3%	T1,T2	CS,D
Italy	15 310	8 702	10 616	8.1%	-4 694	-31%	1 914	22%	T2	CS
Latvia	1 620	198	210	0.2%	-1 410	-87%	11	6%	T1,T2	CS,D
Lithuania	1 567	200	227	0.2%	-1 341	-86%	26	13%	T1,T2	CS,D
Luxembourg	96	331	337	0.3%	241	250%	6	2%	T1,T2	CS,D
Malta	53	50	54	0.0%	2	3%	4	9%	T1	D
Netherlands	4 300	2 879	2 918	2.2%	-1 382	-32%	39	1%	T2	CS
Poland	6 979	2 722	3 001	2.3%	-3 978	-57%	279	10%	T1,T2	CS,D
Portugal	2 196	1 556	1 699	1.3%	-497	-23%	143	9%	T1	D
Romania	26 454	4 923	4 805	3.7%	-21 649	-82%	-118	-2%	T1,T2,T3	CS,D,PS
Slovakia	2 560	994	1 188	0.9%	-1 371	-54%	195	20%	T2	CS
Slovenia	1 094	498	491	0.4%	-603	-55%	-7	-1%	T1,T2	CS,D
Spain	7 802	6 706	7 078	5.4%	-724	-9%	371	6%	R,T1,T2,T3	R,CS,D,PS
Sweden	3 268	2 271	2 281	1.7%	-987	-30%	10	0%	T1,T2	CS
EU-27	**255 856**	**126 621**	**131 478**	**100%**	**-124 378**	**-49%**	**4 857**	**4%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.
Greece includes emissions of 1.A.2.g in category 1.A.2.f

1.A.2.g Other – Liquid Fuels (CO_2)

CO_2 emissions from the use of liquid fuels in category 1.A.2.g amounted 35 833 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 57% and increased by 9% compared to 2020. This category represents 12% of total CO_2 equivalent emissions from category 1.A.2.

Detailed data related to the EU submissions are depicted in Table.3.48. Four Member States reported higher level of emissions (it should be noted that these countries have together 5% share on EU emissions).

Table.3.48: 1.A.2.g Other, liquid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	866	1 384	1 493	4%	627	72%	110	8%	T3,T2	CS
Belgium	1 569	763	740	2%	-830	-53%	-23	-3%	CS,M	CS,D
Bulgaria	8 632	329	420	1%	-8 212	-95%	91	28%	T1	D
Croatia	435	319	371	1%	-63	-15%	53	17%	T1	D
Cyprus	38	59	59	0%	21	54%	0	0%	T1	D
Czechia	2 935	128	158	0%	-2 776	-95%	30	23%	T1	CS,D
Denmark	1 239	681	798	2%	-441	-36%	117	17%	CR,M,T2,T1	CS,D
Estonia	702	166	88	0%	-615	-88%	-78	-47%	T1,T2	CS,D
Finland	1 480	1 313	1 282	4%	-198	-13%	-31	-2%	T3	CS
France	5 904	3 424	3 633	10%	-2 271	-38%	209	6%	0	0
Germany	29 397	13 652	13 464	38%	-15 933	-54%	-188	-1%	CS	CS
Greece	IE	IE	IE	-	-	-	-	-	NA	NA
Hungary	1 498	819	868	2%	-629	-42%	49	6%	T2,T1	CS,D
Ireland	616	275	270	1%	-346	-56%	-5	-2%	-	-
Italy	5 707	2 203	2 860	8%	-2 847	-50%	657	30%	T2	CS
Latvia	1 066	130	127	0%	-939	-88%	-3	-2%	T2	CS
Lithuania	812	68	65	0%	-747	-92%	-3	-4%	T2	CS
Luxembourg	52	259	274	1%	222	423%	15	6%	T2	CS
Malta	53	50	54	0%	2	3%	4	9%	T1	D
Netherlands	2 548	1 741	1 630	5%	-918	-36%	-111	-6%	T2	CS
Poland	1 028	635	679	2%	-349	-34%	44	7%	T1,T2	CS,D
Portugal	2 147	550	607	2%	-1 539	-72%	58	10%	T1	D
Romania	4 824	1 320	1 396	4%	-3 428	-71%	76	6%	T1,T2	CS,D
Slovakia	66	11	12	0%	-54	-82%	1	10%	T2	CS
Slovenia	585	154	152	0%	-434	-74%	-2	-2%	T1	D
Spain	5 738	2 346	2 471	7%	-3 267	-57%	125	5%	CR,T1	CR,D
Sweden	3 056	C	1 863	5%	-1 194	-39%	1 863	∞	T2	CS
EU-27	**79 938**	**32 778**	**33 971**	**100%**	**-45 967**	**-58%**	**1 193**	**4%**	**-**	**-**

Greece includes emissions of 1.A.2.g in category 1.A.2.f
EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.
Note: The information on methodologies and emission factors is not available from the CRF/XML on fuels level. Additional information is provided in Annex III of the EU NIR and in MS NIRs, which are also part of the EU submission.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.94 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Germany (38%), France (10%), Italy (8%), Spain (7%) and Sweden (5%) which together represent 68% share on EU emissions.

Figure 3.94: 1.A.2.g Other, liquid fuels: Emission trend and share for CO_2

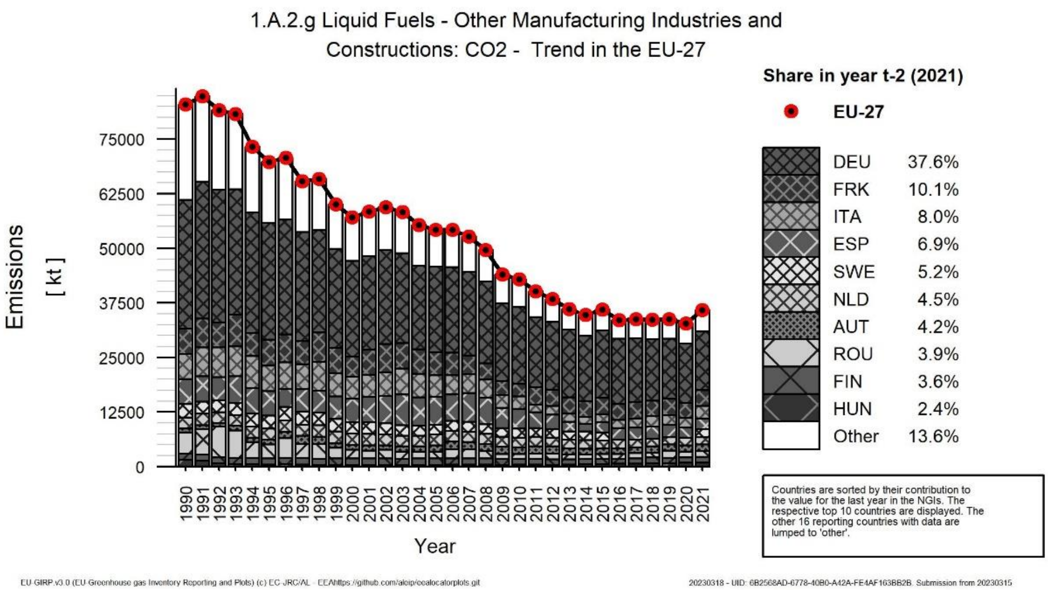


Figure 3.95 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. The CO_2 IEF shows a decreasing trend with minor fluctuations since 2008. This trend is driven mainly by Germany and is caused by changes in fuel mix. CO_2 IEF equaled to 72.54 t/TJ in 2021.

Figure 3.95: 1.A.2.g Other, liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)

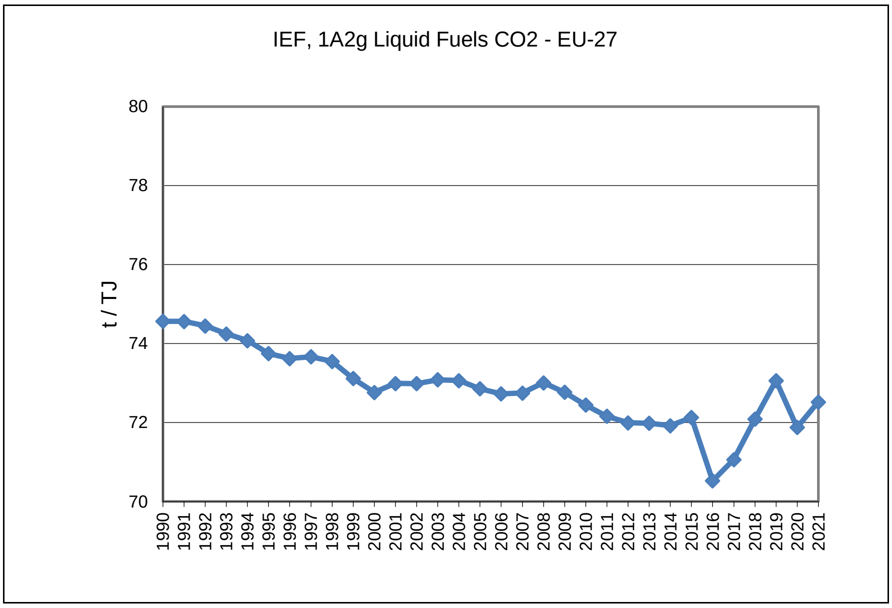
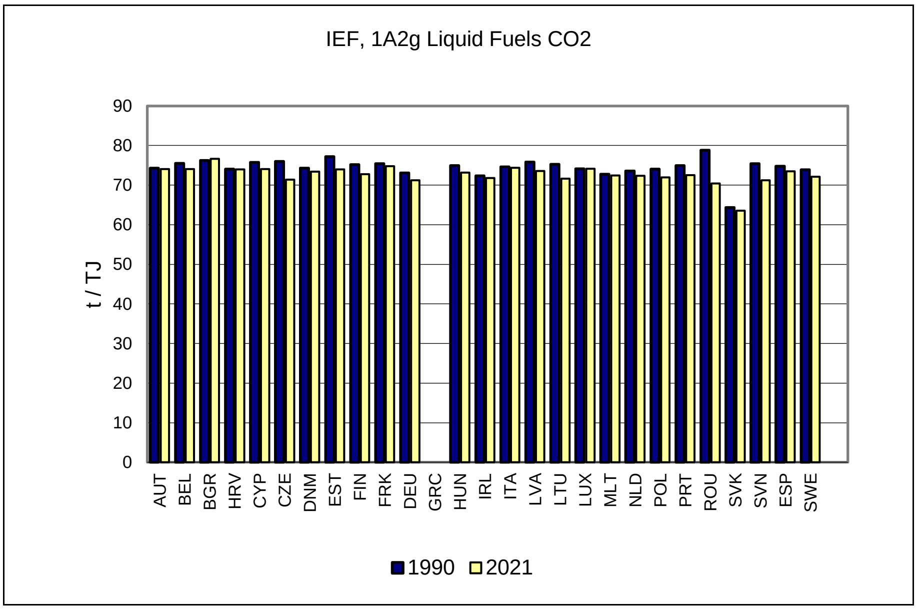


Figure 3.96 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. There is no huge difference across Member States CO_2 IEF in year 2021.

Figure 3.96: 1.A.2.g Other, liquid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.g Other – Solid Fuels (CO_2)

CO_2 emissions from the use of solid fuels in category 1.A.2.g amounted 11 653 kt in 2021 for EU. CO_2 emissions decreased compared to year 1990 by 87% and compared to 2020 by 0.5%. This category represents 2.7% of total CO_2 equivalent emissions from category 1.A.2.

Detailed data related to the EU submissions are depicted in Table 3.49. Eight Member States report emissions as ‘NO’ (not occurring). All countries reported lower level of emissions in 2021 than in 1990 (except Sweden).

Table 3.49: 1.A.2.g Other, solid fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	91	0	1	0%	-90	-99%	1	8699%	T2	CS
Belgium	33	13	17	0%	-16	-48%	4	34%	T1	D
Bulgaria	1 858	45	57	0%	-1 801	-97%	12	27%	-	-
Croatia	NO	NO	NO	-	-	-	-	-	-	-
Cyprus	NO	NO	NO	-	-	-	-	-	-	-
Czechia	13 750	90	130	1%	-13 620	-99%	40	45%	T2	CS,D
Denmark	324	NO	NO	-	-324	-100%	-	-	NA	NA
Estonia	194	0	1	0%	-193	-100%	1	400%	T1,T2	CS,D
Finland	8	NO	NO	-	-8	-100%	-	-	NA	NA
France	664	78	129	1%	-535	-81%	51	66%	-	-
Germany	57 580	10 504	9 690	83%	-47 890	-83%	-814	-8%	CS	CS
Greece	IE	IE	IE	-	-	-	-	-	-	-
Hungary	677	13	5	0%	-672	-99%	-9	-64%	T1,T2	CS,D
Ireland	14	NO	NO	-	-14	-100%	-	-	-	-
Italy	396	30	114	1%	-282	-71%	84	282%	T2	CS
Latvia	27	1	1	0%	-26	-97%	0	14%	T2	CS
Lithuania	79	2	2	0%	-77	-98%	0	-11%	T2	CS
Luxembourg	20	11	16	0%	-4	-18%	6	51%	T1	D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	42	33	30	0%	-12	-29%	-3	-10%	0	0
Poland	5 082	556	631	5%	-4 450	-88%	75	13%	T1,T2	CS,D
Portugal	49	16	23	0%	-26	-53%	7	46%	T1	D
Romania	8 006	5	4	0%	-8 003	-100%	-2	-31%	T1,T2	CS,D
Slovakia	1 422	312	435	4%	-987	-69%	123	39%	T2	CS
Slovenia	89	NO	NO	-	-89	-100%	-	-	-	-
Spain	248	NO	NO	-	-248	-100%	-	-	NA	NA
Sweden	98	C	366	3%	268	272%	366	∞	0	0
EU-27	**90 654**	**11 710**	**11 287**	**100%**	**-79 367**	**-88%**	**-423**	**-4%**	**-**	**-**

Greece includes emissions of 1.A.2.g in category 1.A.2.f
EU trends in this table do not include Sweden for confidentiality reasons and to preserve time series consistency for the EU. This also explains the differences between the numbers in this table and the CRF.
Note: The information on methodologies and emission factors is not available from the CRF/XML on fuels level. Additional information is provided in Annex III of the EU NIR and in MS NIRs, which are also part of the EU submission
Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure.3.97 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest share on total CO_2 emissions (above the average share calculated for EU) correspond to Germany (83%).

Figure.3.97: 1.A.2.g Other, solid fuels: Emission trend and share for CO_2

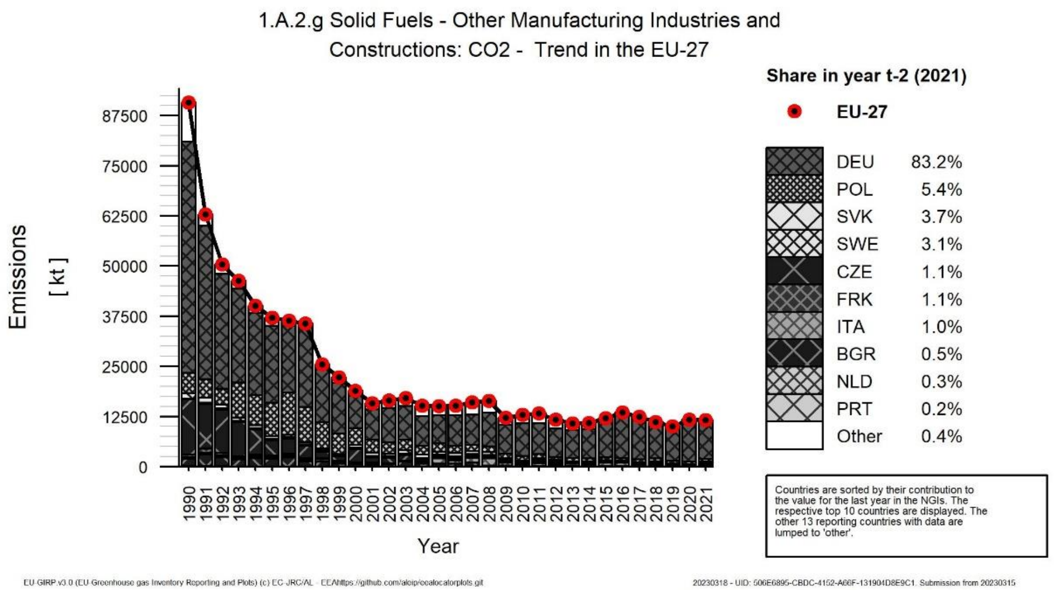


Figure 3.98 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021 which is fluctuating with slightly decreasing trend. CO_2 IEF equaled to 96.5 t/TJ in 2021.

Figure 3.98: 1.A.2.g Other, solid fuels: Implied Emission Factors for CO_2 (in t/TJ)

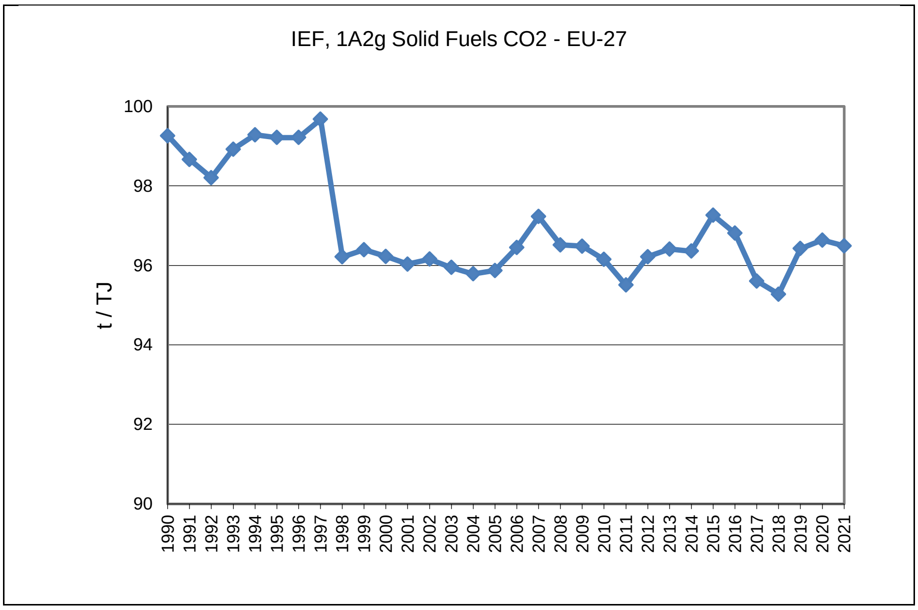
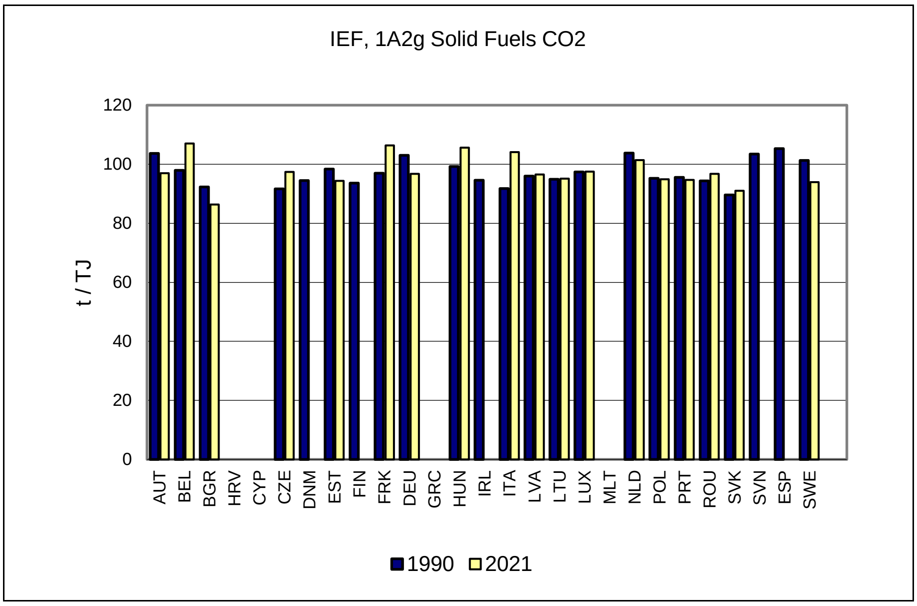


Figure **3.99** shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021.

Figure 3.99: 1.A.2.g Other, solid fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.g Other – Gaseous Fuels (CO_2)

CO_2 emissions from the use of gaseous fuels in category 1.A.2.g amounted 79 482 kt in 2021 for EU. The is no change between 1990 and 2021 CO_2 emissions while there is 5% increase between 2020 and 2021. This category represents 21% of total CO_2 equivalent emissions from category 1.A.2.

Detailed data related to the EU submissions are depicted in Table 3.50. Croatia, Cyprus and Malta report emissions as 'NO' (not occurring). Six Member States reported higher level of emissions in 2021 than in 1990.

Table 3.50: 1.A.2.g Other, gaseous fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 014	1 235	1 323	2%	309	30%	88	7%	T2	CS
Belgium	1 204	1 052	1 102	1%	-101	-8%	50	5%	T1,T3	D,PS
Bulgaria	89	334	414	1%	325	366%	80	24%	0	0
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	-	-
Czechia	2 379	1 786	2 208	3%	-171	-7%	422	24%	T2	CS
Denmark	289	172	173	0%	-117	-40%	0	0%	T3	CS
Estonia	286	56	66	0%	-220	-77%	10	18%	T1,T2	CS,D
Finland	41	42	37	0%	-4	-10%	-5	-12%	T3	CS
France	4 002	3 701	3 822	5%	-180	-5%	120	3%	0	0
Germany	37 693	46 360	47 822	60%	10 128	27%	1 462	3%	CS	CS
Greece	IE	IE	IE	-	-	-	-	-	-	-
Hungary	2 428	1 036	1 189	1%	-1 239	-51%	154	15%	T2	CS
Ireland	158	321	310	0%	152	96%	-12	-4%	-	-
Italy	9 207	6 469	7 642	10%	-1 565	-17%	1 173	18%	T2	CS
Latvia	527	67	80	0%	-447	-85%	12	18%	T2	CS
Lithuania	677	120	145	0%	-532	-79%	25	21%	T2	CS
Luxembourg	24	35	23	0%	-1	-3%	-12	-35%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	1 710	1 105	1 258	2%	-451	-26%	153	14%	-	-
Poland	865	1 524	1 674	2%	808	93%	149	10%	T2	CS
Portugal	NO,IE	987	1 065	1%	1 065	∞	78	8%	T1	D
Romania	13 624	3 598	3 406	4%	-10 218	-75%	-192	-5%	T2	CS
Slovakia	1 071	671	741	1%	-330	-31%	71	11%	T2	CS
Slovenia	420	334	331	0%	-89	-21%	-3	-1%	T2	CS
Spain	1 816	4 361	4 607	6%	2 791	154%	247	6%	T2	CS
Sweden	113	59	45	0%	-68	-60%	-14	-24%	0	0
EU-27	**79 637**	**75 426**	**79 482**	**100%**	**-156**	**0%**	**4 056**	**5%**	**-**	**-**

Greece includes emissions of 1.A.2.g in category 1.A.2.f
Abbreviations explained in the Chapter 'Units and abbreviations'.
Note: The information on methodologies and emission factors is not available from the CRF/XML on fuels level Only information from major emitters have been included to the table as well as voluntarily provided information by countries. Additional information is provided in Annex III of the EU NIR and in MS NIRs, which are also part of the EU submission.

Figure 3.100 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Germany (60%), Italy (10%), Spain (6%) and France (5%) which together represent 80% share on EU emissions.

Figure 3.100: 1.A.2.g Other, gaseous fuels: Emission trend and share for CO_2

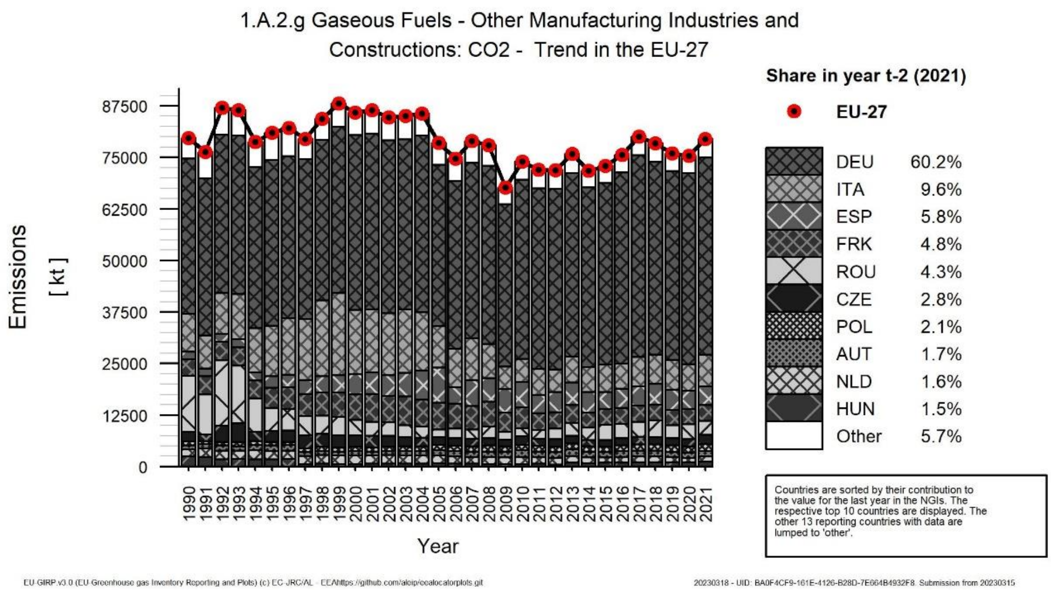


Figure 3.101 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. CO_2 IEF is relatively stable during reporting period. CO_2 IEF equaled to 56.08 t/TJ in 2021.

Figure 3.101: 1.A.2.g Other, gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)

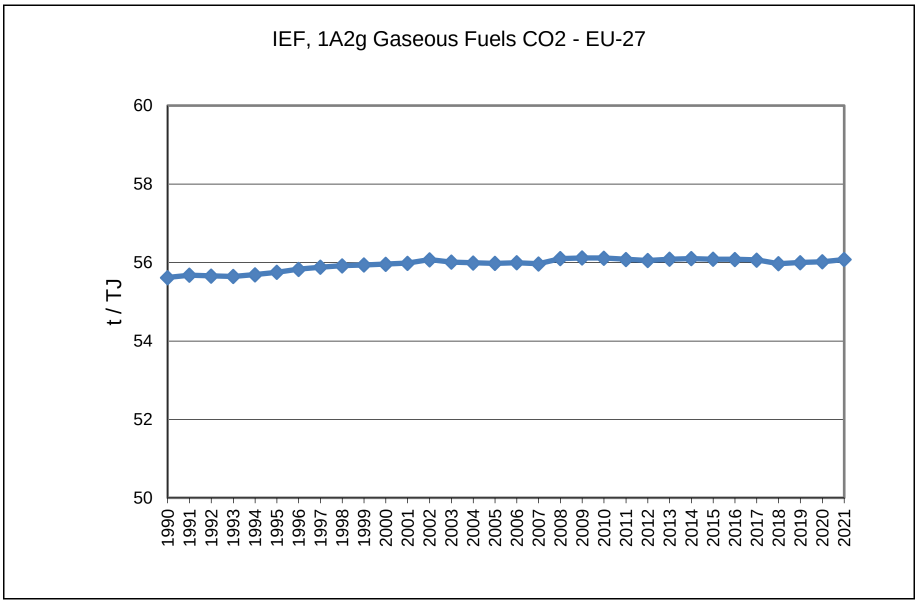
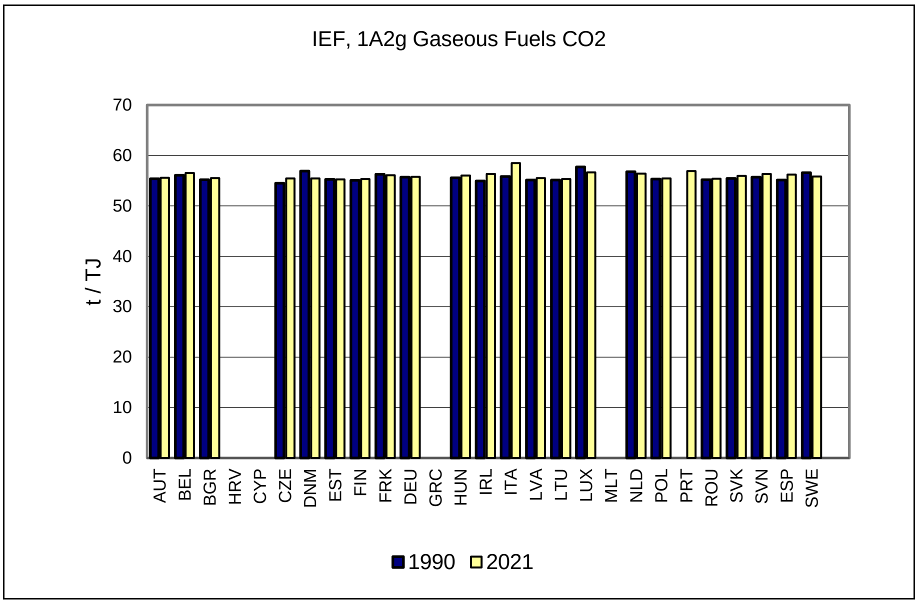


Figure 3.102 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. It can be seen that no major differences between CO_2 IEF used by countries occur, also no major differences between CO_2 IEF calculated by countries for 1990 and 2021 occur.

Figure 3.102: 1.A.2.g Other, gaseous fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



1.A.2.g Other – Other fossil fuels (CO_2)

CO_2 emissions from the use of other fossil fuels in category 1.A.2.g amounted 4 481 kt in 2021 for EU. CO_2 emissions increased compared to year 1990 by 83% and compared to 2020 decreased by 0.1%. This category represents 1% of total CO_2 equivalent emissions from category 1.A.2.

Detailed data related to the EU submissions are depicted in Table 3.51. Eleven Member States report emissions as 'NO' (not occurring). All Member States reported higher level of emissions in 2021 than in 1990.

Table 3.51: 1.A.2.g Other, other fossil fuels: Member States contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	3	36	37	1%	33	963%	1	3%	T2	CS
Belgium	NO	14	15	0%	15	∞	1	7%	NA	NA
Bulgaria	NO	245	259	6%	259	∞	13	5%	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	0	0	0%	0	∞	0	36%	-	-
Czechia	NO	NO	NO	-	-	-	-	-	-	-
Denmark	1	NO	18	0%	17	1612%	18	∞	T2	CS
Estonia	NO	NO	NO	-	-	-	-	-	T1,T2	CS,D
Finland	88	269	312	7%	224	255%	43	16%	T3	CS
France	11	15	17	0%	5	48%	2	10%	0	0
Germany	2 344	3 849	3 749	84%	1 405	60%	-100	-3%	CS,T1	CS
Greece	-	-	-	-	-	-	-	-	-	-
Hungary	NO	NO	NO	-	-	-	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	NO	NO	NO	-	-	-	-	-	-	-
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	11	15	0%	15	∞	4	39%	NA	NA
Luxembourg	NO	25	23	1%	23	∞	-2	-7%	T1	D,NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	-	-
Poland	3	6	17	0%	14	432%	11	173%	T1	D
Portugal	NO,IE	3	4	0%	4	∞	1	28%	NA	NA
Romania	NO	0	0	0%	0	∞	0	145%	T2	CS
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	10	9	0%	9	∞	-1	-11%	-	-
Spain	NO	NO	NO	-	-	-	-	-	NA	NA
Sweden	NO	C	7	0%	7	∞	7	∞	T2	CS
EU-27	**2 451**	**4 484**	**4 474**	**100%**	**2 023**	**83%**	**-10**	**0%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.
Note: The information on methodologies and emission factors are only partially available from the CRF/XML on fuels level.

Figure **3.31**Figure 3.103 shows CO_2 emissions trend as well as the share of the countries with the highest contribution to the total CO_2 emissions. It can be seen that the highest share on total CO_2 emissions correspond to Germany (84%) and Finland (7%) which together contribute to 91% of CO_2 eq. emissions from 1.A.2.g other fossil fuels for 2021.

Figure 3.103: 1.A.2.g Other, other fossil fuels: Emission trend and share for CO_2

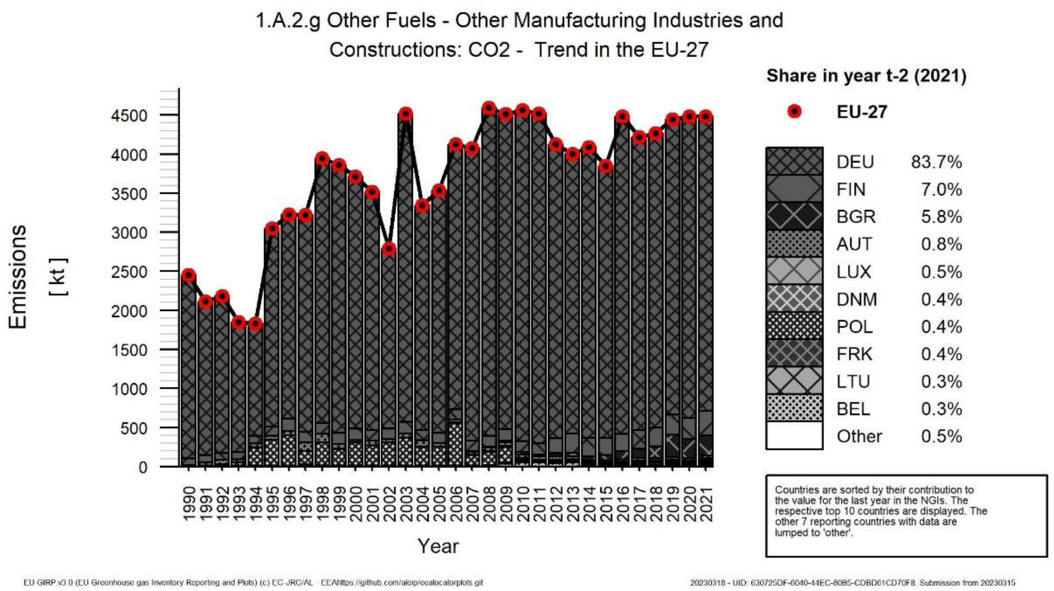


Figure 3.104 shows CO_2 implied emission factor (CO_2 IEF) calculated from EU submissions for 1990-2021. CO_2 IEF equaled to 77.24 t/TJ in 2021.

Figure 3.104: 1.A.2.g Other, other fossil fuels: Implied Emission Factors for CO_2 (in t/TJ)

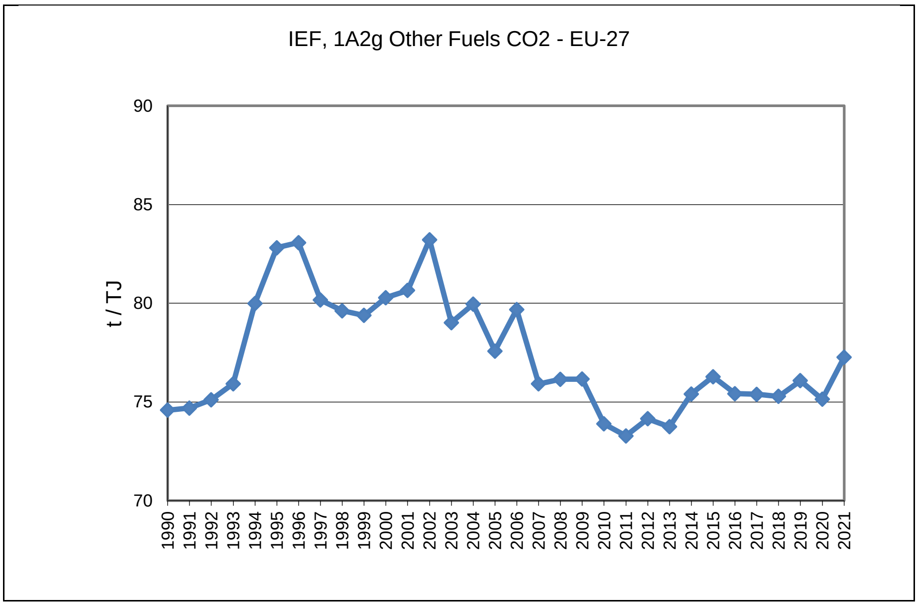
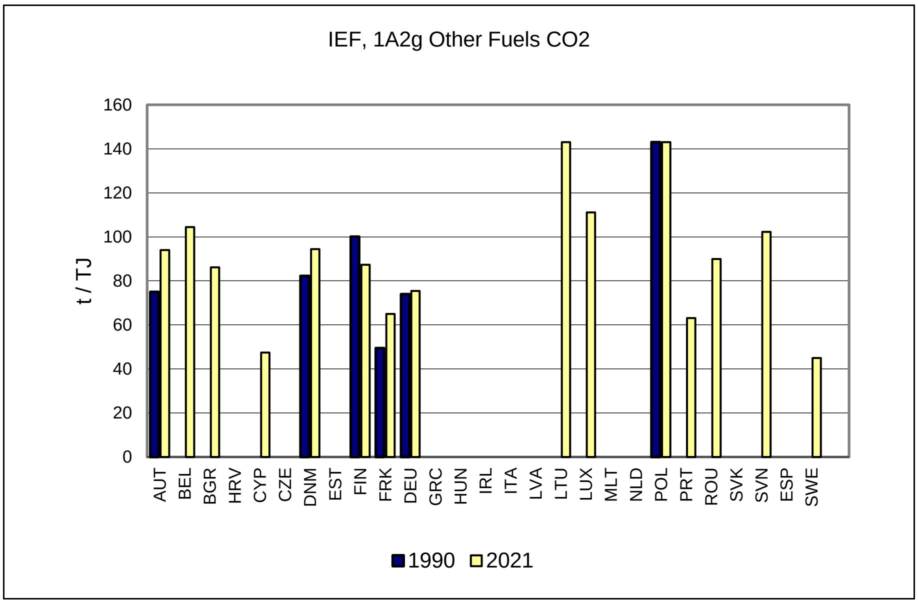


Figure 3.105 shows comparison of CO_2 IEF used by countries for emission estimates in 1990 and 2021. The comparatively low implied emission factor of Austria is mainly due to reporting of industrial waste where carbon content is taken into consideration.

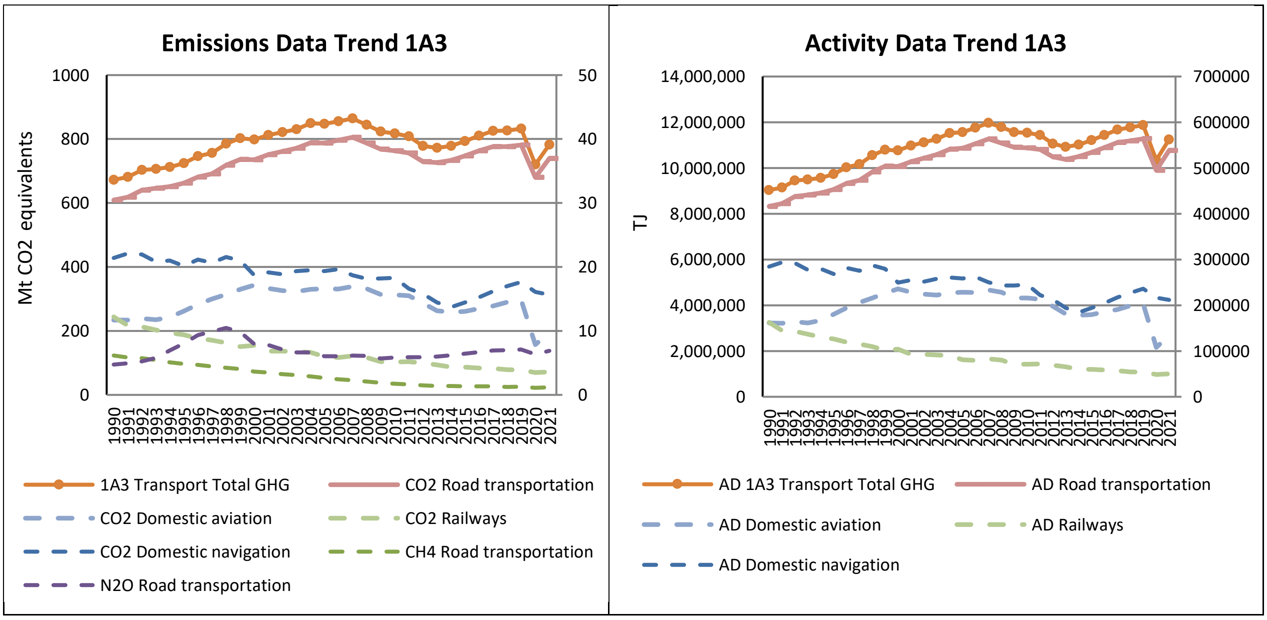
Figure 3.105: 1.A.2.g Other, other fossil fuels: Implied Emission Factors for CO_2 by Member States (in t/TJ)



3.2.3 Transport (CRF Source Category 1A3) (EU)

The time series of greenhouse gas (GHG) emissions and activity data from 1A3 Transport, years 1990-2021, are shown in Figure 3.106. In 2021, CO_2 emissions from the transport sector accounted for 23.4 %, CH_4 for 0.04 %, and N_2O for 0.22 % of total GHG emissions from all sources (including indirect CO_2, with LULUCF and international aviation).

Figure 3.106 1A3 Transport: Greenhouse gas emissions (in Mt of CO_2 equ.) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.54 summarizes the share of countries using higher tier methods for calculating emissions for the key categories of the transport sector. If the information on the tier methods used was not available, the countries NIRs were studied in order to obtain it and calculate the share of higher tiers. In general, most countries use higher tier methods, especially for road transport (83 - 99.8 %) and domestic aviation (94.1 %). Lower percentages are observed for domestic navigation (65.7 - 74.3 %) and railways (73.7 %). It should be noted that as ‘high tier’ are considered all methods apart from T1.

Table 3.52: Key category analysis for the EU (1A3): Key source categories for level and trend analyses and share of countries using higher tier methods

Source category (gas)	kt CO_2 equ.		Trend	Level		Share of higher Tier
	1990	2021		1990	2021	
1.A.3.a Domestic Aviation: Jet Kerosene (CO_2)	11290	9587	0	L	L	94.1 %
1.A.3.b Road Transportation: Diesel Oil (CO_2)	270377	527871	T	L	L	83 %
1.A.3.b Road Transportation: Diesel Oil (N_2O)	1330	5856	T	0	L	95.6 %
1.A.3.b Road Transportation: Gaseous Fuels (CO_2)	508	5064	T	0	L	91.4 %
1.A.3.b Road Transportation: Gasoline (CH_4)	5562	787	T	0	0	97.4 %
1.A.3.b Road Transportation: Gasoline (CO_2)	330546	189637	T	L	L	90 %
1.A.3.b Road Transportation: Liquefied Petroleum Gases (LPG) (CO_2)	7266	14057	T	L	L	99.8 %
1.A.3.b Road Transportation: Other Fuels (CO_2)	1	3069	T	0	0	95 %
1.A.3.c Railways: Liquid Fuels (CO_2)	11535	3532	T	L	0	73.7 %
1.A.3.d Domestic Navigation: Gas/Diesel Oil (CO_2)	12831	9411	0	L	L	74.3 %
1.A.3.d Domestic Navigation: Residual Fuel Oil (CO_2)	7004	4671	0	L	0	65.7 %

Table 3.53 shows the total GHG, CO_2, N_2O, and CH_4 emissions from 1A3 Transport per country and at EU level. Between 1990 and 2021, total GHG from transport increased by 16 % in the EU.

Table 3.53 1A3 Transport: Total GHG, CO_2, N_2O, CH_4, emissions per country (in kt of CO_2 equ.)

Member State	GHG emissions in kt CO2 equivalents		CO2 emissions in kt		N2O emissions in kt CO2 equivalents		CH4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021	1990	2021
Austria	13 952	21 932	13 756	21 684	113	227	83	21
Belgium	20 925	23 861	20 610	23 607	158	233	157	21
Bulgaria	6 516	9 921	6 344	9 811	94	86	77	23
Croatia	3 894	6 262	3 787	6 195	60	57	47	10
Cyprus	1 237	2 051	1 217	2 036	12	12	8	3
Czechia	11 250	18 937	11 078	18 734	85	176	87	28
Denmark	10 752	12 202	10 577	12 075	87	117	88	10
Estonia	2 480	2 351	2 421	2 323	34	25	25	3
Finland	12 091	9 975	11 821	9 886	143	76	126	13
France	122 264	124 079	120 320	122 757	850	1 138	1 095	185
Germany	164 377	147 633	161 352	146 013	1 182	1 377	1 843	244
Greece	14 503	16 752	14 137	16 479	242	201	124	72
Hungary	8 998	13 996	8 811	13 834	110	138	77	23
Ireland	5 143	10 989	5 030	10 865	59	116	54	8
Italy	102 192	103 280	100 319	102 200	860	862	1 012	217
Latvia	3 038	3 228	2 940	3 188	74	36	25	4
Lithuania	5 811	6 125	5 685	6 051	81	66	45	8
Luxembourg	2 631	4 919	2 603	4 868	14	48	14	3
Malta	351	626	346	622	2	4	3	1
Netherlands	27 835	25 488	27 523	25 228	96	192	217	68
Poland	20 741	68 351	20 277	67 559	284	688	180	103
Portugal	10 820	15 914	10 618	15 747	91	146	111	21
Romania	12 432	19 557	12 071	19 282	256	237	105	38
Slovakia	6 816	7 523	6 693	7 436	89	81	34	5
Slovenia	2 737	5 205	2 673	5 147	33	53	31	5
Spain	58 650	85 502	57 728	84 563	462	818	460	121
Sweden	20 038	15 439	19 683	15 205	172	174	183	60
EU-27	**672 476**	**782 101**	**660 421**	**773 397**	**5 743**	**7 384**	**6 312**	**1 320**

3.2.3.1 Domestic Aviation (1A3a) (EU)

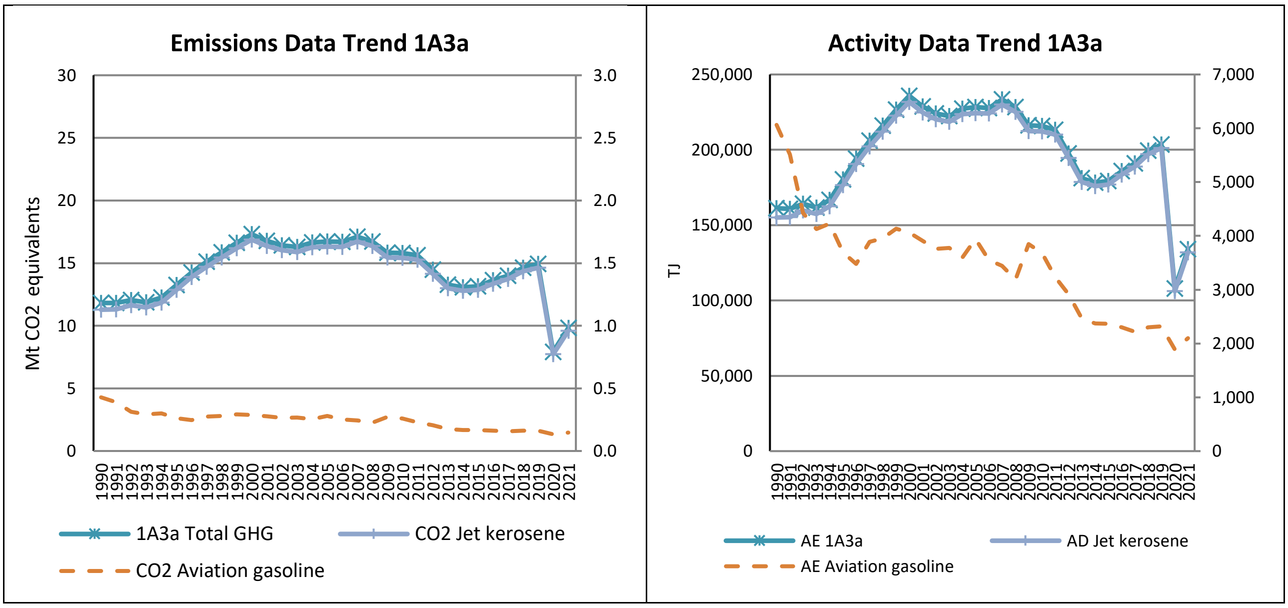
This mobile source category includes emissions from civil domestic aviation, i.e. passenger and freight activity of flights having their origin and destination (O-D) within the same country. The main fuel used is jet kerosene, while there is also a small part of aviation gasoline. The emissions from military mobile sources related to aviation are excluded from 1A3a and are reported separately under category 1A5b (Other mobile military use).

CO_2 emissions from 1A3a Domestic Aviation

CO_2 emissions from domestic aviation accounted only for 0.3 % of total GHG emissions in EU, 2021 (including indirect CO_2, with LULUCF and international aviation). Considering only domestic aviation, CO_2 accounted for 99.2 % of total GHG emissions from domestic aviation in EU, 2021.

The time series of CO_2 emissions and activity data from 1A3a Domestic aviation, years 1990-2021, are shown in Figure 3.107.

Figure 3.107 1A3a Domestic Aviation: CO_2 emissions (in Mt) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.54 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for domestic aviation. Between 1990 and 2021, CO_2 emissions from domestic aviation decreased by 17 % in the EU, while between 2020 and 2021 the corresponding change was 24 % increase. Top five countries in 2021 were France, Spain, Italy, Germany, and Portugal, which accounted for the 90 % of the EU value.

Table 3.54 1A3a Domestic Aviation: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	38	23	24	0.2%	-14	-38%	1	3%	T2,T3	CS
Belgium	15	9	8	0.1%	-6	-43%	-1	-10%	T1	D
Bulgaria	49	12	14	0.1%	-35	-71%	2	18%	T1,T2	D
Croatia	7	17	22	0.2%	16	238%	6	34%	T1	D
Cyprus	26	0	0	0.0%	-26	-99%	0	271%	T1	D
Czechia	NO	12	12	0.1%	12	∞	0	0%	T2	M
Denmark	226	78	85	0.9%	-141	-62%	7	9%	CR,M,T2	CS
Estonia	6	4	6	0.1%	0	1%	2	56%	T2	D
Finland	385	88	79	0.8%	-306	-79%	-8	-10%	T1,T2	CS
France	4 130	3 052	3 768	38.7%	-362	-9%	716	23%	T3	M
Germany	2 263	970	732	7.5%	-1 531	-68%	-237	-24%	CS,T1,T2	CS,D,M
Greece	336	213	320	3.3%	-16	-5%	107	50%	T2,T3	D
Hungary	4	4	6	0.1%	2	49%	1	33%	T1,T2	CS,D
Ireland	48	14	19	0.2%	-29	-60%	6	42%	M,T3	CS
Italy	1 493	1 195	1 703	17.5%	210	14%	509	43%	T1,T2	CS
Latvia	0	1	4	0.0%	4	6321%	3	182%	T1	D
Lithuania	8	2	2	0.0%	-6	-73%	0	15%	T1	CS
Luxembourg	0	0	1	0.0%	0	179%	0	21%	T1	D
Malta	1	0	0	0.0%	-1	-87%	0	2%	T1	D
Netherlands	84	24	27	0.3%	-57	-68%	3	12%	T1	CS,D
Poland	63	51	54	0.6%	-9	-15%	2	5%	T1	D
Portugal	178	257	340	3.5%	162	91%	83	32%	T1,T3	D
Romania	25	116	140	1.4%	115	462%	24	21%	T1,T2	D,OTH
Slovakia	4	1	1	0.0%	-2	-65%	0	47%	T3	D
Slovenia	1	2	2	0.0%	1	52%	0	4%	T1	D
Spain	1 655	1 516	2 175	22.3%	520	31%	659	43%	T3	D
Sweden	673	195	190	1.9%	-483	-72%	-5	-3%	T1	D
EU-27	**11 718**	**7 856**	**9 735**	**1**	**-1 983**	**-17%**	**1 879**	**24%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

1A3a Domestic Aviation – Jet Kerosene (CO_2)

CO_2 emissions from jet kerosene accounted for 97.7 % of total GHG emissions from domestic aviation in 2021.

Table 3.55 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for domestic aviation – jet kerosene. Between 1990 and 2021, CO_2 emissions decreased by 15 % in the EU, while between 2020 and 2021 the corresponding change was 24 % increase. Top five countries in 2021 were France, Spain, Italy, Germany, and Portugal, which accounted for the 90 % of the EU value.

Table 3.55 1A3a Domestic Aviation – Jet Kerosene: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	31	18	18	0.2%	-13	-42%	0	0%	T3	CS
Belgium	12	8	7	0.1%	-5	-44%	-1	-18%	T1	D
Bulgaria	28	12	14	0.1%	-14	-51%	2	17%	T2	D
Croatia	6	15	21	0.2%	14	230%	5	35%	T1	D
Cyprus	26	0	0	0.0%	-26	-99%	0	271%	T1	D
Czechia	NO	6	6	0.1%	6	∞	0	0%	T2	M
Denmark	218	75	83	0.9%	-134	-62%	9	12%	CR,M,T2	CS
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	377	86	77	0.8%	-300	-80%	-9	-10%	T2	CS
France	4 039	3 013	3 720	38.8%	-319	-8%	707	23%	T3	M
Germany	2 126	956	722	7.5%	-1 404	-66%	-234	-24%	CS,T2	CS,M
Greece	311	208	314	3.3%	3	1%	107	51%	T3	D
Hungary	1	1	3	0.0%	1	131%	1	123%	T2	CS
Ireland	45	11	17	0.2%	-28	-62%	6	50%	M,T3	CS
Italy	1 459	1 184	1 692	17.6%	232	16%	508	43%	T1,T2	CS
Latvia	0	1	3	0.0%	3	5819%	2	246%	T1	D
Lithuania	7	1	1	0.0%	-7	-87%	0	44%	T1	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	1	0	0	0.0%	-1	-95%	0	-38%	T1	D
Netherlands	73	21	23	0.2%	-49	-68%	2	8%	T1	D
Poland	38	40	42	0.4%	4	10%	2	4%	T1	D
Portugal	176	256	339	3.5%	163	93%	83	32%	T3	D
Romania	25	112	135	1.4%	110	444%	23	20%	T2	OTH
Slovakia	4	1	1	0.0%	-2	-66%	0	54%	T3	D
Slovenia	NO	0	0	0.0%	0	∞	0	1%	T1	D
Spain	1 628	1 506	2 162	22.6%	534	33%	656	44%	T3	D
Sweden	658	192	187	2.0%	-471	-72%	-5	-3%	T1	D
EU-27	**11 290**	**7 723**	**9 587**	**1**	**-1 702**	**-15%**	**1 865**	**24%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Figure 3.109 shows the time series of CO_2 emissions in EU from domestic aviation – jet kerosene and the highest shares of countries. Figure 3.108 shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 73 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.109 1A3a Domestic Aviation – Jet Kerosene: Time series of CO_2 emissions in EU and highest shares of countries

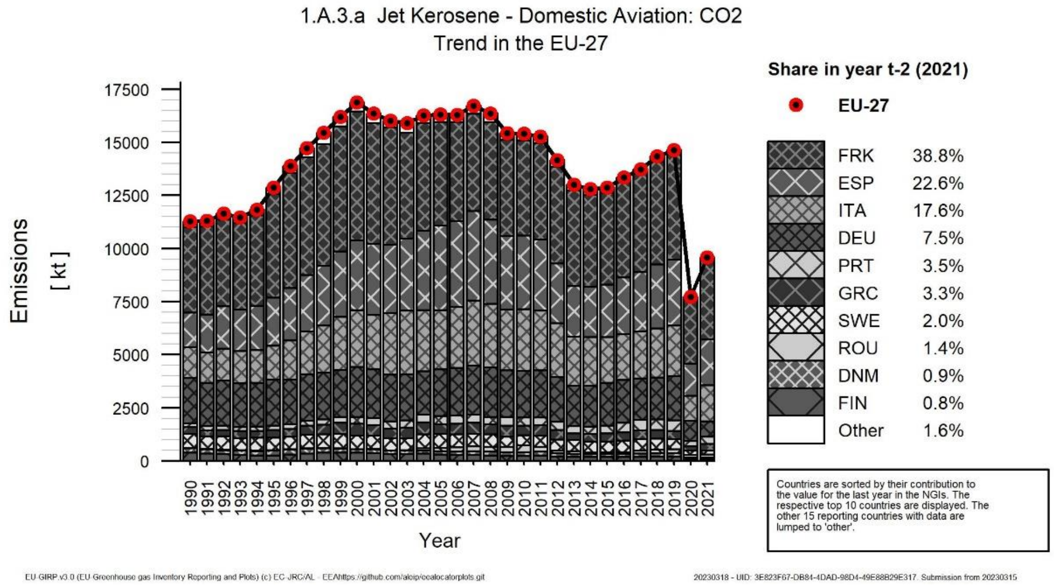
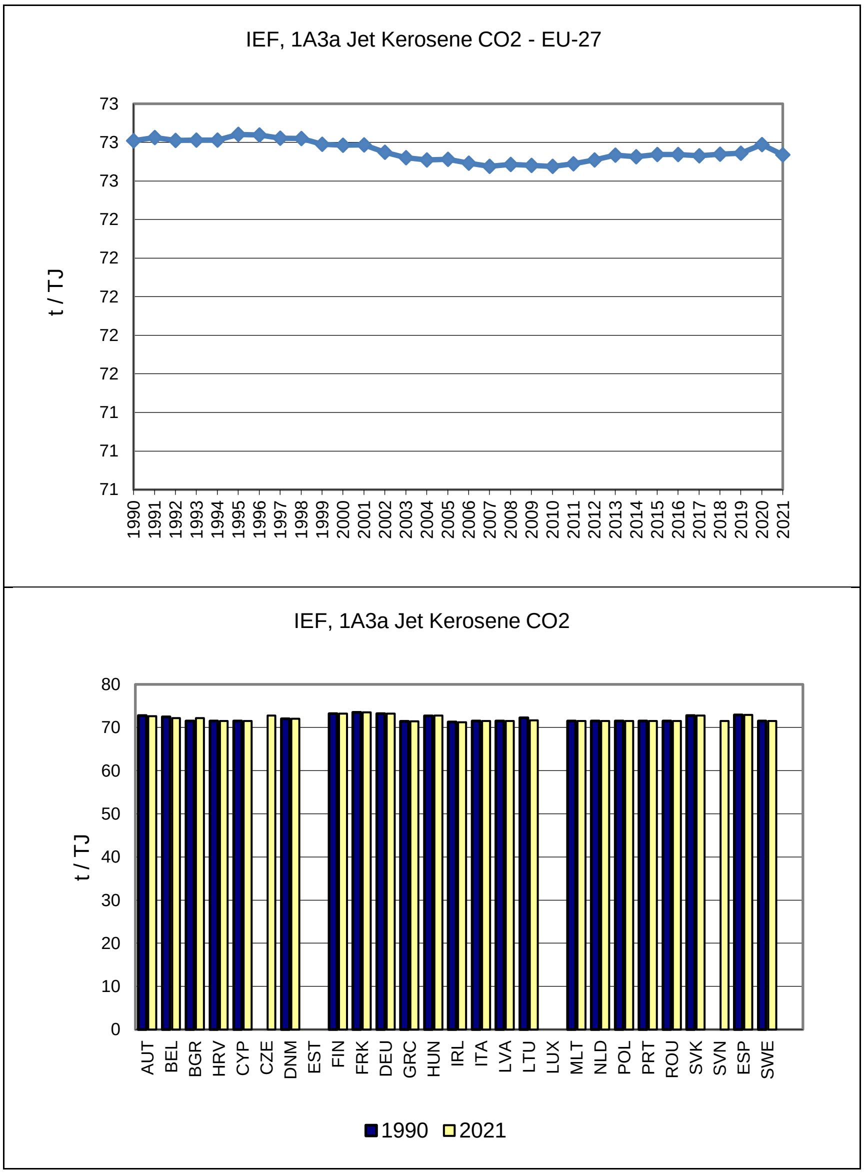


Figure 3.110 1A3a Domestic Aviation - Jet Kerosene: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



3.2.3.2 Road Transportation (1A3b) (EU)

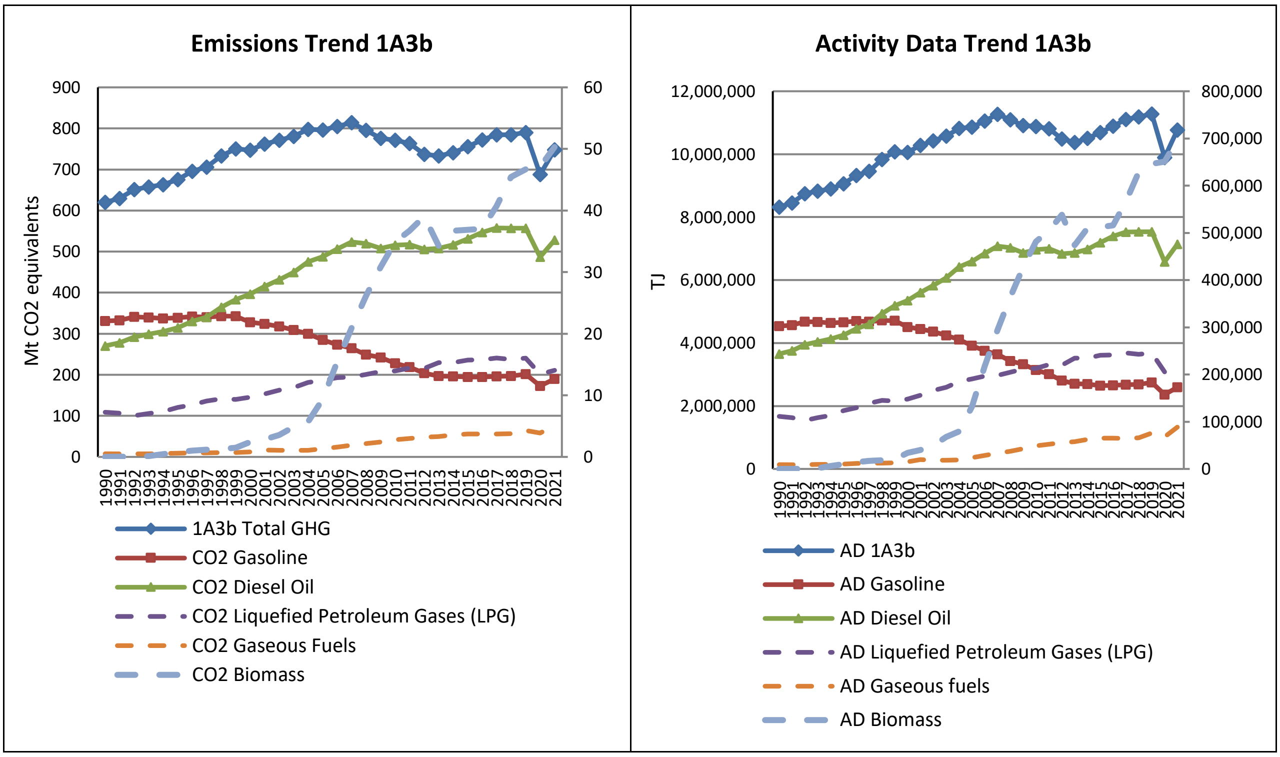
The mobile source category 1A3b Road transportation includes all types of light and heavy duty vehicles, i.e. passenger cars, light commercial vehicles, lorries, tractors, trailers and semi-trailers, and buses; in addition, all types of two and three-wheelers, i.e. mopeds and motorcycles (including tricycles). All these vehicles operate on various liquid and gaseous fuel types.

CO_2 emissions from 1A3b Road Transportation

CO_2 emissions from road transport is one of the largest key source categories among all sources in the EU accounting for 22.3 % of total GHG emissions in 2021 (including indirect CO_2, with LULUCF and international aviation). Considering only road transport, CO_2 accounted for 98.92 % of total GHG emissions from road transport in EU, 2021.

The time series of CO_2 emissions and activity data from 1A3b Road transportation, years 1990-2021, are shown in Figure 3.111. From this figure it can be observed that the largest contribution to emissions comes from the usage of diesel oil and gasoline.

Figure 3.111 1A3b Road Transportation: CO_2 emissions (in Mt) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.56 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation. Between 1990 and 2021, CO_2 emissions increased by 21 % in the EU, while between 2020 and 2021 the corresponding change was 9 % increase. Top five countries in 2021 were Germany, France, Italy, Spain, and Poland, which accounted for the 68 % of the EU value.

Table 3.56 1A3b Road Transportation: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	13 283	20 313	21 162	2.9%	7 880	59%	850	4%	T1,T2	CS,D
Belgium	19 677	20 577	22 716	3.1%	3 039	15%	2 140	10%	M,T2	CS,M
Bulgaria	5 784	8 993	9 635	1.3%	3 851	67%	642	7%	T1,T2	CR,D
Croatia	3 506	5 546	5 979	0.8%	2 473	71%	433	8%	T1	D
Cyprus	1 188	1 901	2 033	0.3%	845	71%	133	7%	T1,T2	D,M
Czechia	10 251	17 189	18 434	2.5%	8 183	80%	1 245	7%	T2	M
Denmark	9 338	11 062	11 262	1.5%	1 924	21%	200	2%	CR,M,T2	CS
Estonia	2 235	2 148	2 256	0.3%	21	1%	108	5%	T2	CS
Finland	10 804	9 845	9 383	1.3%	-1 421	-13%	-463	-5%	T2	CS
France	113 880	103 976	117 110	15.8%	3 230	3%	13 134	13%	T3	M
Germany	151 890	140 593	142 141	19.2%	-9 749	-6%	1 548	1%	M,T1,T2,T3	CS,D
Greece	11 793	13 192	14 323	1.9%	2 530	21%	1 131	9%	T1,T2,T3	CS,D
Hungary	7 917	12 244	13 652	1.8%	5 735	72%	1 408	12%	T1,T2	CS,D
Ireland	4 690	9 592	10 219	1.4%	5 528	118%	627	7%	T2,T3	CS,M
Italy	92 332	77 837	94 996	12.8%	2 664	3%	17 158	22%	T2	CS,M
Latvia	2 402	2 979	3 099	0.4%	697	29%	120	4%	T1,T2	CS,D
Lithuania	5 247	5 854	5 843	0.8%	596	11%	-12	0%	T1,T2	CS,D
Luxembourg	2 577	4 562	4 859	0.7%	2 282	89%	297	7%	T1,T2	CS,D
Malta	333	529	553	0.1%	220	66%	24	5%	T1	D,M
Netherlands	26 263	24 234	24 280	3.3%	-1 983	-8%	46	0%	T1,T2	CS
Poland	18 440	61 284	66 460	9.0%	48 021	260%	5 176	8%	T2	D
Portugal	10 001	14 194	15 175	2.1%	5 174	52%	981	7%	T2	OTH
Romania	10 366	17 505	18 557	2.5%	8 192	79%	1 052	6%	T1,T3	D,OTH
Slovakia	4 503	6 744	7 226	1.0%	2 723	60%	482	7%	T2	CS,D
Slovenia	2 607	4 504	5 124	0.7%	2 517	97%	620	14%	M	M
Spain	50 429	68 797	79 283	10.7%	28 854	57%	10 486	15%	CR	CR,CS
Sweden	17 402	13 931	13 996	1.9%	-3 406	-20%	65	0%	T2	CS
EU-27	**609 138**	**680 125**	**739 758**	**1**	**130 621**	**21%**	**59 633**	**9%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Table 3.57 shows the share of different fuels in total EU fuel consumption for road transport in 2021. Diesel oil has the largest percentage with 66.3 %, followed by gasoline with 24.1 %, biomass 6.5 %, LPG 2 %, gaseous fuels 0.8 %, and other fossil fuels 0.3 %.

Table 3.57 1A3b Road Transportation: Share of different fuels in total EU consumption (2021)

Diesel oil	Gasoline	Biomass	Liquefied petroleum gases (LPG)	Gaseous fuels	Other fossil
66.3 %	24.1 %	6.5 %	2.0 %	0.8 %	0.3 %

1A3b Road Transportation – Diesel Oil (CO_2)

CO_2 emissions from diesel oil accounted for 70.6 % of total GHG emissions from road transport in 2021. Table 3.8 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation – diesel oil. Between 1990 and 2021, CO_2 emissions increased by 95 % in the EU, while between 2020 and 2021 the corresponding change was 8 % increase. Top five countries in 2021 were Germany, France, Italy, Spain, and Poland, which accounted for the 68 % of the EU value.

Table 3.8 1A3b Road Transportation – Diesel Oil: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	5 360	16 243	16 839	3%	11 479	214%	597	4%	T2	CS
Belgium	11 027	15 782	16 907	3%	5 880	53%	1 125	7%	M,T2	CS,M
Bulgaria	1 539	6 242	6 779	1%	5 240	341%	538	9%	T2	CR
Croatia	1 159	4 179	4 454	1%	3 296	284%	276	7%	T1	D
Cyprus	669	982	1 050	0%	381	57%	68	7%	T2	M
Czechia	6 655	12 533	13 583	3%	6 929	104%	1 051	8%	T2	M
Denmark	4 417	7 503	7 552	1%	3 135	71%	49	1%	CR,M,T2	CS
Estonia	693	1 475	1 633	0%	940	136%	158	11%	T2	CS
Finland	4 923	6 450	5 963	1%	1 040	21%	-487	-8%	T2	CS
France	54 622	82 318	90 865	17%	36 243	66%	8 547	10%	T3	M
Germany	54 478	91 768	92 844	18%	38 367	70%	1 077	1%	CS,T2	CS
Greece	4 264	6 836	7 232	1%	2 968	70%	396	6%	T3,T2	CS
Hungary	2 388	8 202	9 369	2%	6 980	292%	1 167	14%	T2	CS
Ireland	1 914	7 870	8 396	2%	6 482	339%	526	7%	T2,T3	CS,M
Italy	47 808	53 877	66 254	13%	18 447	39%	12 377	23%	T2	CS
Latvia	623	2 352	2 487	0%	1 864	299%	134	6%	T2	CS
Lithuania	2 134	4 854	4 846	1%	2 712	127%	-7	0%	T2	CS
Luxembourg	1 290	3 750	3 883	1%	2 593	201%	133	4%	T2	CS
Malta	150	322	330	0%	180	120%	7	2%	T1	D
Netherlands	13 012	13 449	13 118	2%	106	1%	-331	-2%	T2	CS
Poland	8 769	43 142	46 705	9%	37 936	433%	3 562	8%	T2	D
Portugal	5 625	11 288	11 995	2%	6 370	113%	707	6%	T2	OTH
Romania	3 648	13 586	14 389	3%	10 741	294%	804	6%	T3	OTH
Slovakia	3 123	5 147	5 586	1%	2 463	79%	439	9%	T2	CS
Slovenia	867	3 504	3 971	1%	3 104	358%	467	13%	M	M
Spain	24 706	55 174	62 525	12%	37 819	153%	7 351	13%	CR	CS
Sweden	4 515	8 283	8 315	2%	3 800	84%	31	0%	T2	CS
EU-27	**270 377**	**487 111**	**527 871**	**100%**	**257 494**	**95%**	**40 760**	**8%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Figure 3.113 shows the time series of CO_2 emissions in EU from road transport – diesel oil and the highest shares of countries. Figure 3.112 shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 74 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.113 1A3b Road Transportation - Diesel Oil: Time series of CO_2 emissions in EU and highest shares of countries

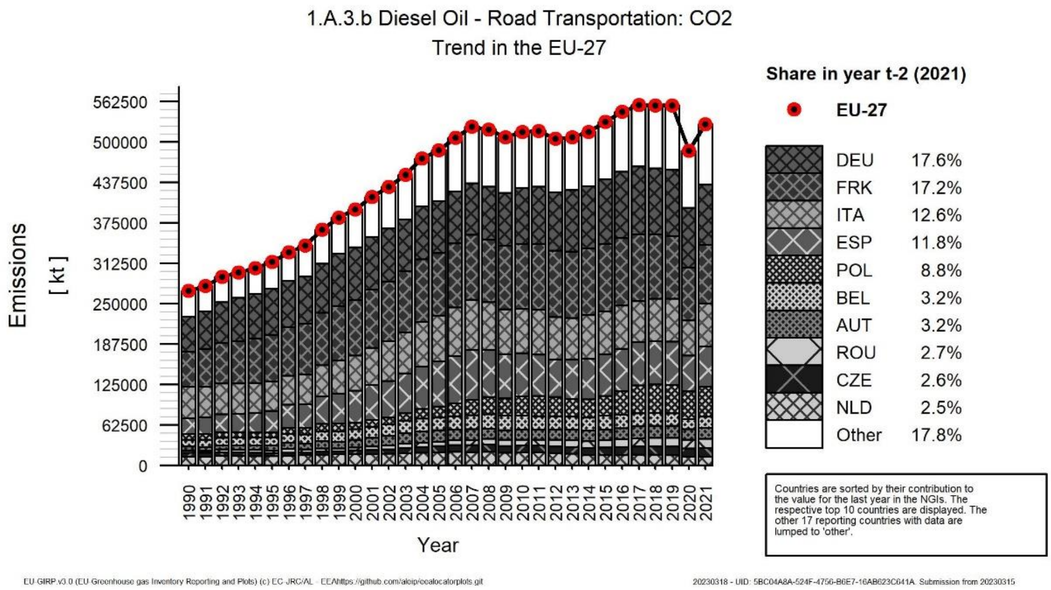
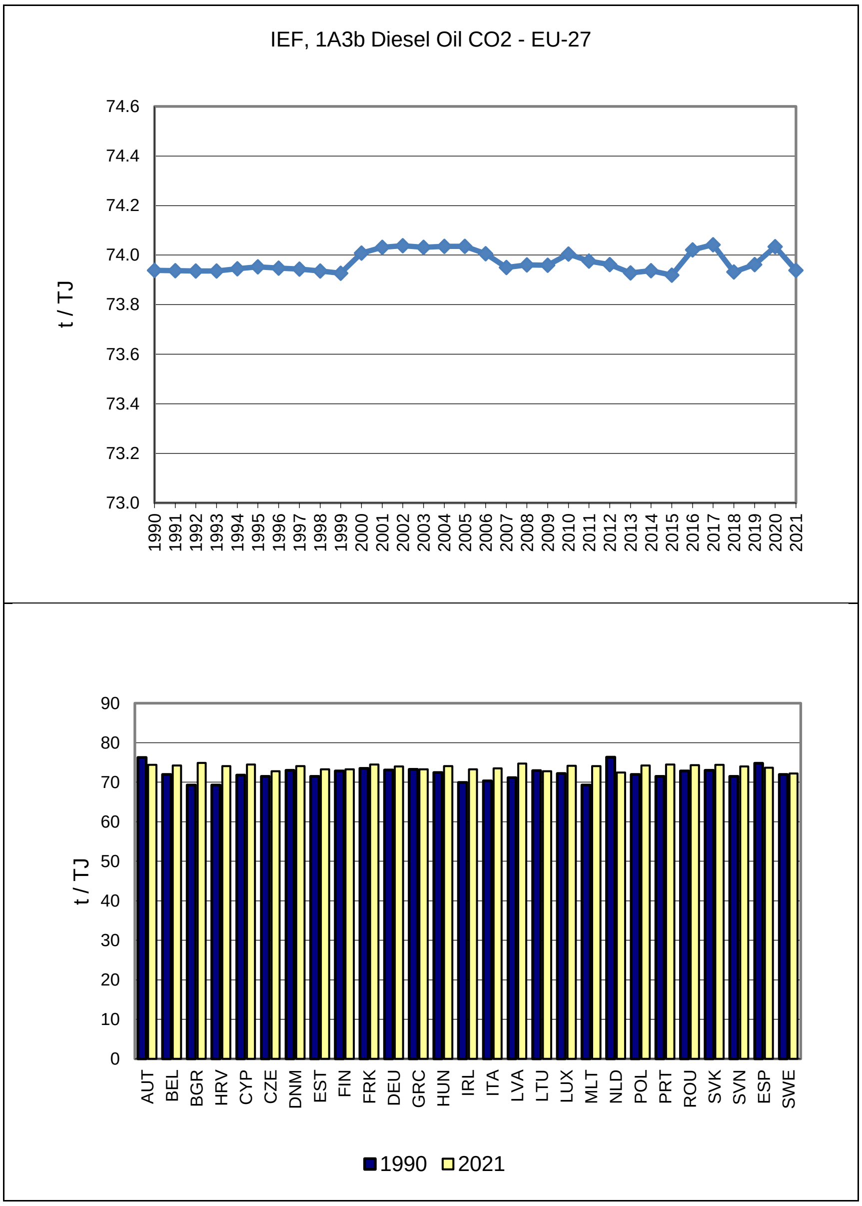


Figure 3.114 1A3b Road Transportation – Diesel Oil: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



1A3b Road Transportation – Gasoline (CO_2)

CO_2 emissions from gasoline accounted for 25.4 % of total GHG emissions from road transport in 2021. Table 3. shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation – gasoline. Between 1990 and 2021, CO_2 emissions decreased by 43 % in the EU, while between 2020 and 2021 the corresponding change was 10 % increase. Top five countries in 2021 were Germany, France, Italy, Spain, and Poland, which accounted for the 65 % of the EU value.

Table 3.9 1A3b Road Transportation – Gasoline: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	7 896	3 962	4 213	2%	-3 683	-47%	251	6%	T2	CS
Belgium	8 479	4 481	5 467	3%	-3 012	-36%	986	22%	M,T2	CS,M
Bulgaria	4 241	1 380	1 508	1%	-2 733	-64%	128	9%	T2	CR
Croatia	2 347	1 193	1 336	1%	-1 010	-43%	143	12%	T1	D
Cyprus	519	913	978	1%	459	89%	65	7%	T2	M
Czechia	3 596	4 210	4 404	2%	807	22%	194	5%	T2	M
Denmark	4 912	3 514	3 664	2%	-1 248	-25%	150	4%	CR,M,T2	CS
Estonia	1 542	623	578	0%	-964	-63%	-45	-7%	T2	CS
Finland	5 880	3 376	3 398	2%	-2 483	-42%	21	1%	T2	CS
France	59 097	20 035	24 151	13%	-34 946	-59%	4 117	21%	T3	M
Germany	97 217	47 177	47 524	25%	-49 693	-51%	347	1%	CS,T3	CS
Greece	7 438	5 609	6 326	3%	-1 112	-15%	717	13%	T3,T2	CS
Hungary	5 494	3 951	4 193	2%	-1 301	-24%	242	6%	T2	CS
Ireland	2 758	1 692	1 793	1%	-965	-35%	100	6%	T2,T3	CS,M
Italy	39 949	18 120	21 994	12%	-17 955	-45%	3 874	21%	T2	CS
Latvia	1 722	500	495	0%	-1 228	-71%	-5	-1%	T2	CS
Lithuania	3 053	696	697	0%	-2 356	-77%	1	0%	T2	CS
Luxembourg	1 275	795	964	1%	-311	-24%	168	21%	T2	CS
Malta	183	205	221	0%	38	21%	17	8%	T1	D
Netherlands	10 672	10 335	10 660	6%	-12	0%	325	3%	T2	CS
Poland	9 671	12 778	14 133	7%	4 462	46%	1 355	11%	T2	D
Portugal	4 370	2 772	3 027	2%	-1 343	-31%	255	9%	T2	OTH
Romania	6 591	3 687	3 933	2%	-2 657	-40%	246	7%	T3	OTH
Slovakia	1 380	1 469	1 492	1%	112	8%	23	2%	T2	CS
Slovenia	1 740	952	1 082	1%	-658	-38%	130	14%	M	M
Spain	25 639	12 823	15 791	8%	-9 848	-38%	2 968	23%	CR	CS
Sweden	12 884	5 567	5 616	3%	-7 268	-56%	49	1%	T2	CS
EU-27	**330 546**	**172 814**	**189 637**	**100%**	**-140 910**	**-43%**	**16 823**	**10%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Figure 3.115 shows the time series of CO_2 emissions in EU from road transport – gasoline and the highest shares of countries. Figure 3.116 shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 73 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.115 1A3b Road Transportation – Gasoline: Time series of CO_2 emissions in EU and highest shares of countries

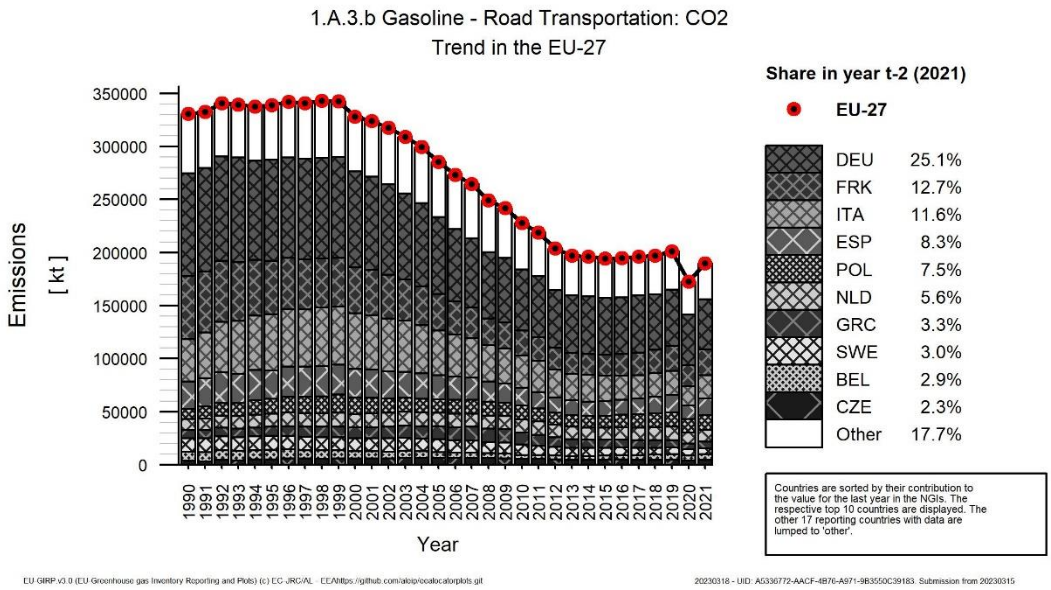
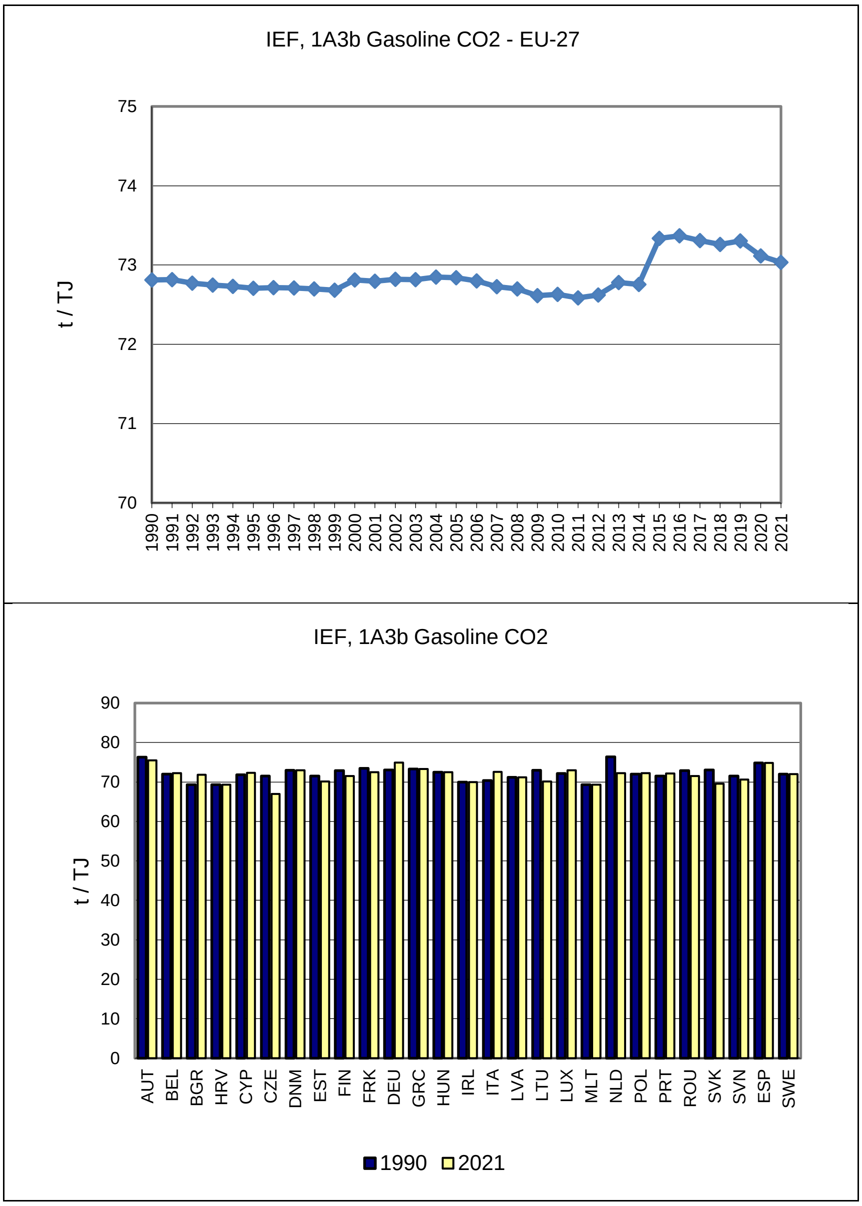


Figure 3.116 1A3b Road Transportation – Gasoline: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



1A3b Road Transportation – LPG (CO_2)

CO_2 emissions from LPG accounted for 1.9 % of total GHG emissions from road transport in 2021. Table 3.10 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation – LPG. Between 1990 and 2021, CO_2 emissions increased by 93 % in the EU, while between 2020 and 2021 the corresponding change was 5 % increase. Top five countries in 2021 were Poland, Italy, Bulgaria, Germany, and Greece, which accounted for the 85 % of the EU value.

Table 3.10 1A3b Road Transportation – LPG: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	26	8	10	0%	-16	-62%	2	23%	T2	CS
Belgium	169	130	129	1%	-41	-24%	-1	-1%	M,T2	CS,M
Bulgaria	NO	1 144	1 107	8%	1 107	∞	-37	-3%	T2	CR
Croatia	NO	156	164	1%	164	∞	7	5%	T1	D
Cyprus	NO	1	1	0%	1	∞	0	15%	T1	D
Czechia	NO	224	227	2%	227	∞	3	1%	T2	M
Denmark	9	0	0	0%	-9	-100%	0	-10%	CR,M,T2	CS
Estonia	1	27	28	0%	27	4589%	1	3%	T2	CS
Finland	NO,NA	NO,NA	NO,NA	-	-	-	-	-	NA	NA
France	150	107	149	1%	-1	0%	43	40%	T3	M
Germany	9	634	630	4%	621	6865%	-3	-1%	CS,T2	CS
Greece	91	534	519	4%	428	472%	-15	-3%	T2	CS
Hungary	NO	38	38	0%	38	∞	0	0%	T1	D
Ireland	19	3	3	0%	-15	-83%	0	1%	T2,T3	CS,M
Italy	4 026	3 962	4 257	30%	231	6%	295	7%	T2	CS
Latvia	37	115	104	1%	67	179%	-11	-10%	T2,T2	CS
Lithuania	60	271	258	2%	198	329%	-13	-5%	T2	CS
Luxembourg	11	1	1	0%	-11	-93%	0	47%	T2	CS
Malta	NO	2	2	0%	2	∞	0	15%	T1	D
Netherlands	2 578	263	267	2%	-2 312	-90%	3	1%	T2	CS
Poland	NO,IE	5 182	5 421	39%	5 421	∞	239	5%	T2	D
Portugal	0	84	94	1%	94	148668%	11	13%	T2	OTH
Romania	NO	233	235	2%	235	∞	2	1%	T3	OTH
Slovakia	NO	99	117	1%	117	∞	19	19%	T2	D
Slovenia	NO	25	44	0%	44	∞	19	76%	M	M
Spain	79	199	251	2%	173	220%	52	26%	CR	CS
Sweden	0	NO,IE	NO,IE	-	0	-100%	-	-	NA	NA
EU-27	**7 266**	**13 440**	**14 057**	**100%**	**6 791**	**93%**	**617**	**5%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

1A3b Road Transportation – Gaseous Fuels (CO_2)

CO_2 emissions from gaseous fuels accounted for 0.7 % of total GHG emissions from road transport in 2021. Table 3.8 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation – gaseous fuels. Between 1990 and 2021, CO_2 emissions increased by 898 % in the EU, while between 2020 and 2021 the corresponding change was 31 % increase. Top five countries in 2021 were Italy, Germany, France, Spain, and Bulgaria, which accounted for the 84.5 % of the EU value.

3.8 1A3b Road Transportation – Gaseous Fuels: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	NO	44	43	1%	43	∞	-2	-4%	T2	CS
Belgium	NO,IE	45	47	1%	47	∞	1	3%	M,T2	CS,M
Bulgaria	NO	202	215	4%	215	∞	13	6%	T2	CR
Croatia	NO	7	9	0%	9	∞	2	31%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	176	179	4%	179	∞	3	2%	T2	M
Denmark	0	16	16	0%	16	107583%	0	3%	CR,M,T2	CS
Estonia	NO	20	15	0%	15	∞	-5	-25%	T2	CS
Finland	NO,NA	20	22	0%	22	∞	3	13%	T2	CS
France	0	454	636	13%	636	178491%	182	40%	T3	M
Germany	NA	471	654	13%	654	∞	183	39%	CS,T3	CS
Greece	NO	37	55	1%	55	∞	17	46%	T2	CS
Hungary	0	19	17	0%	17	5574%	-2	-8%	T2	CS
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	487	1 674	2 261	45%	1 773	364%	587	35%	T2	CS
Latvia	17	1	3	0%	-14	-82%	2	150%	T2	CS
Lithuania	NO	19	23	0%	23	∞	4	19%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	143	187	4%	187	∞	44	31%	T2	CS
Poland	NO	47	66	1%	66	∞	20	42%	T2	D
Portugal	NO	48	57	1%	57	∞	9	18%	T2	OTH
Romania	NO	0	0	0%	0	∞	0	-16%	T3	OTH
Slovakia	NO	8	8	0%	8	∞	0	4%	T2	D
Slovenia	NO	8	11	0%	11	∞	3	31%	M	M
Spain	NO	398	517	10%	517	∞	119	30%	CR	CS
Sweden	3	22	22	0%	20	674%	1	4%	T2	CS
EU-27	**508**	**3 879**	**5 064**	**100%**	**4 556**	**898%**	**1 185**	**31%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

3.7 shows the time series of CO_2 emissions in EU from road transport – gaseous fuels and the highest shares of countries. 3.10 shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 56 - 57 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021 (where available).

Figure 3.117: 1A3b Road Transportation – Gaseous Fuels: Time series of CO_2 emissions in EU and highest shares of countries

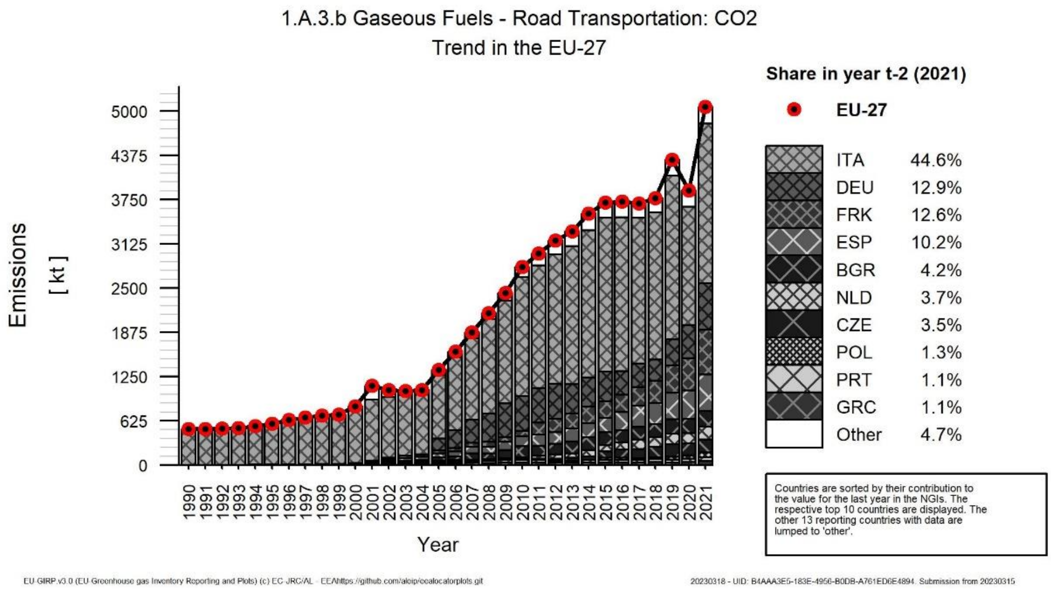
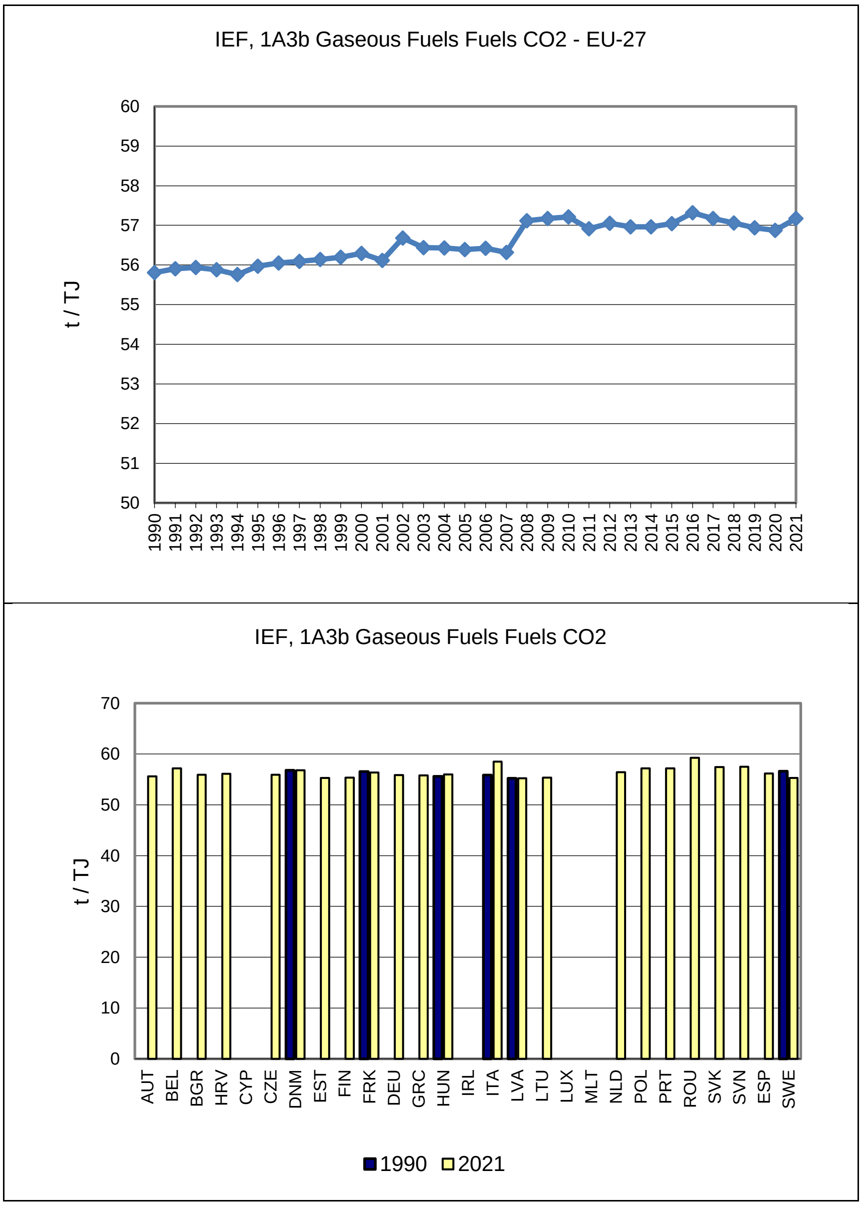


Figure 3.118 1A3b Road Transportation – Gaseous Fuels: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



1.A.3.b Road Transportation: Other Fossil Fuels (CO_2)

This category covers the CO_2 emissions from the fossil part of biofuels. According to the 2006 IPCC Guidelines (vol. 2, chapter 3, section 'CO_2 emissions from biofuels'. p. 3.17*): "… it is important to assess the biofuel origin so as to identify and separate fossil from biogenic feedstocks".* In other words, a part of the carbon of biofuels (and the associated CO_2 emissions) may have a fossil origin. The IPCC Guidelines provide some examples about biofuels' fossil part: *"… biodiesel made from coal methanol with animal feedstocks has a non-zero fossil fuel fraction and is therefore not fully carbon neutral. Ethanol from the fermentation of agricultural products will generally be purely biogenic (carbon neutral), except in some cases, such as fossil-fuel derived methanol. Products which have undergone further chemical transformation may contain substantial amounts of fossil carbon ranging from about 5-10 percent in the fossil methanol used for biodiesel production upwards to 46 percent in ethyl-tertiary-butyl-ether (ETBE) from fossil isobutene. Some processes may generate biogenic by-products such as glycol or glycerine, which may then be used elsewhere."*

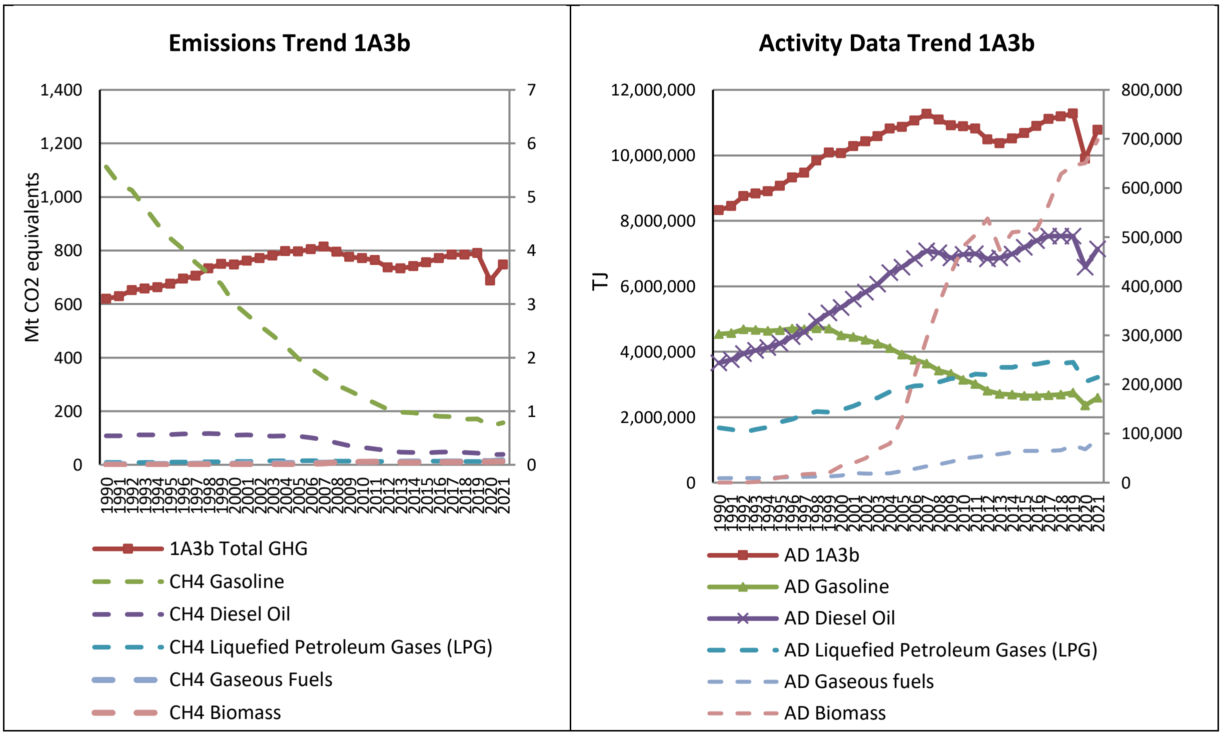
Based on the above, all countries are encouraged to calculate these emissions and include them separately in the CRF tables under "Other fossil fuels". The contribution of this category to total GHG emissions from road transport was 0.4 % in 2021 (i.e. very small), hence, no further analysis per country is considered necessary.

CH_4 emissions from 1A3b Road Transportation

CH_4 emissions from road transport accounted only for 0.036 % of total GHG emissions in EU, 2021 (including indirect CO_2, with LULUCF and international aviation). Considering only road transport, CH_4 accounted for 0.16 % of total GHG emissions from road transport in EU, 2021.

The time series of CH_4 emissions and activity data from 1A3b Road transportation, years 1990-2021, are shown in Figure 3.119. From this figure it can be observed that the largest contribution to emissions comes from the usage of gasoline.

Figure 3.119 1A3b Road Transportation: CH_4 emissions (in Mt of CO_2 equ.) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.58 shows the CH_4 emissions per country and at EU level (in kt of CO_2 equ.), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation. Between 1990 and 2021, CH_4 emissions decreased by 81 % in the EU, while between 2020 and 2021 the corresponding change was 8 % increase. Top five countries in 2021 were Germany, Italy, France, Spain, and Poland, which accounted for the 67 % of the EU value.

Table 3.58 1A3b Road Transportation: CH_4 emissions per country (in kt of CO_2 equ.), share in EU (%), change, method and EF information

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	82	20	21	1.7%	-61	-75%	1	3%	T3	CS
Belgium	156	17	20	1.7%	-136	-87%	3	18%	M,T3	CS,M
Bulgaria	76	23	23	1.9%	-53	-69%	1	3%	T2	CR
Croatia	46	10	9	0.8%	-37	-80%	-1	-7%	T1,T3	CR,D
Cyprus	8	3	3	0.3%	-5	-59%	0	13%	T1,T2	D,M
Czechia	86	26	27	2.3%	-59	-69%	1	5%	T3	M
Denmark	88	9	9	0.7%	-79	-90%	0	1%	CR,M,T3	CR
Estonia	24	3	3	0.3%	-21	-87%	0	-5%	T3	CS
Finland	120	9	8	0.7%	-111	-93%	-1	-7%	T3	CR
France	1 072	132	158	13.2%	-914	-85%	26	20%	T3	M
Germany	1 813	234	231	19.4%	-1 581	-87%	-3	-1%	CS,M,T2,T3	CS,M
Greece	120	63	68	5.7%	-51	-43%	6	9%	M,T1,T2	D,M
Hungary	75	22	23	1.9%	-52	-69%	1	3%	T1,T3	D,M
Ireland	54	7	7	0.6%	-47	-87%	0	2%	T3	M
Italy	971	171	197	16.5%	-774	-80%	26	15%	T3	M
Latvia	24	4	3	0.3%	-20	-86%	0	-3%	T1,T3	CR,D,M
Lithuania	44	8	8	0.6%	-37	-83%	0	0%	T1,T3	CR,D
Luxembourg	14	3	3	0.3%	-11	-76%	0	9%	T3	M
Malta	3	1	1	0.1%	-2	-68%	0	0%	T3	M
Netherlands	214	62	64	5.4%	-150	-70%	3	4%	T1,T2,T3	CS
Poland	177	100	102	8.6%	-75	-42%	3	3%	T3	D
Portugal	109	19	21	1.7%	-88	-81%	1	7%	T3	OTH
Romania	101	35	37	3.1%	-64	-64%	2	6%	T1,T3	D,OTH
Slovakia	33	5	5	0.4%	-27	-84%	0	9%	T3	CS,D
Slovenia	31	4	5	0.4%	-26	-85%	0	11%	M	M
Spain	445	91	112	9.4%	-333	-75%	21	23%	CR	CR
Sweden	178	24	23	2.0%	-154	-87%	-1	-4%	M,T2	CS,D
EU-27	**6 163**	**1 104**	**1 194**	**1**	**-4 969**	**-81%**	**90**	**8%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

1A3b Road Transportation – Gasoline (CH_4)

CH_4 emissions from gasoline accounted for 0.11 % of total GHG emissions from road transport in 2021. Table 3.59 shows the CH_4 emissions per country and at EU level (in kt of CO_2 equ.), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation – gasoline. Between 1990 and 2021, CH_4 emissions decreased by 86 % in the EU, while between 2020 and 2021 the corresponding change was 8 % increase. Top five countries in 2021 were Germany, Italy, France, Spain, and Poland, which accounted for the 67 % of the EU value.

Table 3.59 1A3b Road Transportation – Gasoline: CH_4 emissions per country (in kt of CO_2 equ.), share in EU (%), change, method and EF information

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	77	8	7	1%	-70	-90%	0	-3%	T3	CS
Belgium	129	13	15	2%	-114	-88%	3	22%	M,T3	CS,M
Bulgaria	72	7	7	1%	-64	-90%	1	10%	T2	CR
Croatia	43	7	7	1%	-37	-85%	0	-4%	T3	CR
Cyprus	6	2	3	0%	-4	-58%	0	10%	T2	M
Czechia	66	17	19	2%	-47	-72%	1	8%	T3	M
Denmark	77	7	7	1%	-70	-91%	0	1%	CR,M,T3	CR
Estonia	22	2	2	0%	-20	-90%	0	-6%	T3	CS
Finland	104	7	6	1%	-98	-94%	-1	-9%	T3	CR
France	961	94	112	14%	-849	-88%	18	19%	T3	M
Germany	1 762	156	147	19%	-1 615	-92%	-9	-6%	CS,M,T3	CS,M
Greece	109	44	49	6%	-60	-55%	5	12%	M	M,D
Hungary	68	16	16	2%	-52	-76%	1	4%	T3	M
Ireland	48	5	5	1%	-43	-89%	0	7%	T3	M
Italy	821	119	134	17%	-686	-84%	15	12%	T3	M
Latvia	21	2	2	0%	-19	-93%	0	-5%	T3	CR
Lithuania	36	2	2	0%	-34	-94%	0	-2%	T3	CR
Luxembourg	13	1	1	0%	-12	-92%	0	11%	T3	M
Malta	2	1	1	0%	-2	-71%	0	2%	T3	M
Netherlands	174	49	50	6%	-125	-72%	0	1%	T3	CS
Poland	155	48	51	6%	-104	-67%	3	7%	T3	D
Portugal	94	13	14	2%	-80	-85%	1	7%	T3	OTH
Romania	91	22	24	3%	-67	-74%	2	8%	T3	OTH
Slovakia	23	3	3	0%	-20	-87%	0	1%	T3	D,CS
Slovenia	28	3	4	0%	-25	-88%	0	10%	M	M
Spain	383	68	86	11%	-297	-78%	18	27%	CR	CR
Sweden	174	13	12	2%	-161	-93%	-1	-5%	M	CS
EU-27	**5 562**	**729**	**787**	**100%**	**-4 775**	**-86%**	**58**	**8%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Figure 3.17 shows the time series of CH_4 emissions in EU from road transport – gasoline and the highest shares of countries. Figure 3.17 shows the CH_4 implied emission factor (IEF) in EU and per country (in kg/TJ). From the latter it is observed that the CH_4 IEF at EU level decreases over time from 44 kg/TJ in 1990 to 11 kg/TJ in 2021, while the corresponding values per country present deviations from this EU average value in both 1990 and 2021.

Figure 3.120 1A3b Road Transportation – Gasoline: Time series of CH_4 emissions in EU and highest shares of countries

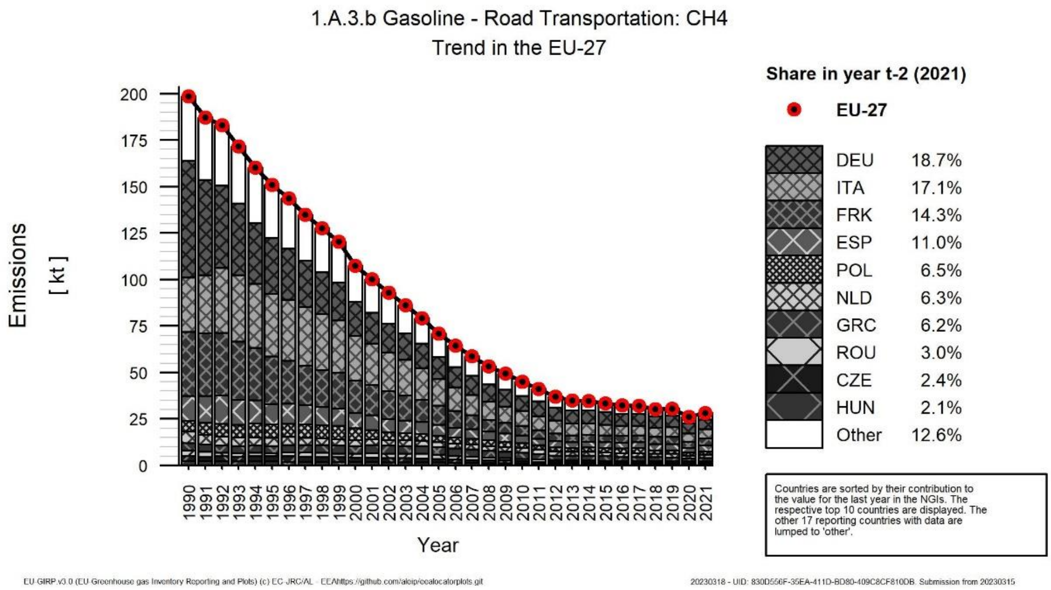
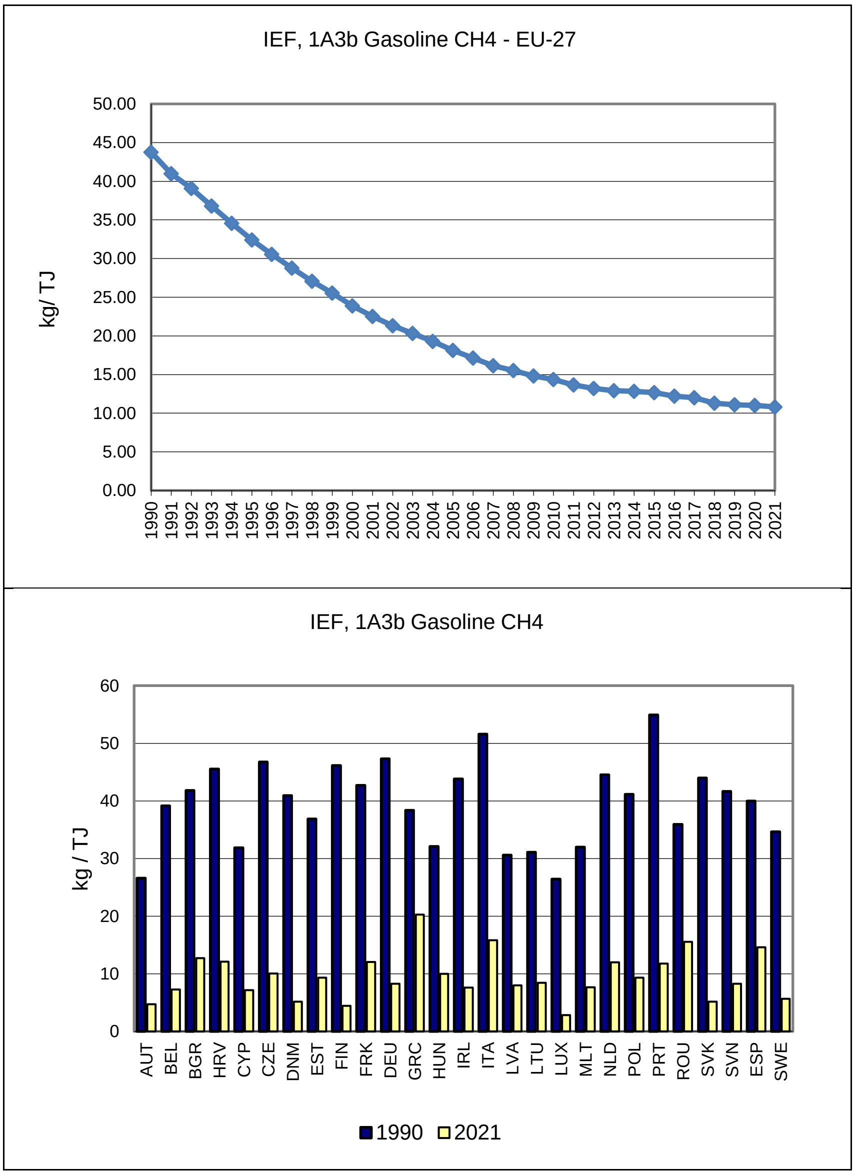


Figure 3.121 1A3b Road Transportation – Gasoline: CH_4 Implied Emission Factor (IEF) in EU and per country (in kg/TJ)

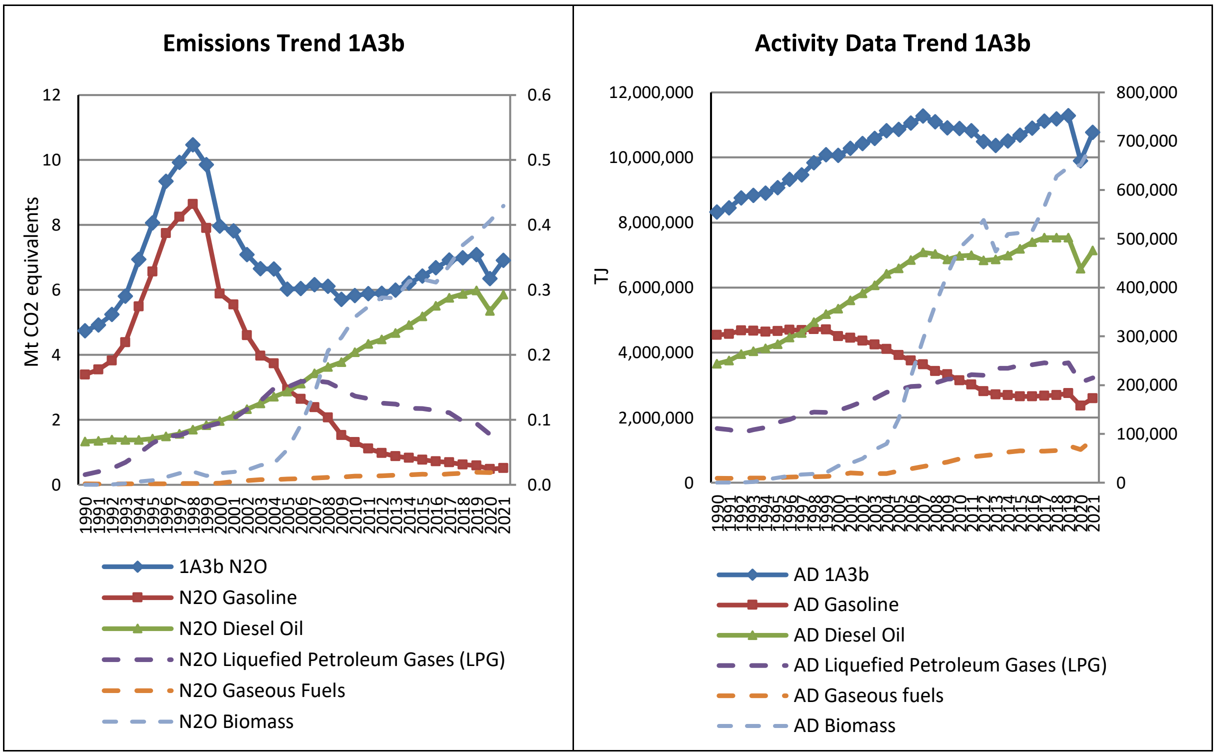


N_2O emissions from 1A3b Road Transportation

N_2O emissions from road transport accounted only for 0.21 % of total GHG emissions in EU, 2021 (including indirect CO_2, with LULUCF and international aviation). Considering only road transport, N_2O accounted for 0.92 % of total GHG emissions from road transport in EU, 2021.

The time series of N_2O emissions and activity data from 1A3b Road transportation, years 1990-2021, are shown in Figure 3.122. From this figure it can be observed that the largest contribution to emissions comes from the usage of diesel oil since 2006; for years prior to 2006 the higher contribution was coming from gasoline.

Figure 3.122 1A3b Road Transportation: N_2O emissions (in Mt of CO_2 equ.) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.60 shows the N_2O emissions per country and at EU level (in kt of CO_2 equ.), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation. Between 1990 and 2021, N_2O emissions increased by 46 % in the EU, while between 2020 and 2021 the corresponding change was 9 % increase. Top five countries in 2021 were Germany, France, Italy, Spain, and Poland, which accounted for the 68 % of the EU value.

Table 3.60 1A3b Road Transportation: N_2O emissions per country (in kt of CO_2 equ.), share in EU (%), change, method and EF information

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	94	210	219	3.2%	126	134%	9	4%	T3	CS
Belgium	140	208	223	3.2%	84	60%	16	7%	M,T3	CS,M
Bulgaria	47	78	83	1.2%	36	77%	5	6%	T2	CR
Croatia	47	50	51	0.7%	4	10%	1	2%	T1,T3	CR,D
Cyprus	12	12	12	0.2%	-1	-4%	0	1%	T1,T2	D,M
Czechia	83	160	175	2.5%	92	112%	15	10%	T3	M
Denmark	77	109	111	1.6%	34	43%	2	2%	CR,M,T3	CR
Estonia	19	18	20	0.3%	1	4%	2	10%	T3	CS
Finland	137	73	73	1.0%	-64	-47%	-1	-1%	T3	CR
France	801	990	1 097	15.9%	295	37%	107	11%	T3	M
Germany	1 123	1 337	1 351	19.5%	228	20%	15	1%	CS,M,T2,T3	CS,M
Greece	104	96	105	1.5%	0	0%	8	8%	M,T1,T2	D,M
Hungary	54	113	127	1.8%	74	136%	14	13%	T1,T3	D,M
Ireland	45	94	102	1.5%	58	129%	8	8%	T3	M
Italy	745	654	796	11.5%	51	7%	142	22%	T3	M
Latvia	19	26	28	0.4%	9	45%	2	7%	T1,T3	CR,D,M
Lithuania	44	47	48	0.7%	4	8%	1	3%	T1,T3	CR,D
Luxembourg	14	45	48	0.7%	34	247%	2	5%	T3	M
Malta	2	3	3	0.0%	1	47%	0	-1%	T3	M
Netherlands	89	187	186	2.7%	97	108%	-1	0%	T1,T2	CS
Poland	146	579	659	9.5%	512	351%	80	14%	T3	D
Portugal	70	127	139	2.0%	69	99%	12	10%	OTH,T3	CR,OTH
Romania	202	183	193	2.8%	-9	-4%	10	6%	T1,T3	D,OTH
Slovakia	50	58	72	1.0%	22	43%	14	24%	T3	CS,D
Slovenia	27	46	51	0.7%	25	93%	5	11%	M	M
Spain	412	690	783	11.3%	370	90%	93	13%	CR	CR
Sweden	138	155	160	2.3%	22	16%	4	3%	M,T1,T2	CS,D
EU-27	**4 742**	**6 348**	**6 914**	**1**	**2 172**	**46%**	**566**	**9%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

1A3b Road Transportation – Diesel Oil (N_2O)

N_2O emissions from diesel oil accounted for 0.78 % of total GHG emissions from road transport in 2021. Table 3.61 shows the N_2O emissions per country and at EU level (in kt of CO_2 equ.), share of each country in EU (%), change between years, method and EF information for 1A3b Road transportation – diesel oil. Between 1990 and 2021, N_2O emissions increased by 340 % in the EU, while between 2020 and 2021 the corresponding change was 9 % increase. Top five countries in 2021 were Germany, France, Spain, Italy, and Poland, which accounted for the 69 % of the EU value.

Table 3.61 1A3b Road Transportation – Diesel Oil: N_2O emissions per country (in kt of CO_2 equ.), share in EU (%), change, method and EF information

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	11	190	199	3%	188	1753%	9	5%	T3	CS
Belgium	54	176	188	3%	134	249%	12	7%	M,T3	CS,M
Bulgaria	11	53	58	1%	47	422%	4	8%	T2	CR
Croatia	10	42	44	1%	33	333%	1	3%	T3	CR
Cyprus	3	8	8	0%	5	165%	0	1%	T2	M
Czechia	46	131	146	2%	99	214%	15	12%	T3	M
Denmark	27	94	95	2%	68	256%	1	1%	CR,M,T3	CR
Estonia	6	15	17	0%	10	165%	2	14%	T3	CS
Finland	58	55	49	1%	-9	-16%	-6	-11%	T3	CR
France	207	837	924	16%	717	347%	86	10%	T3	M
Germany	129	1 176	1 206	21%	1 077	833%	31	3%	CS,M,T3	CS,M
Greece	35	53	56	1%	22	62%	4	7%	M	M
Hungary	19	87	101	2%	82	436%	14	15%	T3	M
Ireland	13	85	93	2%	80	640%	8	9%	T3	M
Italy	305	531	658	11%	353	116%	127	24%	T3	M
Latvia	6	22	24	0%	18	291%	2	9%	T3	CR
Lithuania	20	43	44	1%	24	117%	1	3%	T3	CR
Luxembourg	2	40	42	1%	40	1813%	2	6%	T3	M
Malta	0	2	2	0%	2	395%	0	2%	T3	M
Netherlands	24	144	140	2%	116	482%	-4	-3%	T2	CS
Poland	64	447	526	9%	462	722%	80	18%	T3	D
Portugal	26	97	105	2%	79	303%	7	8%	T3,OTH	OTH
Romania	27	139	148	3%	120	439%	9	6%	T3	OTH
Slovakia	37	48	61	1%	24	65%	12	26%	T3	D
Slovenia	9	40	44	1%	36	416%	5	12%	M	M
Spain	169	649	731	12%	563	334%	82	13%	CR	CR
Sweden	12	145	149	3%	136	1092%	4	3%	M	CS
EU-27	**1 330**	**5 349**	**5 856**	**100%**	**4 527**	**340%**	**508**	**9%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Figure 3.124 shows the time series of N_2O emissions in EU from road transport – diesel oil and the highest shares of countries. 3.123 shows the N_2O implied emission factor (IEF) in EU and per country (in kg/TJ). From the latter it is observed that the N_2O IEF at EU level increased from 1.37 kg/TJ in 1990 to 3.1 kg/TJ in 2021, while the corresponding values per country present deviations from this EU average value in both 1990 and 2021.

Figure 3.124 1A3b Road Transportation – Diesel Oil: Time series of N_2O emissions in EU and highest shares of countries

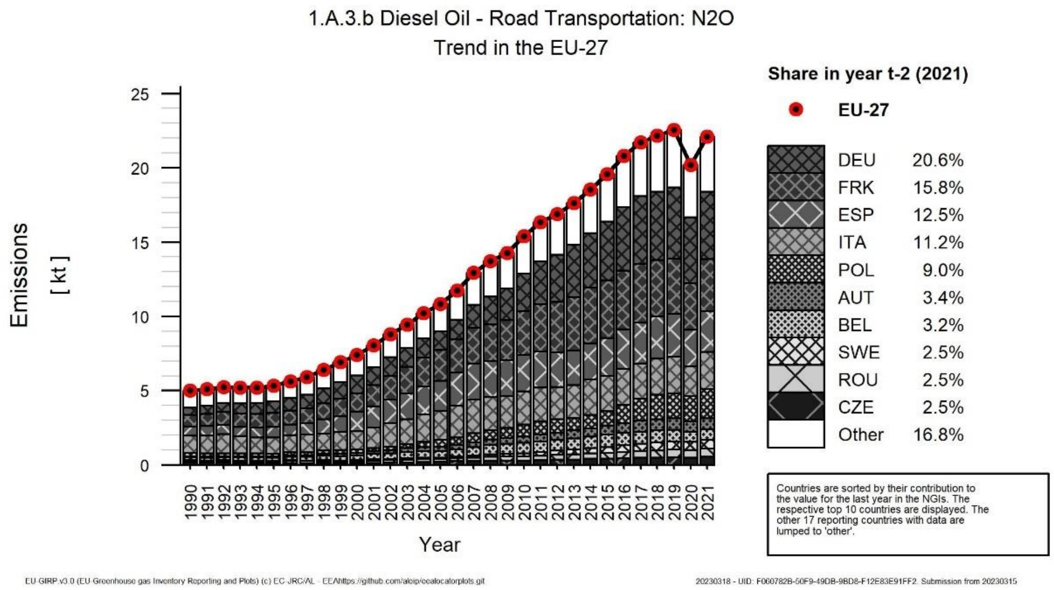
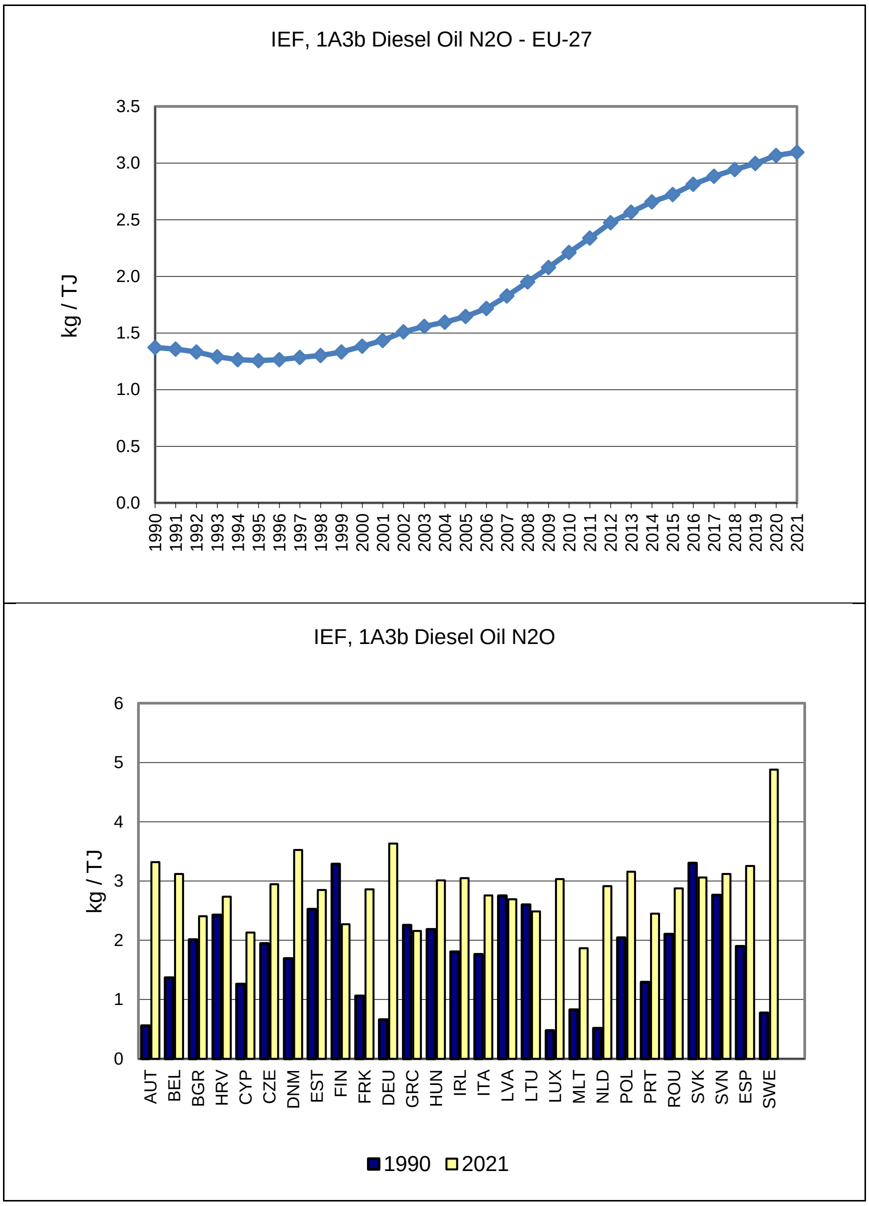


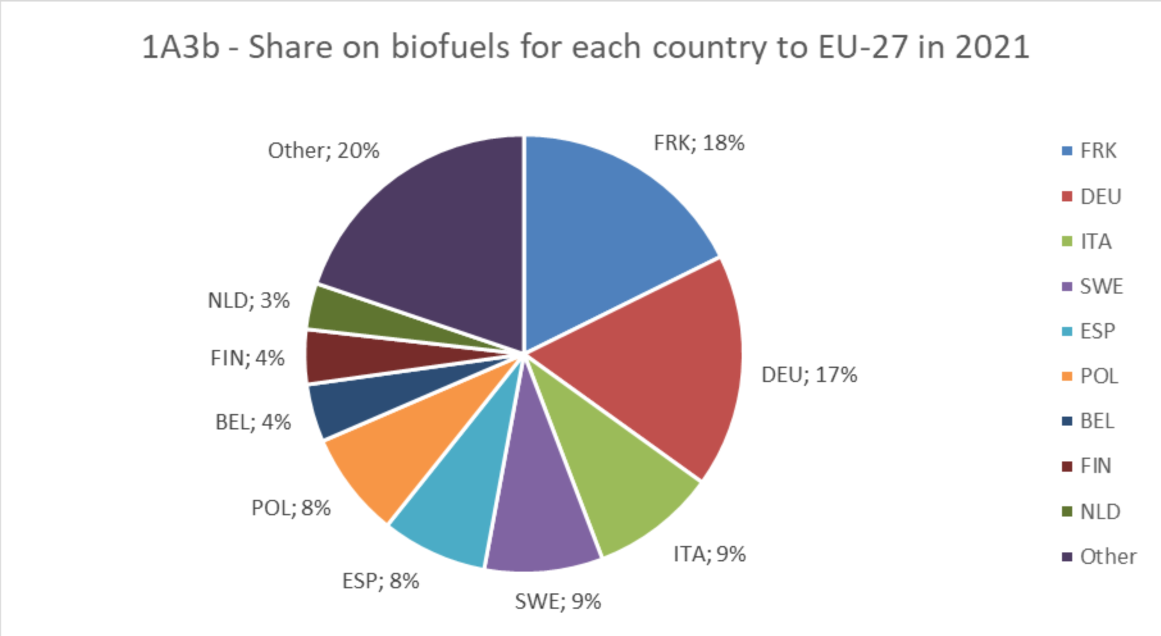
Figure 3.125 1A3b Road Transportation – Diesel Oil: N_2O Implied Emission Factor (IEF) in EU and per country (in kg/TJ)



1A3b Road Transportation – Biofuels (activity data)

Figure 3.126 shows the share of activity data biofuels of each country in EU (%) in 2021. Top five countries in 2021 were France, Germany, Italy, Sweden, and Spain, which accounted for the 61 % of the EU value.

Figure 3.126 1A3b Road Transportation – Biofuels: Share of activity data of each country in EU (%)



3.2.3.3 Railways (1A3c) (EU)

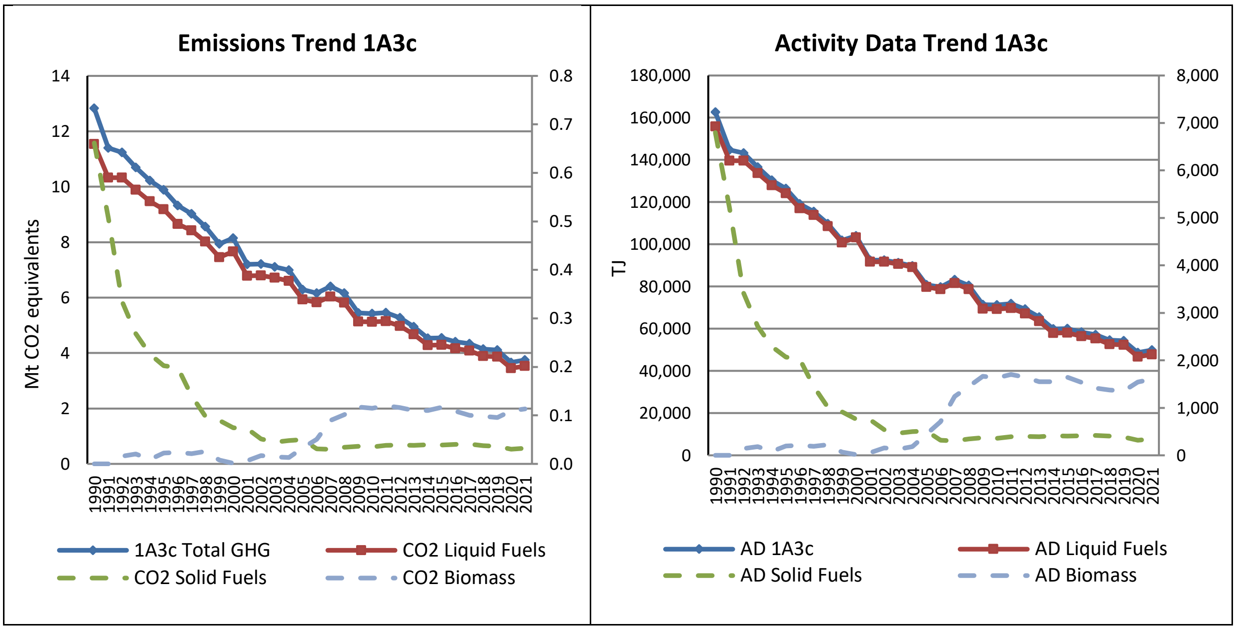
The mobile source category 1A3c Railways includes all types of locomotives operating mainly on liquid fuels; in addition, there is a small part of solid fuels usage.

CO_2 emissions from 1A3c Railways

CO_2 emissions from railways accounted only for 0.11 % of total GHG emissions in EU, 2021 (including indirect CO_2, with LULUCF and international aviation). Considering only railways, CO_2 accounted for 95.3 % of total GHG emissions from railways in EU, 2021.

The time series of CO_2 emissions and activity data from 1A3c Railways, years 1990-2021, are shown in Figure 3.127. From this figure it can be observed that the largest contribution to emissions comes from the usage of liquid fuels.

Figure 3.127 1A3c Railways: CO_2 emissions (in Mt) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.62 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3c Railways. Between 1990 and 2021, CO_2 emissions decreased by 71 % in the EU, while between 2020 and 2021 the corresponding change was 2 % increase. Top five countries in 2021 were Germany, Romania, France, Poland, and Czechia, which accounted for the 59 % of the EU value.

Table 3.62 1A3c Railways: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	178	81	81	2.3%	-97	-55%	0	0%	T1,T2	CS,D
Belgium	222	69	71	2.0%	-152	-68%	2	2%	T3	CS,D
Bulgaria	323	29	32	0.9%	-291	-90%	2	8%	T1	D
Croatia	140	42	45	1.3%	-95	-68%	3	8%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	768	230	228	6.4%	-540	-70%	-3	-1%	T1,T2	D
Denmark	297	197	185	5.2%	-112	-38%	-12	-6%	CR,T2	CS
Estonia	159	44	43	1.2%	-116	-73%	-1	-3%	T2	CS
Finland	191	64	71	2.0%	-120	-63%	7	11%	T2	CS
France	1 078	301	343	9.6%	-735	-68%	43	14%	T1	OTH
Germany	3 122	830	853	23.9%	-2 269	-73%	23	3%	CS,M,T1	CS,D,M
Greece	199	23	NO	-	-199	-100%	-23	-100%	NA	NA
Hungary	533	105	105	2.9%	-428	-80%	0	0%	T1,T2	CS,D
Ireland	133	97	105	2.9%	-28	-21%	8	8%	T2	CS
Italy	613	136	118	3.3%	-496	-81%	-18	-14%	T2	CS
Latvia	537	81	76	2.1%	-460	-86%	-5	-6%	T1,T2	CS,D
Lithuania	350	162	153	4.3%	-197	-56%	-9	-6%	T1,T2	CS,D
Luxembourg	25	7	7	0.2%	-17	-70%	1	10%	T1,T2	CS,D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	91	60	56	1.6%	-35	-39%	-5	-8%	T2	CS
Poland	1 624	258	280	7.8%	-1 344	-83%	22	8%	T1	D
Portugal	177	26	26	0.7%	-152	-86%	0	-1%	T1	D
Romania	473	345	404	11.3%	-69	-15%	59	17%	T1,T2	CS,D
Slovakia	372	73	82	2.3%	-290	-78%	10	13%	T1	CS
Slovenia	65	17	21	0.6%	-45	-68%	4	21%	T1	D
Spain	422	170	148	4.1%	-274	-65%	-22	-13%	T1	D
Sweden	103	44	44	1.2%	-58	-57%	0	1%	T2	CS
EU-27	**12 196**	**3 492**	**3 576**	**1**	**-8 620**	**-71%**	**85**	**2%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

1A3c Railways – Liquid Fuels (CO_2)

CO_2 emissions from liquid fuels accounted for 94.2 % of total GHG emissions from railways in 2021. Table 3.63 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3c Railways – liquid fuels. Between 1990 and 2021, CO_2 emissions decreased by 69 % in the EU, while between 2020 and 2021 the corresponding change was 2 % increase. Top five countries in 2021 were Germany, Romania, France, Poland, and Czechia, which accounted for the 59 % of the EU value.

Table 3.63 1A3c Railways – Liquid Fuels: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	171	80	80	2.3%	-91	-53%	0	0%	T2	CS
Belgium	222	69	71	2.0%	-152	-68%	2	2%	T3	CS,D
Bulgaria	323	29	32	0.9%	-291	-90%	2	8%	T1	D
Croatia	119	42	45	1.3%	-74	-62%	3	8%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	768	230	227	6.4%	-541	-70%	-3	-1%	T2	D
Denmark	297	190	178	5.0%	-119	-40%	-13	-7%	CR,T2	CS
Estonia	142	44	43	1.2%	-99	-70%	-1	-3%	T2	CS
Finland	191	64	71	2.0%	-120	-63%	7	11%	T2	CS
France	1 078	299	342	9.7%	-737	-68%	42	14%	T1	OTH
Germany	2 847	798	820	23.2%	-2 027	-71%	21	3%	CS,M	CS,M
Greece	199	23	NO	-	-199	-100%	-23	-100%	NA	NA
Hungary	528	105	105	3.0%	-424	-80%	0	0%	T2	CS
Ireland	133	97	105	3.0%	-28	-21%	8	8%	T2	CS
Italy	613	136	118	3.3%	-496	-81%	-18	-14%	T2	CS
Latvia	537	81	76	2.2%	-460	-86%	-5	-6%	T2	CS
Lithuania	350	162	153	4.3%	-197	-56%	-9	-6%	T1,T2	CS,D
Luxembourg	25	7	7	0.2%	-17	-70%	1	10%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	91	60	56	1.6%	-35	-39%	-5	-8%	T2	CS
Poland	1 319	258	280	7.9%	-1 039	-79%	22	8%	T1	D
Portugal	177	26	26	0.7%	-152	-86%	0	-1%	T1	D
Romania	441	345	404	11.4%	-37	-8%	59	17%	T1,T2	CS,D
Slovakia	372	73	82	2.3%	-290	-78%	10	13%	T1	CS
Slovenia	65	17	21	0.6%	-44	-68%	4	21%	T1	D
Spain	422	170	148	4.2%	-274	-65%	-22	-13%	T1	D
Sweden	103	44	44	1.3%	-58	-57%	0	1%	T2	CS
EU-27	**11 535**	**3 450**	**3 532**	**1**	**-8 002**	**-69%**	**82**	**2%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Figure 3.129 shows the time series of CO_2 emissions in EU from railways – liquid fuels and the highest shares of countries. Figure 3.128 shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 74 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.129 1A3c Railways – Liquid Fuels: Time series of CO_2 emissions in EU and highest shares of countries

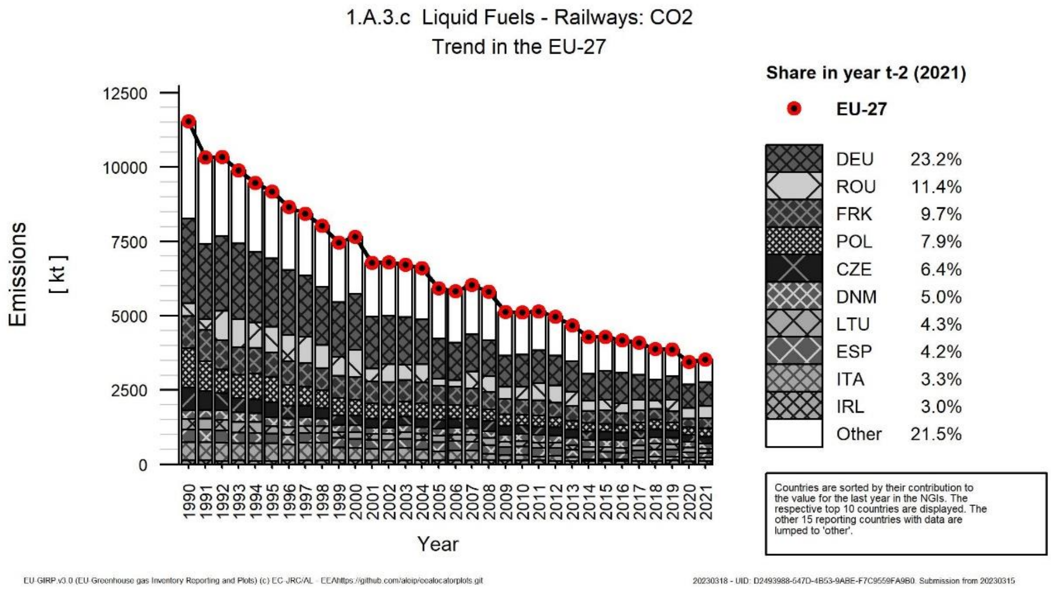
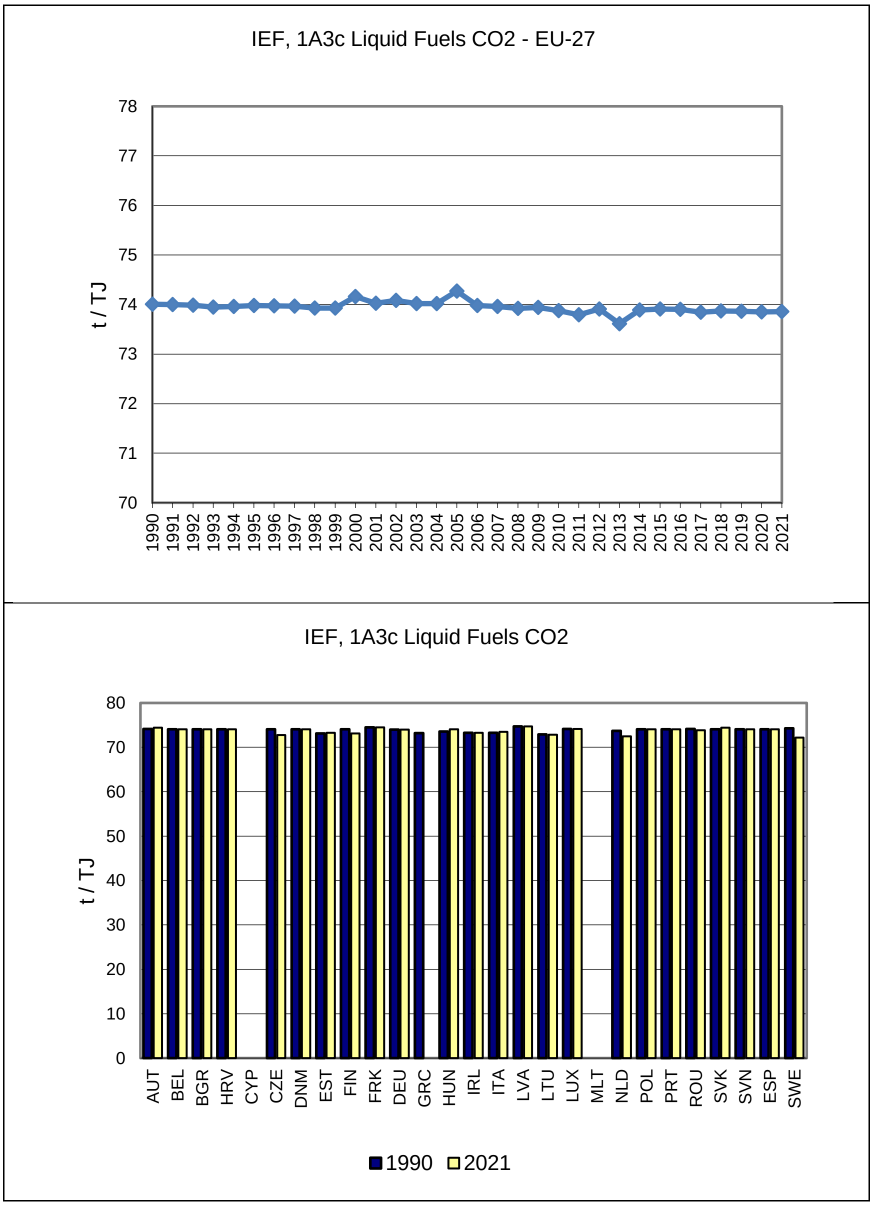


Figure 3.130 1A3c Railways – Liquid Fuels: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



3.2.3.4 Domestic Navigation (1A3d) (EU)

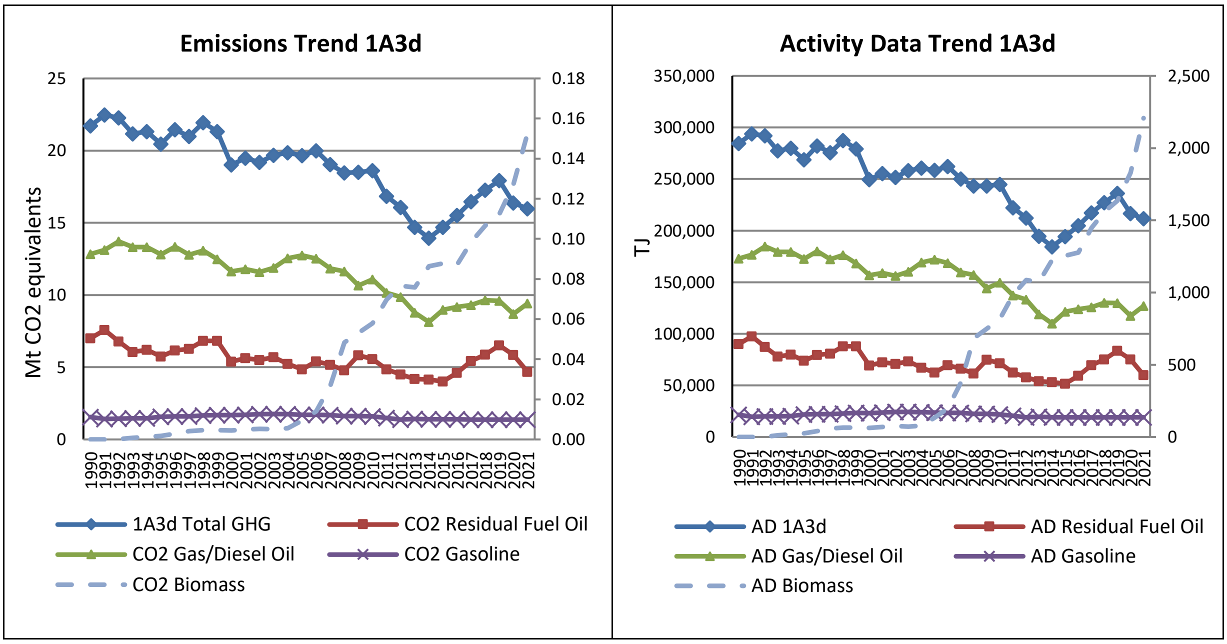
This mobile source category includes emissions from domestic waterborne transport, i.e. passenger and freight activity of trips having their origin and destination (O-D) within the same country. The main fuel used is gas/diesel oil, followed by residual fuel oil, while there is also a small part of gasoline. The emissions from military mobile sources related to navigation are excluded from 1A3d and are reported separately under category 1A5b (Other mobile military use). Fishing vessels are also excluded and they are reported separately under category 1A4ciii (Other sectors – Fishing).

CO_2 emissions from 1A3d Domestic Navigation

CO_2 emissions from domestic navigation accounted only for 0.5 % of total GHG emissions in EU, 2021 (including indirect CO_2, with LULUCF and international aviation). Considering only domestic navigation, CO_2 accounted for 98.1 % of total GHG emissions from domestic navigation in EU, 2021.

The time series of CO_2 emissions and activity data from 1A3d Domestic navigation, years 1990-2021, are shown in Figure 3.131. From this figure it can be observed that the largest contribution to emissions comes from the usage of gas/diesel oil, followed by residual fuel oil.

Figure 3.131 1A3d Domestic Navigation: CO_2 emissions (in Mt) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.64 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3c Railways. Between 1990 and 2021, CO_2 emissions decreased by 27 % in the EU, while between 2020 and 2021 the corresponding change was 3 % decrease. Top five countries in 2021 were Italy, Spain, Greece, Germany, and France, which accounted for the 76 % of the EU value.

Table 3.64 1A3d Domestic Navigation: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	28	23	35	0.2%	7	26%	12	52%	T1,T2	CS,D
Belgium	362	369	389	2.5%	27	8%	21	6%	T1,T3	CS,D
Bulgaria	56	5	4	0.0%	-52	-92%	0	-9%	T1	D
Croatia	134	127	149	0.9%	14	10%	21	17%	T1	D
Cyprus	2	1	3	0.0%	0	20%	1	129%	T1	D
Czechia	54	13	13	0.1%	-41	-76%	0	0%	T1	D
Denmark	715	478	543	3.5%	-173	-24%	65	14%	CR,M,T2	CS
Estonia	22	20	18	0.1%	-3	-16%	-2	-8%	T2	CS
Finland	441	350	353	2.3%	-88	-20%	3	1%	T2	CS
France	1 021	1 282	1 297	8.3%	276	27%	15	1%	T1	CS
Germany	2 993	1 407	1 450	9.2%	-1 544	-52%	43	3%	CS,M	CS,M
Greece	1 809	1 668	1 835	11.7%	26	1%	167	10%	T1	CS
Hungary	209	13	10	0.1%	-200	-95%	-3	-25%	T1	D
Ireland	85	335	370	2.4%	285	336%	35	10%	T2	CS
Italy	5 470	5 798	4 532	28.9%	-938	-17%	-1 265	-22%	T1,T2	CS
Latvia	1	7	8	0.1%	7	684%	1	8%	T1,T2	CS,D
Lithuania	15	12	12	0.1%	-3	-21%	1	6%	T1	CS
Luxembourg	1	0	1	0.0%	-1	-41%	0	100%	T1,T2	CS,D
Malta	12	54	68	0.4%	56	478%	14	26%	T1	D
Netherlands	743	692	773	4.9%	30	4%	81	12%	T2	CS
Poland	151	15	28	0.2%	-122	-81%	13	84%	T1	D
Portugal	263	202	207	1.3%	-55	-21%	5	3%	T2	D
Romania	1 142	131	160	1.0%	-981	-86%	29	22%	T2	CS
Slovakia	0	5	6	0.0%	6	25802%	0	9%	T1	CS
Slovenia	0	0	0	0.0%	0	507%	0	-22%	T1	D
Spain	5 203	2 475	2 809	17.9%	-2 393	-46%	335	14%	T1,T2	CS,D
Sweden	452	623	600	3.8%	148	33%	-23	-4%	T2	CS
EU-27	**21 384**	**16 105**	**15 675**	**1**	**-5 709**	**-27%**	**-431**	**-3%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

1A3d Domestic Navigation – Gas/Diesel Oil (CO_2)

CO_2 emissions from gas/diesel oil accounted for 59 % of total GHG emissions from domestic navigation in 2021. Table 3.65 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3d Domestic navigation – gas/diesel oil. Between 1990 and 2021, CO_2 emissions decreased by 27 % in the EU, while between 2020 and 2021 the corresponding change was 8 % increase. Top five countries in 2021 were Italy, Spain, Germany, Greece, and the Netherlands, which accounted for the 74 % of the EU value.

Table 3.65 1A3d Domestic Navigation – Gas/Diesel Oil: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	18	17	29	0.3%	10	56%	12	73%	T2	CS
Belgium	362	369	389	4.1%	27	8%	21	6%	T1,T3	CS,D
Bulgaria	56	5	4	0.0%	-52	-92%	0	-9%	T1	D
Croatia	128	127	148	1.6%	21	16%	21	17%	T1	D
Cyprus	2	1	3	0.0%	0	20%	1	130%	T1	D
Czechia	54	13	13	0.1%	-41	-76%	0	0%	T1	D
Denmark	359	336	372	3.9%	13	4%	35	11%	CR,M,T2	CS
Estonia	22	20	18	0.2%	-3	-16%	-2	-8%	T2	CS
Finland	186	182	181	1.9%	-5	-3%	-1	-1%	T2	CS
France	324	375	385	4.1%	61	19%	10	3%	T1	CS
Germany	2 754	1 363	1 403	14.9%	-1 351	-49%	40	3%	CS	CS,M
Greece	1 063	691	842	8.9%	-221	-21%	151	22%	T1	CS
Hungary	28	13	10	0.1%	-19	-67%	-3	-25%	T1	D
Ireland	22	335	370	3.9%	348	1566%	35	10%	T2	CS
Italy	2 326	2 382	2 448	26.0%	122	5%	66	3%	T1,T2	CS
Latvia	1	7	7	0.1%	6	770%	0	4%	T2	CS
Lithuania	15	12	12	0.1%	-3	-21%	1	6%	T1	CS
Luxembourg	1	0	1	0.0%	0	-33%	0	83%	T2	CS
Malta	6	53	67	0.7%	61	956%	14	26%	T1	D
Netherlands	697	629	710	7.5%	13	2%	81	13%	T2	CS
Poland	81	15	28	0.3%	-53	-65%	13	84%	T1	D
Portugal	73	56	58	0.6%	-15	-21%	2	3%	T2	D
Romania	112	128	158	1.7%	47	42%	30	23%	T2	CS
Slovakia	0	5	6	0.1%	6	25802%	0	9%	T1	CS
Slovenia	0	0	0	0.0%	0	442%	0	-25%	T1	D
Spain	3 960	1 334	1 529	16.2%	-2 431	-61%	195	15%	T1	D
Sweden	181	221	220	2.3%	40	22%	-1	0%	T2	CS
EU-27	**12 831**	**8 690**	**9 411**	**1**	**-3 420**	**-27%**	**721**	**8%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Figure 3.133 shows the time series of CO_2 emissions in EU from domestic navigation – gas/diesel oil and the highest shares of countries. Figure 3.132 shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 74 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.133 1A3d Domestic Navigation – Gas/Diesel Oil: Time series of CO_2 emissions in EU and highest shares of countries

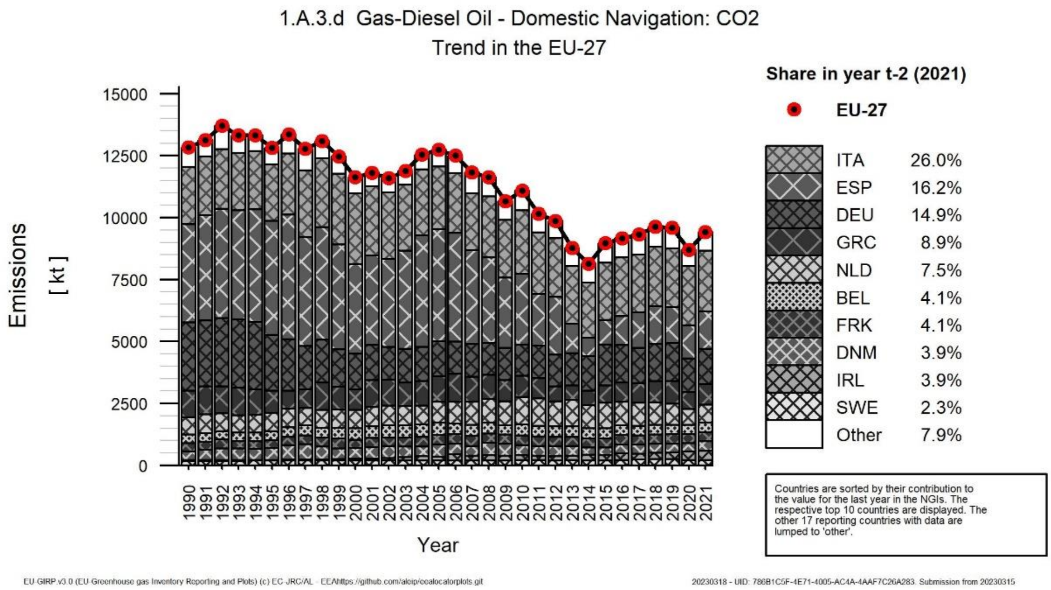
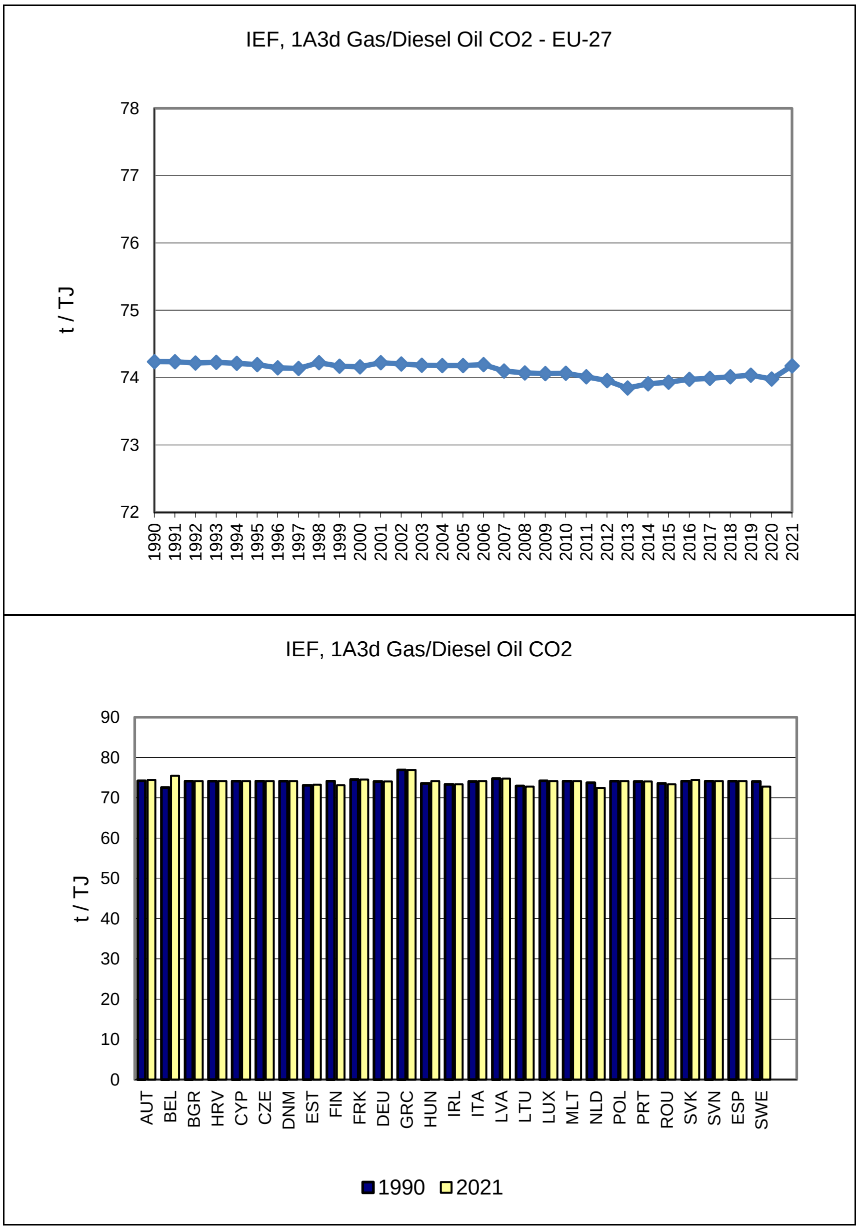


Figure 3.134 1A3d Domestic Navigation – Gas/Diesel Oil: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



1A3d Domestic Navigation – Residual Fuel Oil (CO_2)

CO_2 emissions from residual fuel oil accounted for 29 % of total GHG emissions from domestic navigation in 2021. Table 3.66 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3d Domestic navigation – residual fuel oil. Between 1990 and 2021, CO_2 emissions decreased by 33 % in the EU, while between 2020 and 2021 the corresponding change was 20 % decrease. Top five countries in 2021 were Italy, Spain, Greece, Sweden, and Denmark, which accounted for the 94 % of the EU value.

Table 3.66 1A3d Navigation, residual fuel oil: Member States' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	NO	NO	NO	-	-	-	-	-	NA	NA
Belgium	IE	IE	IE	-	-	-	-	-	NA	NA
Bulgaria	NO	NO	NO	-	-	-	-	-	NA	NA
Croatia	7	NO	NO	-	-7	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	357	133	162	3.5%	-195	-55%	29	22%	CR,T2	CS
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	123	19	13	0.3%	-110	-89%	-5	-29%	T2	CS
France	159	64	70	1.5%	-89	-56%	5	8%	T1	CS
Germany	240	28	30	0.6%	-209	-87%	2	7%	CS	CS,M
Greece	746	977	993	21.3%	247	33%	16	2%	T1	CS
Hungary	3	NO	NO	-	-3	-100%	-	-	NA	NA
Ireland	63	NO	NO	-	-63	-100%	-	-	NA	NA
Italy	2 576	3 134	1 797	38.5%	-779	-30%	-1 338	-43%	T1,T2	CS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	5	NO	NO	-	-5	-100%	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	70	NO	NO	-	-70	-100%	-	-	NA	NA
Portugal	190	146	150	3.2%	-40	-21%	4	3%	T2	D
Romania	1 029	NO	NO	-	-1 029	-100%	-	-	NA	NA
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	1 242	1 140	1 280	27.4%	38	3%	140	12%	T2	CS
Sweden	195	221	177	3.8%	-18	-9%	-43	-20%	T2	CS
EU-27	**7 004**	**5 862**	**4 671**	**1**	**-2 332**	**-33%**	**-1 190**	**-20%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

Figure 3.136 shows the time series of CO_2 emissions in EU from domestic navigation – residual fuel oil and the highest shares of countries. Figure 3.135 shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 77.6 - 78.0 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.136 1A3d Domestic Navigation – Residual Fuel Oil: Time series of CO_2 emissions in EU and highest shares of countries

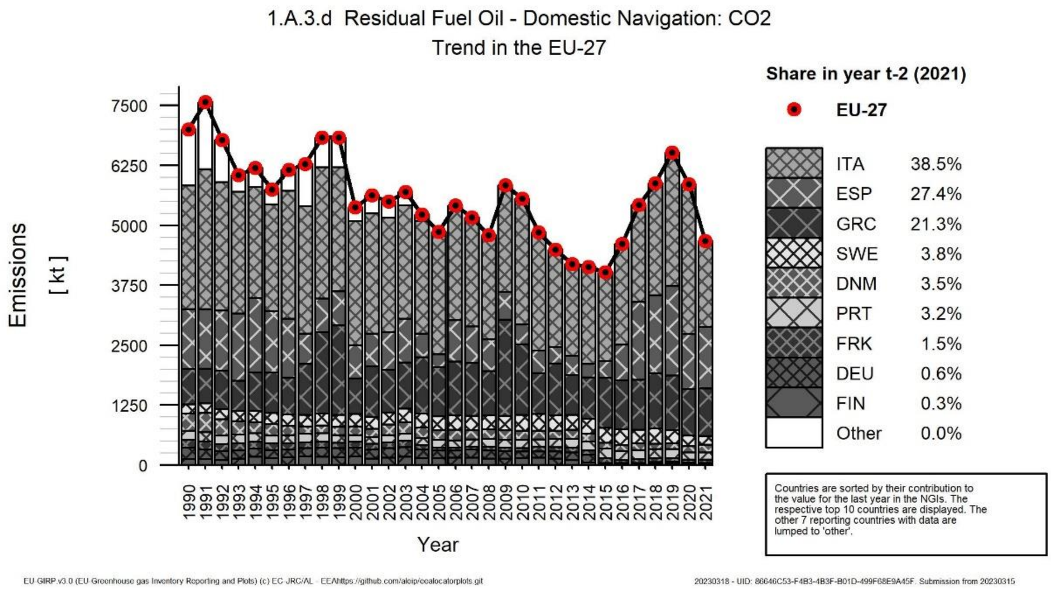
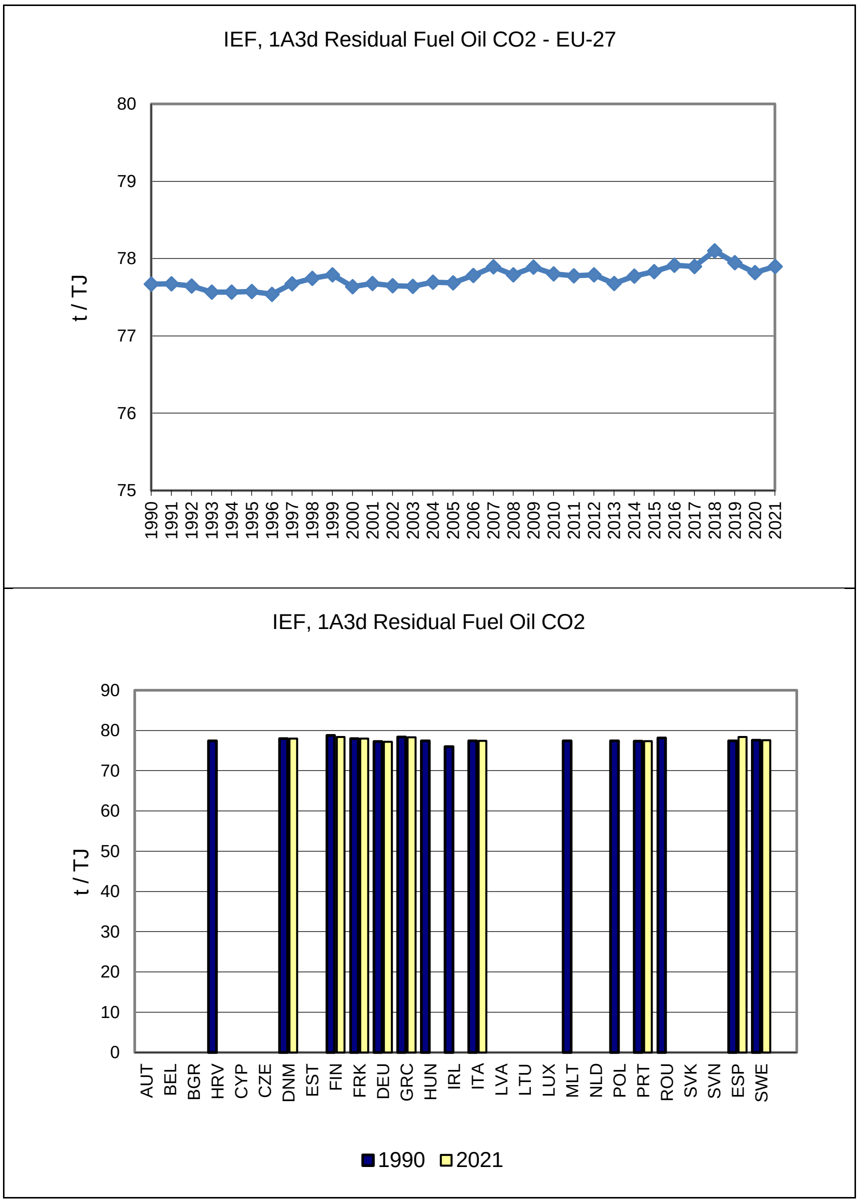


Figure 3.137 1A3d Domestic Navigation – Residual Fuel Oil: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



3.2.3.5 Other (1A3e) (EU)

This mobile source category includes mainly emissions from pipeline transport using gaseous fuels; in addition, there is a small part from ground activities in airports and harbours using liquid fuels.

CO_2 emissions from 1A3e Other

CO_2 emissions from 1A3e Other accounted only for 0.14 % of total GHG emissions in EU, 2021 (including indirect CO_2, with LULUCF and international aviation).

Table 3.67 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), change between years, method and EF information for 1A3e Other. Between 1990 and 2021, CO_2 emissions decreased by 22 % in the EU, while between 2020 and 2021 the corresponding change was 1 % increase. Top five countries in 2021 were Italy, Germany, Poland, Belgium, and Austria, which accounted for the 69 % of the EU value.

Table 3.67 1A3e Other: CO_2 emissions per country (in kt), share in EU (%), change, method and EF information

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	229	479	382	8.2%	153	67%	-97	-20%	T1,T2	CS,D
Belgium	334	413	422	9.1%	87	26%	8	2%	CS,T3	D
Bulgaria	132	82	126	2.7%	-6	-5%	44	53%	T2	CS
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	5	90	47	1.0%	41	760%	-43	-48%	T2	CS
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
France	210	310	238	5.1%	28	13%	-72	-23%	T2	CS
Germany	1 083	768	836	18.0%	-247	-23%	69	9%	CS	CS
Greece	NO	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Hungary	149	125	63	1.4%	-86	-58%	-62	-50%	T2	CS
Ireland	73	148	152	3.3%	79	108%	4	3%	T2	CS
Italy	411	674	851	18.3%	440	107%	177	26%	T2	CS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	64	35	41	0.9%	-23	-36%	6	16%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	342	89	93	2.0%	-249	-73%	4	5%	T2	CS
Poland	NO	765	737	15.8%	737	∞	-28	-4%	T1	D
Portugal	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Romania	65	4	20	0.4%	-45	-69%	17	422%	T1,T2	CS,D
Slovakia	1 814	168	121	2.6%	-1 693	-93%	-47	-28%	T2	CS
Slovenia	NO	1	1	0.0%	1	∞	0	-4%	T2	CS
Spain	19	99	148	3.2%	129	674%	50	50%	T1	CS,D
Sweden	1 053	351	374	8.0%	-679	-64%	24	7%	NO,T2	CS,NO
EU-27	**5 985**	**4 600**	**4 652**	**1**	**-1 333**	**-22%**	**52**	**1%**	**-**	**-**

Methods and emission factor information refer to the last inventory year.

3.2.4 Other Sectors (CRF Source Category 1.A.4.)

Category 1.A.4. mainly includes emissions from 'small scale fuel combustion' used for space heating and hot water production in commercial and institutional buildings, households, agriculture and forestry. It includes also emissions from mobile machinery used within these categories (e.g. mowers, harvesters, tractors, chain saws, motor pumps) as well as fuel used for grain drying, horticultural greenhouse heating or CO_2 fertilisation and stall heating. Category 1.A.4.c includes emissions from domestic inland, coastal, deep sea and international fishing. Emissions from transportation of agricultural goods are reported under category 1.A.3 Transport. The emissions reported under 1.A.4 can be generally defined as heat production processes for internal consumption.

The main driving force for CO_2 emissions in the 1.A.4 in energy consumption is the combustion for purposes of space heating. The fluctuations in consumption can be ascribed to difference in cold winter periods. The trend in eventually decreasing CO_2 emissions is a result of higher standards for new buildings and of successful execution of energy-efficiency-oriented modernization of existing buildings.

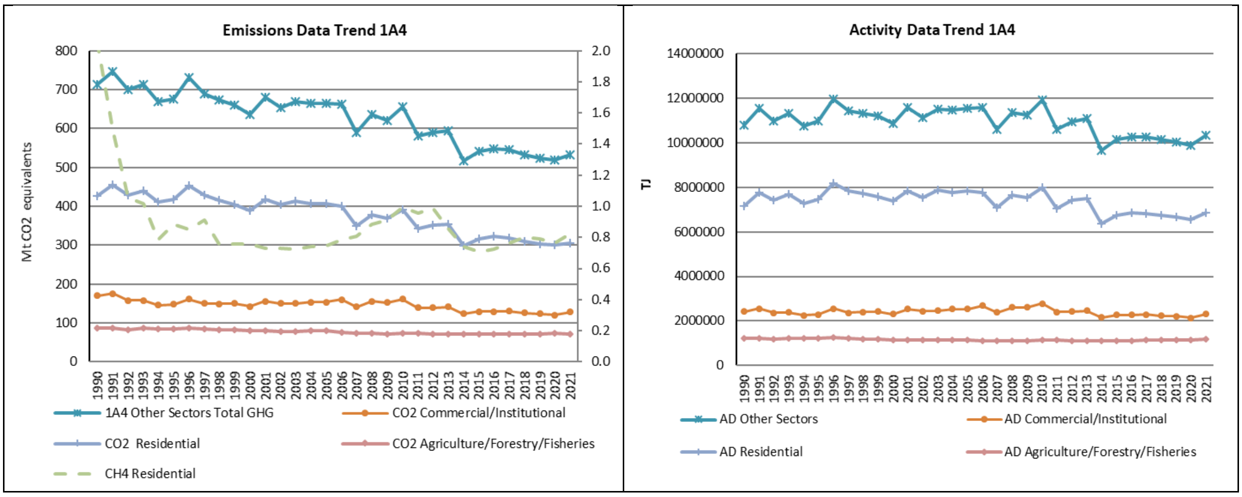
The following enumeration shows the correspondence of 1.A.4 subcategories and ISIC 3.1 rev codes:

- 1.A.4.a Commercial/Institutional: ISIC categories 4103, 42, 6, 719, 72, 8, and 91-96
- 1.A.4.b Residential: All emissions from fuel combustion in households
- 1.A.4.c Agriculture/Forestry/Fishing: ISIC categories 05, 11, 12, 1302

In 2021 category 1.A.4 contributed to 532 534 kt CO_2 equivalents of which 96.1 % CO_2, 3.6 % CH_4 and 1.3 % N_2O.

Figure **3.138** shows the trend of total GHG emissions within source category 1.A.4 and the dominating sources which are CO_2 emissions from 1.A.4.b Residential and from 1.A.4.a Commercial/Institutional. The emission trends of the large key sources show larger fluctuations between 1990 and 2021. Between 1990 and 2021, emissions from 1.A.4 decreased by 25 %. From 2020 to 2021 emissions increased by 2 % (12.8 Mt CO_2 equivalents) which is mainly due to an increase of category 1.A.4.a CO_2 emissions which increased by 4 %. The trend of 1.A.4 CO_2 emissions between 1990 and 2021 is mostly influenced by Germany (-86.1 Mt CO_2).

Figure 3.138 1.A.4. Other Sectors: Total, CO_2 and CH_4 emission trends



Data displayed as dashed line refers to the secondary axis.

In 2021 GHG emissions from source category 1.A.4. accounted for 16 % of total GHG emissions. This source category includes twelve key sources which contributed to 98 % of total 1.A.4. GHG emissions in 2021. The following list shows the key sources and their contribution to total 1.A.4 GHG emissions for the year 2021:

1.A.4.a Commercial/Institutional: Gaseous Fuels (CO_2) - 16.6 %

1.A.4.a Commercial/Institutional: Liquid Fuels (CO_2) - 5.8 %

1.A.4.a Commercial/Institutional: Other Fuels (CO_2) - 1.1 %

1.A.4.a Commercial/Institutional: Solid Fuels (CO_2) - 0.7 %

1.A.4.b Residential: Biomass (CH_4) - 2.3

1.A.4.b Residential: Gaseous Fuels (CO_2) - 38.3 %

1.A.4.b Residential: Liquid Fuels (CO_2) - 14.1 %

1.A.4.b Residential: Solid Fuels (CH_4) - 0.4 %

1.A.4.b Residential: Solid Fuels (CO_2) - 4.9 %

1.A.4.c Agriculture/Forestry/Fishing: Gaseous Fuels (CO_2) - 2.4 %

1.A.4.c Agriculture/Forestry/Fishing: Liquid Fuels (CO_2) - 10.7 %

1.A.4.c Agriculture/Forestry/Fishing: Solid Fuels (CO_2) - 0.5 %

The following table shows the share of higher tier methods used for each key source of category 1.A.4. It comprises all methods and method combinations as reported by countries for any of the 1.A.4 key sources.

Table 3.68: Key source categories for level and trend analyses and share of EU emissions using higher tier methods for sector 1.A.4. (Table excerpt)

Source category gas	kt CO_2 equ.		Trend	Level		Share of higher Tier
	1990	2021		1990	2021	
1.A.4.a Commercial/Institutional: Gaseous Fuels (CO_2)	50214	88309	T	L	L	94 %
1.A.4.a Commercial/Institutional: Liquid Fuels (CO_2)	73404	30656	T	L	L	80 %
1.A.4.a Commercial/Institutional: Other Fuels (CO_2)	748	6004	T	0	L	97 %
1.A.4.a Commercial/Institutional: Solid Fuels (CO_2)	44985	3497	T	L	0	98 %
1.A.4.b Residential: Biomass (CH_4)	10438	12446	T	L	L	50 %
1.A.4.b Residential: Gaseous Fuels (CO_2)	130249	204136	T	L	L	94 %
1.A.4.b Residential: Liquid Fuels (CO_2)	173398	74950	T	L	L	83 %
1.A.4.b Residential: Solid Fuels (CH_4)	8908	2284	T	L	0	8 %
1.A.4.b Residential: Solid Fuels (CO_2)	118866	25937	T	L	L	98 %
1.A.4.c Agriculture/Forestry/Fishing: Gaseous Fuels (CO_2)	12291	12634	T	L	L	87 %
1.A.4.c Agriculture/Forestry/Fishing: Liquid Fuels (CO_2)	64579	56783	T	L	L	77 %
1.A.4.c Agriculture/Forestry/Fishing: Solid Fuels (CO_2)	9686	2671	T	L	0	97 %

The following table shows the share of specific tier methods used for each 1.A.4 category emission estimates. Most countries use combination of T1 and T2 method for emission estimates.

Table 3.69: Share of Tier methods for 1.A.4 by type of reported method and method combinations.

Methods and method combinations	Share of emissions which are estimated by specific Tier method
CS	0.3 %
T1	3.0 %
T1,T2	28.5 %
T1,T3	0.02 %
T2	23.4 %
T2,T3	0.5 %
T3	0.01 %
T1,T2,T3	21.2 %
CS,T1,T2	14.3 %
CS,T1,T3	2.4 %
CS,T1,T2,T3	4.4 %
Other combination	1.9 %

Table 3.70 shows total GHG, CO_2 and CH_4 emissions from 1.A.4. Other sectors. Between 1990 and 2021 CO_2 emissions from 1.A.4. Other Sectors decreased by 26%, CH_4 decreased by 20 % and N_2O emissions increased by 4 %.

Table 3.70 1.A.4. Other Sectors: Member States' contributions to total GHG, CO_2 and CH_4 emissions

Member State	GHG emissions in kt CO2 equivalents		CO2 emissions in kt		N2O emissions in kt CO2 equivalents		CH4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021	1990	2021
Austria	14 286	10 070	13 543	9 604	171	142	573	324
Belgium	28 176	25 294	27 808	24 663	80	106	287	524
Bulgaria	8 146	2 098	7 654	1 657	172	81	320	360
Croatia	4 245	3 374	3 719	2 859	126	113	401	402
Cyprus	434	480	430	468	1	2	3	10
Czechia	33 990	12 844	31 954	11 619	158	130	1 879	1 095
Denmark	9 009	3 724	8 766	3 525	50	65	193	134
Estonia	1 874	651	1 790	626	8	7	76	17
Finland	7 750	3 664	7 490	3 397	78	55	183	211
France	98 295	75 548	91 762	72 391	1 308	1 253	5 225	1 903
Germany	208 478	123 373	202 919	121 686	869	409	4 690	1 278
Greece	8 643	6 048	8 066	5 731	310	76	267	241
Hungary	22 362	13 363	21 311	12 759	90	81	961	523
Ireland	10 524	9 084	9 927	8 845	93	71	505	169
Italy	78 248	83 246	75 428	78 347	1 543	2 186	1 276	2 713
Latvia	5 933	1 584	5 493	1 346	140	76	300	162
Lithuania	7 304	1 574	6 903	1 364	166	37	235	174
Luxembourg	1 361	1 670	1 343	1 656	5	4	13	11
Malta	265	153	264	151	1	1	1	1
Netherlands	39 678	34 983	38 995	33 124	45	49	638	1 810
Poland	57 185	54 421	53 442	49 305	601	1 099	3 142	4 017
Portugal	4 139	4 407	3 463	4 016	193	150	483	241
Romania	11 387	13 411	10 877	11 901	41	271	468	1 238
Slovakia	11 543	5 317	11 067	4 968	41	63	435	285
Slovenia	1 906	1 253	1 686	1 076	39	42	180	136
Spain	26 421	38 476	25 306	37 357	187	227	928	892
Sweden	11 091	2 423	10 876	2 292	83	65	132	65
EU-27	**712 673**	**532 534**	**682 283**	**506 733**	**6 596**	**6 862**	**23 794**	**18 939**

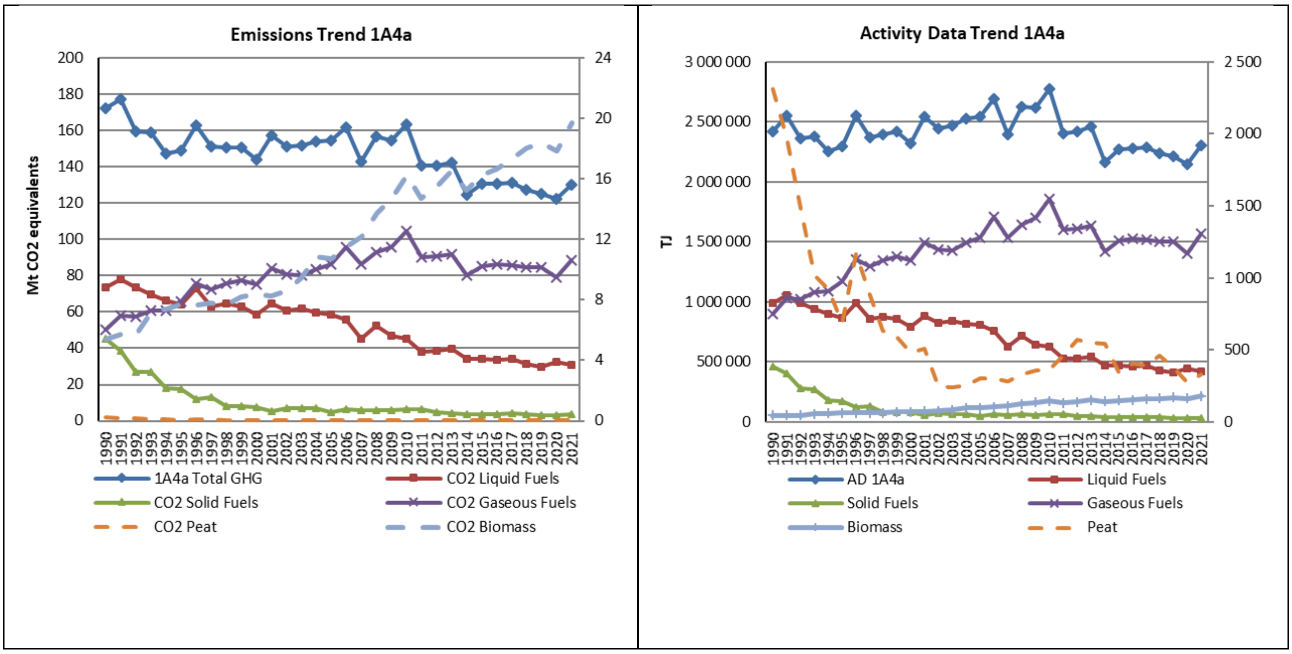
Abbreviations explained in the Chapter 'Units and abbreviations'.

3.2.4.1 Commercial/Institutional (1.A.4.a)

CO_2 emissions from 1.A.4.a Commercial/Institutional accounted for 5 % of total GHG emissions from 1.A Fuel Combustion in 2021. The subcategory 1.A.4.a. includes all combustion sources that utilize heat combustion for heating production halls and operational buildings in institutions, commercial facilities, services and trade.

Figure 3.139 shows the emission trend within the category 1.A.4.a, which is mainly dominated by CO_2 emissions from gaseous and liquid fuels. Between 1990 and 2021 CO_2 emissions decreased by 24 % (see also the Table **3.71**), mainly due to decreases in CO_2 emissions from solid (-92 %) and liquid (-58 %) fuels while CO_2 emissions from gaseous fuels increased by 76 % and show a fluctuating trend since 2006. Between 2020 and 2021 the GHG emissions increased by 6 %, mainly driven by the increase in gaseous fuels.

Figure 3.139 1.A.4.a Commercial/Institutional: Total and CO_2 emission and activity trends



Data displayed as dashed line refers to the secondary axis.

Main factors influencing CO_2 emissions from this source category are (1) outdoor temperature, (2) number and size of offices, (3) building codes, (4) thermal properties of building stock, (5) fuel split for heating and warm water, (6) use of renewable energy sources, e.g. biomass or solar panels, and (7) use of district heating. Fuel consumption in 1.A.4.a decreased by 5 % between 1990 and 2021 and biomass consumption increased by 302 %.

Germany, Italy and France contributed the most to the EU CO_2 emissions from this source (62 % together). Member States with the highest increases in absolute terms were Spain and Italy. The Member State with the highest reduction in absolute terms was Germany (Table 3.71).

Table 3.71 1.A.4.a Commercial/Institutional: Member States' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	2 292	1 290	1 554	1.2%	-737	-32%	265	21%	T1,T2	CS,D
Belgium	4 289	5 333	5 812	4.5%	1 523	36%	479	9%	T1	D
Bulgaria	3 117	303	365	0.3%	-2 752	-88%	61	20%	T1,T2	CS,D
Croatia	855	571	654	0.5%	-201	-24%	83	15%	T1	D
Cyprus	75	86	90	0.1%	15	19%	4	5%	T1	D
Czechia	9 907	2 678	2 563	2.0%	-7 344	-74%	-115	-4%	T1,T2	CS,D
Denmark	1 566	685	754	0.6%	-812	-52%	69	10%	M,T1,T2,T3	CS,D
Estonia	165	242	252	0.2%	88	53%	10	4%	T1,T2	CS,D
Finland	2 473	1 065	1 168	0.9%	-1 305	-53%	103	10%	T1,T2,T3	CS,D
France	26 589	20 057	21 413	16.7%	-5 176	-19%	1 356	7%	T1,T2	CS,D
Germany	64 111	32 514	33 307	25.9%	-30 804	-48%	793	2%	CS,T1,T2,T3	CS,D
Greece	519	583	624	0.5%	106	20%	42	7%	T1,T2	CS,D
Hungary	2 898	2 778	2 893	2.3%	-5	0%	116	4%	T1,T2	CS,D
Ireland	2 130	1 522	1 481	1.2%	-649	-30%	-41	-3%	T2	CS
Italy	11 902	23 459	24 603	19.1%	12 701	107%	1 144	5%	T2	CS
Latvia	2 726	399	442	0.3%	-2 284	-84%	43	11%	T1,T2	CS,D
Lithuania	3 059	261	290	0.2%	-2 768	-91%	29	11%	T1,T2	CS
Luxembourg	639	544	648	0.5%	9	1%	103	19%	T1,T2	CS,D
Malta	165	83	89	0.1%	-75	-46%	7	8%	T1	D
Netherlands	8 334	6 314	6 776	5.3%	-1 558	-19%	461	7%	T2	CS,D
Poland	9 715	5 926	7 609	5.9%	-2 106	-22%	1 683	28%	T1,T2	CS,D
Portugal	704	961	982	0.8%	278	39%	21	2%	T1,T2	CS,D
Romania	NO	2 050	2 006	1.6%	2 006	∞	-43	-2%	T1,T2	CS,D
Slovakia	4 148	1 150	1 450	1.1%	-2 697	-65%	301	26%	T2	CS
Slovenia	624	334	250	0.2%	-373	-60%	-84	-25%	T1,T2	CS,D
Spain	3 809	8 964	9 776	7.6%	5 966	157%	811	9%	CR,T2	R,CS,D,OTH
Sweden	2 776	639	648	0.5%	-2 127	-77%	10	2%	T1,T2	CS
EU-27	**169 584**	**120 788**	**128 500**	**100%**	**-41 084**	**-24%**	**7 712**	**6.4%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

1.A.4. a Commercial/Institutional – Liquid Fuels (CO_2)

In 2021 CO_2 emissions from liquid fuels had a share of 24 % within source category 1.A.4.a (compared to 41 % in 1990). Between 1990 and 2021, CO_2 emissions decreased by 58 % (Table 3.72). Only three Member States increased the use of liquid fuels in the time series. The highest absolute increase is noted for Poland. It is important to note, however, that Poland hasn't been using the liquid fuels at the beginning of 90's. The highest absolute decreases were achieved in Germany and France. Generally, in number of Member States, there is apparent strong decrease from 2006 to 2007 due to low gasoil sales to end consumers. Many end consumers did not restock their oil tanks in 2007 because of high outdoor temperatures and rising oil prices. Additionally, end consumer gasoil stocks were comparatively high in 2007 due to a mild winter 2006. Between 2020 and 2021 EU CO_2

emissions decreased by 6 %. According to the methodology as described in chapter 3.2.4 about 80 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.72 1.A.4.a Commercial/Institutional, liquid fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 420	447	631	2%	-788	-56%	184	41%	T2	CS
Belgium	2 315	1 101	1 120	4%	-1 194	-52%	20	2%	T1	D
Bulgaria	2 986	94	110	0%	-2 876	-96%	16	17%	T1	D,NA
Croatia	526	111	106	0%	-419	-80%	-4	-4%	T1	D,NA
Cyprus	75	86	90	0%	15	19%	4	5%	T1	D
Czechia	2 000	49	58	0%	-1 942	-97%	9	19%	T1	CS,D
Denmark	1 161	287	259	1%	-902	-78%	-28	-10%	T1,T2,CR,M	CS,D
Estonia	140	64	64	0%	-76	-54%	0	0%		-
Finland	2 423	1 000	1 089	4%	-1 334	-55%	88	9%	T2,T3	CS
France	16 555	7 311	6 306	21%	-10 249	-62%	-1 005	-14%	-	-
Germany	28 138	12 819	11 165	36%	-16 973	-60%	-1 655	-13%	CS,T2,T3	CS
Greece	499	252	276	1%	-223	-45%	24	9%	T2	CS
Hungary	1 124	104	89	0%	-1 034	-92%	-14	-14%	T1	D
Ireland	1 768	668	658	2%	-1 110	-63%	-10	-2%	T2	CS
Italy	1 530	1 440	1 579	5%	49	3%	139	10%	-	-
Latvia	1 017	110	131	0%	-886	-87%	22	20%	T1,T2	CS,D
Lithuania	1 166	8	9	0%	-1 157	-99%	2	20%	T2,T1	CS
Luxembourg	469	368	351	1%	-119	-25%	-17	-5%	T2	CS
Malta	165	83	89	0%	-75	-46%	7	8%	T1	D
Netherlands	474	476	451	1%	-24	-5%	-25	-5%	T2	CS
Poland	IE,NO	1 173	1 283	4%	1 283	∞	110	9%	T1,T2	CS,D
Portugal	704	318	274	1%	-431	-61%	-44	-14%	T1	D
Romania	NO	264	255	1%	255	∞	-9	-4%	T1,T2	CS
Slovakia	384	22	17	0%	-367	-96%	-6	-25%	T2	CS
Slovenia	391	278	199	1%	-192	-49%	-79	-28%	T1	D
Spain	3 284	3 210	3 590	12%	305	9%	379	12%	T2,CR	D,CR
Sweden	2 690	398	408	1%	-2 282	-85%	10	2%	T1,T2	CS
EU-27	**73 404**	**32 539**	**30 656**	**100%**	**-42 748**	**-58%**	**-1 883**	**-6%**	**-**	**-**

Notes: From 1990 to 1993 Poland does not report any liquid fuels for stationary sources and reports liquid fuels from 'Off-road vehicles and other machinery' under category 1A3 and therefore the notation key 'IE, NO' is reported. Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.140 and Figure **3.141** show CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Germany, France, Spain, Italy, Poland and Finland; together they cause 82 % of the CO_2 emissions from liquid fuels in 1.A.4.a. Fuel consumption decreased by 57 % between 1990 and 2021. The CO_2 implied emission factor for liquid fuels was 72.70 t/TJ in 2021.

Figure 3.140 1.A.4.a Commercial/Institutional, liquid fuels: Emission trend and share for CO_2

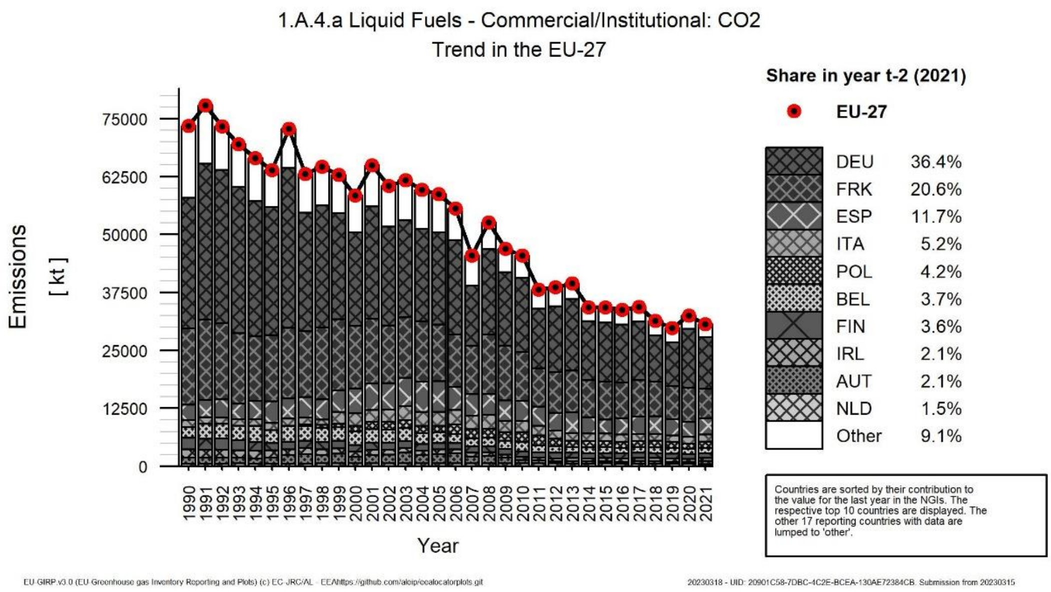
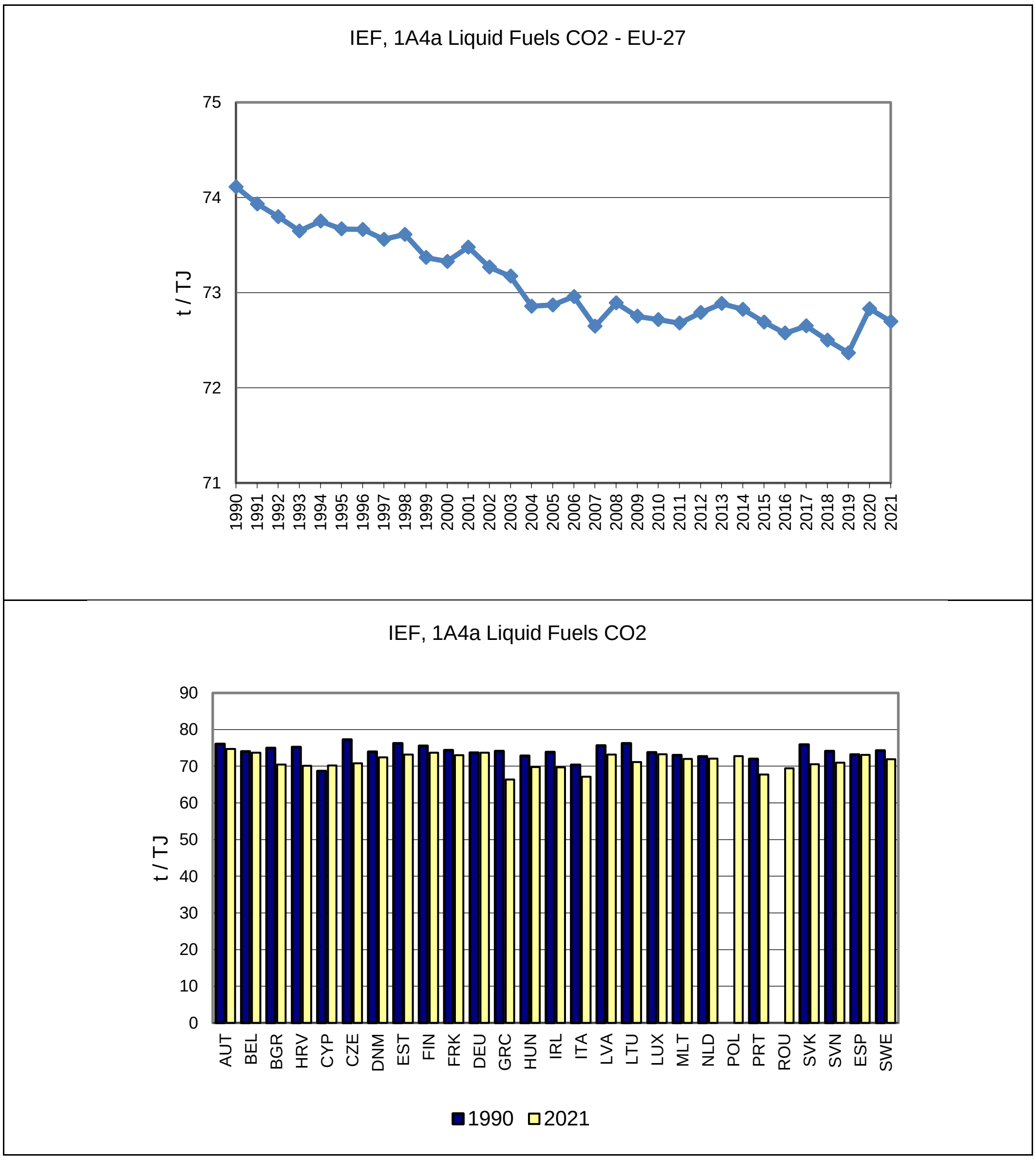


Figure 3.141   1.A.4.a Commercial/Institutional, liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)



1.A.4.a Commercial/Institutional – Solid Fuels (CO_2)

In 2021, CO_2 from solid fuels had a share of 3 % within source category 1.A.4.a (compared to 25 % in 1990). Between 1990 and 2021 CO_2 emissions decreased by 92 % (Table 3.73). Twelve Member States and Iceland report emissions as ‘Not occurring’ or ‘Included elsewhere’ in 2021; all other Member States reduced emissions between 1990 and 2021 except Spain and Estonia. Between 2020 and 2021 CO_2 emissions increased by 18 %. According to the methodology as described in chapter 3.2.1 about 98 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.73 1.A.4.a Commercial/Institutional, solid fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	91	NO	NO	-	-91	-100%	-	-	NA	NA
Belgium	9	0	0	0%	-9	-100%	0	100%	T1	D
Bulgaria	89	12	10	0%	-80	-89%	-3	-21%	T1,T2	CS,D
Croatia	88	NO,IE	NO,IE	-	-88	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	6 237	84	102	3%	-6 135	-98%	19	22%	T2	CS,D
Denmark	8	NO	NO	-	-8	-100%	-	-	NA	NA
Estonia	NO	4	4	0%	4	∞	0	-2%	-	-
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	1 938	127	150	4%	-1 788	-92%	23	18%	-	-
Germany	22 426	6	3	0%	-22 423	-100%	-3	-48%	CS	CS
Greece	20	NO,IE	NO,IE	-	-20	-100%	-	-	NA	NA
Hungary	475	5	5	0%	-470	-99%	0	-1%	T1,T2	CS,D
Ireland	3	2	2	0%	-1	-38%	0	0%	T2	CS
Italy	NO	NO	NO	-	-	-	-	-	-	-
Latvia	1 366	7	6	0%	-1 360	-100%	0	-6%	T2	CS
Lithuania	1 173	75	93	3%	-1 080	-92%	17	23%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	101	2	3	0%	-99	-97%	0	16%	T2	CS,D
Poland	8 881	2 036	2 524	72%	-6 358	-72%	487	24%	T1,T2	CS,D
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	NO	0	0	0%	0	∞	0	69%	T1,T2	CS,D
Slovakia	1 729	213	238	7%	-1 491	-86%	25	12%	T2	CS
Slovenia	203	NO	NO	-	-203	-100%	-	-	NA	NA
Spain	147	395	359	10%	212	145%	-36	-9%	T2	CS
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**44 985**	**2 967**	**3 497**	**100%**	**-41 488**	**-92%**	**530**	**18%**	**-**	**-**

Greece reports emissions from stationary combustion as 'NO' and emissions from mobile sources as 'IE'
Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.142 and Figure 3.143 show CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Poland, Spain and Slovakia; together they cause 89 % of the CO_2 emissions from solid fuels in 1.A.4.a. Fuel consumption in the EU decreased by 92 % between 1990 and 2021. The CO_2 implied emission factor for solid fuels was 95.51 t/TJ in 2021. The comparatively low IEFs of Spain and Greece in 1990 are due to a high share of gas works gas consumption in the 1990s.

Figure 3.142 1.A.4.a Commercial/Institutional, solid fuels: Emission trend and share for CO_2

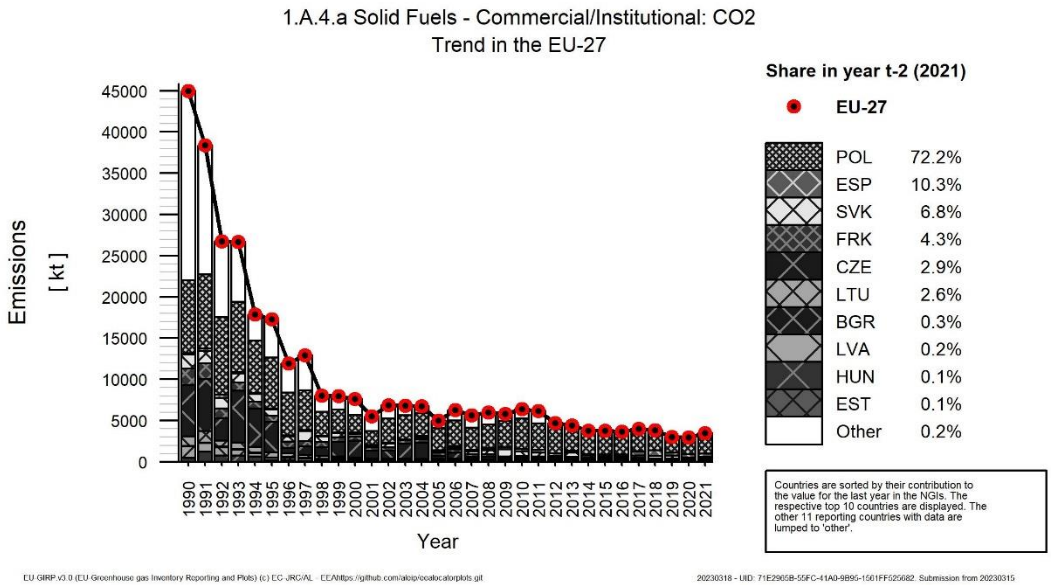
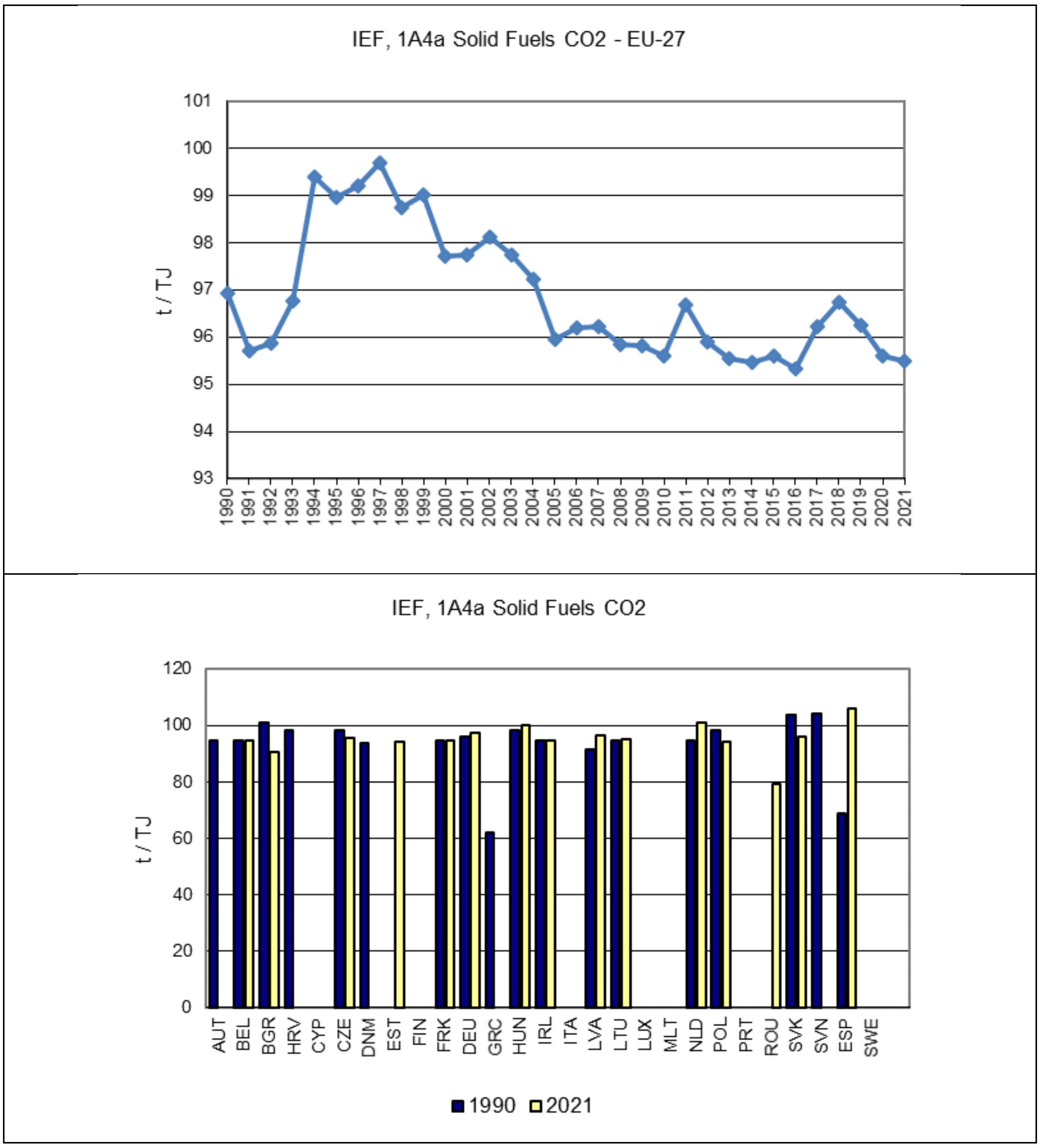


Figure 3.143 1.A.4.a Commercial/Institutional, solid fuels: of Implied Emission Factors for CO_2 (in t/TJ)



1.A.4.a Commercial/Institutional – Gaseous Fuels (CO_2)

In 2021 CO_2 from gaseous fuels had a share of 69 % within source category 1.A.4.a (compared to 34% in 1990). Between 1990 and 2021, the emissions increased by 76 % (Table 3.74). All Member States except Lithuania, the Netherlands and Slovakia reported increasing emissions. The highest absolute increases occurred in Germany, Italy and France. Between 2020 and 2021 CO_2 emissions increased by 12 %. According to the methodology as described in chapter 3.2.4 about 94 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.74 1.A.4.a Commercial/Institutional, gaseous fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	698	842	923	1%	225	32%	80	10%	T2	CS
Belgium	1 936	4 113	4 571	5%	2 634	136%	457	11%	T1	D
Bulgaria	42	197	245	0%	203	483%	48	24%	T2	CS
Croatia	241	460	547	1%	307	128%	87	19%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	1 670	2 546	2 403	3%	732	44%	-143	-6%	T2	CS
Denmark	363	398	495	1%	132	36%	97	24%	T3	CS
Estonia	19	174	184	0%	165	887%	10	6%	-	-
Finland	37	55	68	0%	31	82%	13	24%	T2	CS
France	8 096	12 615	14 951	17%	6 855	85%	2 335	19%	-	-
Germany	13 547	19 686	22 137	25%	8 591	63%	2 451	12%	CS	CS
Greece	IE,NO	331	349	0%	349	∞	18	5%	T2	CS
Hungary	1 299	2 515	2 638	3%	1 339	103%	123	5%	T2	CS
Ireland	223	853	822	1%	598	268%	-31	-4%	T2	CS
Italy	9 842	16 223	17 398	20%	7 556	77%	1 175	7%	-	-
Latvia	276	281	302	0%	26	10%	22	8%	T2	CS
Lithuania	708	161	168	0%	-540	-76%	7	4%	T2	CS
Luxembourg	170	176	297	0%	127	75%	121	68%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	7 758	5 835	6 321	7%	-1 437	-19%	486	8%	T2	CS
Poland	762	2 653	3 727	4%	2 965	389%	1 073	40%	T2	CS
Portugal	NO	643	708	1%	708	∞	65	10%	T2	CS
Romania	NO	1 776	1 742	2%	1 742	∞	-35	-2%	T2	CS
Slovakia	2 035	915	1 196	1%	-839	-41%	281	31%	T2	CS
Slovenia	29	57	52	0%	22	76%	-5	-9%	T2	CS
Spain	379	5 359	5 827	7%	5 449	1439%	468	9%	T2	CS,D
Sweden	86	240	240	0%	154	179%	0	0%	T1	CS
EU-27	**50 214**	**79 104**	**88 309**	**100%**	**38 095**	**76%**	**9 205**	**12%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.144 and Figure 3.145 show CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Germany, Italy, France, the Netherlands, Spain and Belgium; together they cause 81 % of the CO_2 emissions from gaseous fuels in 1.A.4.a. Fuel consumption increased by 74 % between 1990 and 2021. The CO_2 implied emission factor for gaseous fuels was 56.45 t/TJ in 2021.

Figure 3.144 1.A.4.a Commercial/Institutional, gaseous fuels: Emission trend and share for CO_2

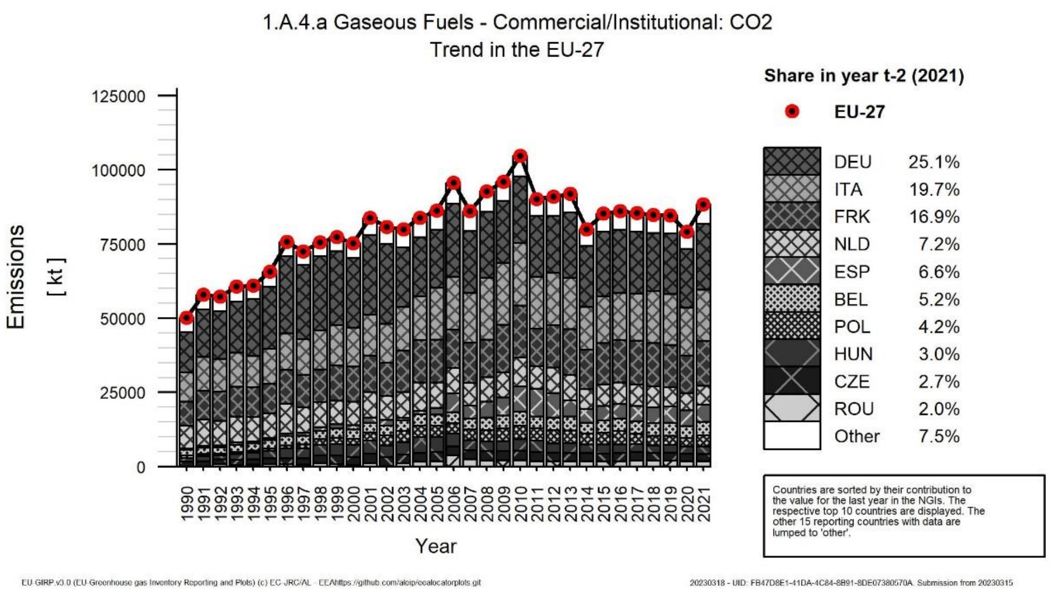
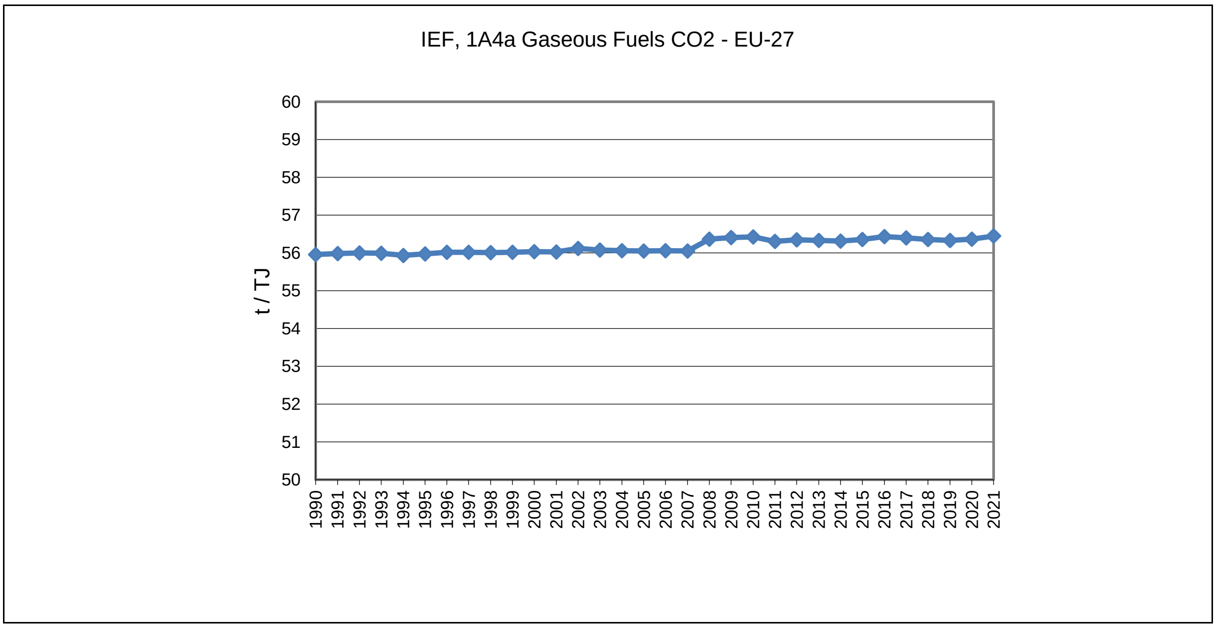
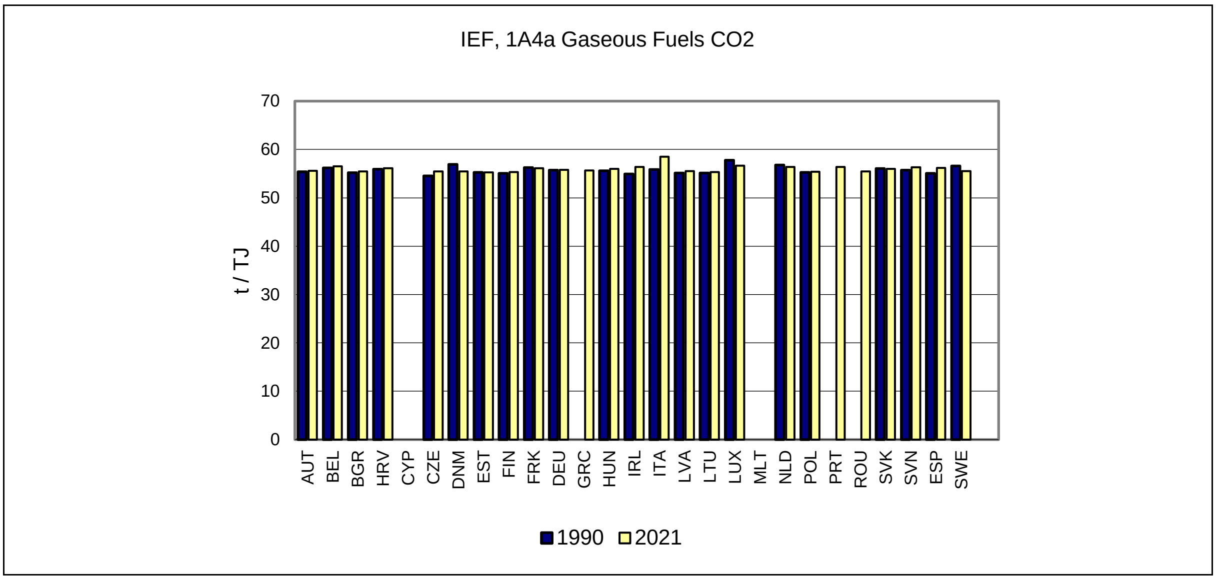


Figure 3.145 1.A.4.a Commercial/Institutional, gaseous fuels: Overview of outliers of Implied Emission Factors for CO_2 (in t/TJ)





1.A.4.a Commercial/Institutional – Other Fossil Fuels (CO_2)

Under this key category Member States report CO_2 emissions from waste incineration plants with energy recovery, whose main economic activity is the treatment of waste (as opposed to waste incineration plants with energy recovery whose main economic activity is power and heat production; these are reported under 1A1a).

In 2021, CO_2 from other fossil fuels had a share of 5 % within category 1.A.4.a. Between 1990 and 2021 CO_2 emissions increased by 702 % (Table 3.75). Fifteen Member States report emissions as 'Not occurring' or 'Included elsewhere' in 2021; between 2020 and 2021 CO_2 decreased by 2%. Level of emissions is strongly driven by Italy. In this category, Italy includes all emissions due to the non-renewable part of wastes used in electricity generation. According to the methodology as described in chapter 3.2.4 about 97 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.75: 1.A.4.a Commercial/Institutional, other fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	83	0	0	0%	-83	-100%	0	11%	T2	CS
Belgium	29	119	121	2%	92	316%	2	2%	T1	D
Bulgaria	NO	NO	NO	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	0	0	0%	0	∞	0	38%	T1	D
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	34	NO	NO	-	-34	-100%	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	-	-
Finland	0	NO	NO	-	0	-100%	-	-	NA	NA
France	NO	4	6	0%	6	∞	2	57%	-	-
Germany	NO	2	2	0%	2	∞	0	-18%	CS,T1	CS
Greece	IE,NO	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Hungary	NO	153	161	3%	161	∞	7	5%	T2	CS
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	530	5 796	5 627	94%	5 097	962%	-169	-3%	-	-
Latvia	NO	0	0	0%	0	∞	0	0%	T1	D
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	1	1	0%	1	∞	0	10%	T2	CS
Poland	72	63	75	1%	3	4%	12	19%	T1	D
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	NO	9	10	0%	10	∞	0	2%	T2	CS
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	NO	NO	NO	-	-	-	-	-	NA	NA
Sweden	NO	1	1	0%	1	∞	0	-27%	T2	CS
EU-27	**748**	**6 149**	**6 004**	**100%**	**5 255**	**702%**	**-145**	**-2%**	**-**	**-**

Greece reports emissions from stationary combustion as 'NO' and emissions from mobile sources as 'IE'

Figure 3.147 shows CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest share on total CO_2 emissions (above the average share calculated for EU) corresponds to Italy; it causes 94 % of the CO_2 emissions from other fossil fuels in 1.A.4.a. The CO_2 implied emission factor for other fossil fuels was 94.75 t/TJ in 2021. The comparatively high implied emission factor is a calculated value from a mass balance calculation method and data from energy statistics.

Figure 3.146 1.A.4.a Commercial/Institutional, other fuels: Emission trend and share for CO_2

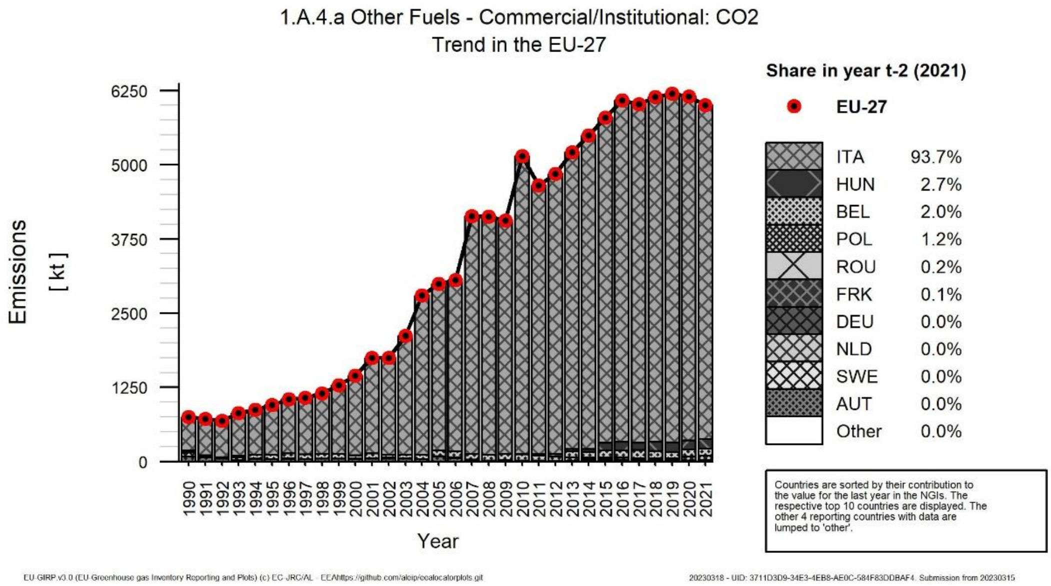
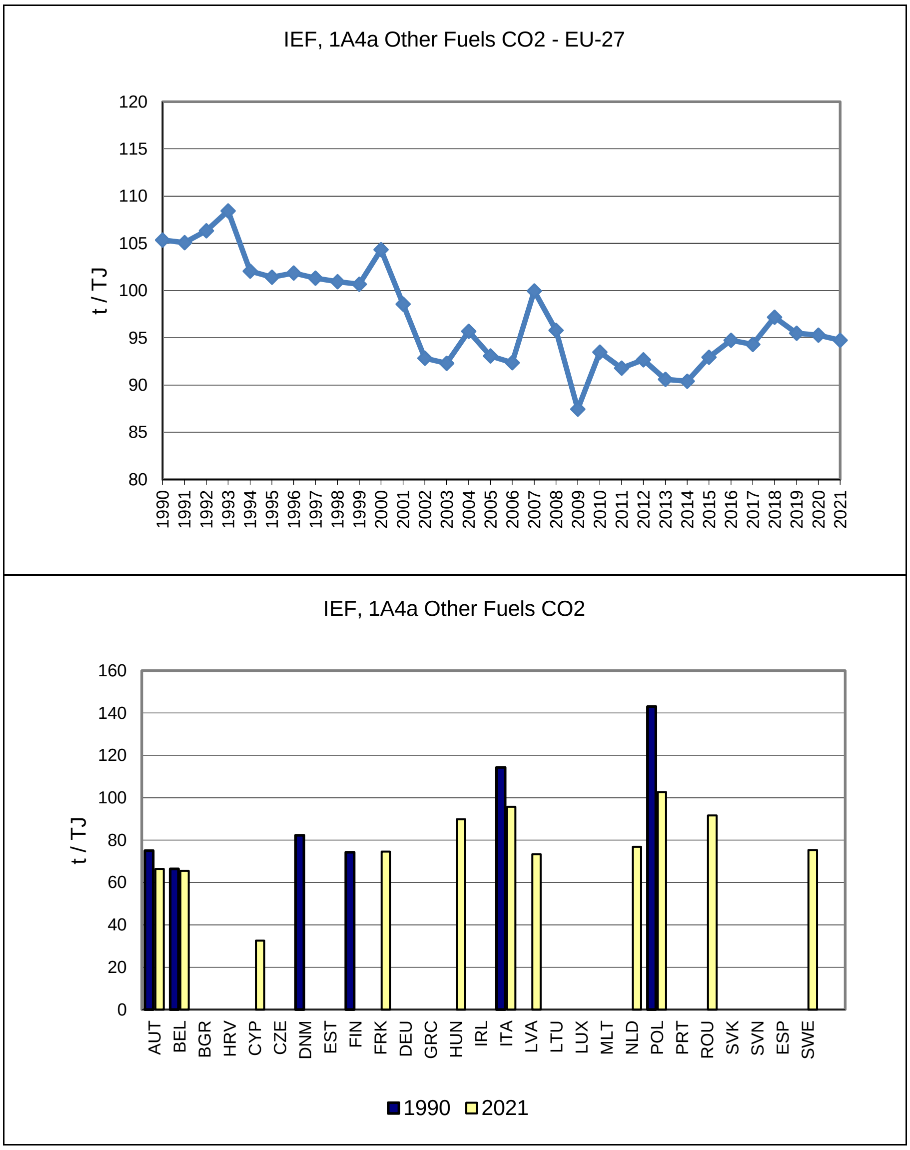


Figure 3.147 1.A.4.a Commercial/Institutional, other fuels: Overview of outliers of Implied Emission Factors for CO_2 (in t/TJ)



3.2.4.2 Residential (1.A.4.b)

CO_2 emissions from 1.A.4.b Residential account for 12 % of total GHG emissions from 1.A Fuel Combustion in 2021.

Figure 3.148 shows the emission trend within the category 1.A.4.b, which is mainly dominated by CO_2 emissions from gaseous and liquid fuels. Total GHG emissions decreased by 28 % since 1990, although CO_2 emissions from gaseous fuels increased strongly (57 %) which was counterbalanced by decreasing emissions from liquid and solid fuels. From 2020 to 2021, CO_2 emissions increased by 1.5 % and energy consumption increased by 5 %. Biomass consumption reached a share of 28 % in the year 2021 while the share of solid fossil fuels consumption dropped to 4 %.

Trend in fuel consumption is in most Member States rather increasing, although some of the Member States have a strong decrease for 1.A.4.b in 2021 (e. g. Latvia). On the contrary more than half of the Member States experienced increasing trend in heating degree days. Nevertheless, for most of the Member States trend in fuel consumption correlates with trend in heating degree days, this does not apply only for eight Member States. The following Table **3.76: EU heating degree days 2020 and**

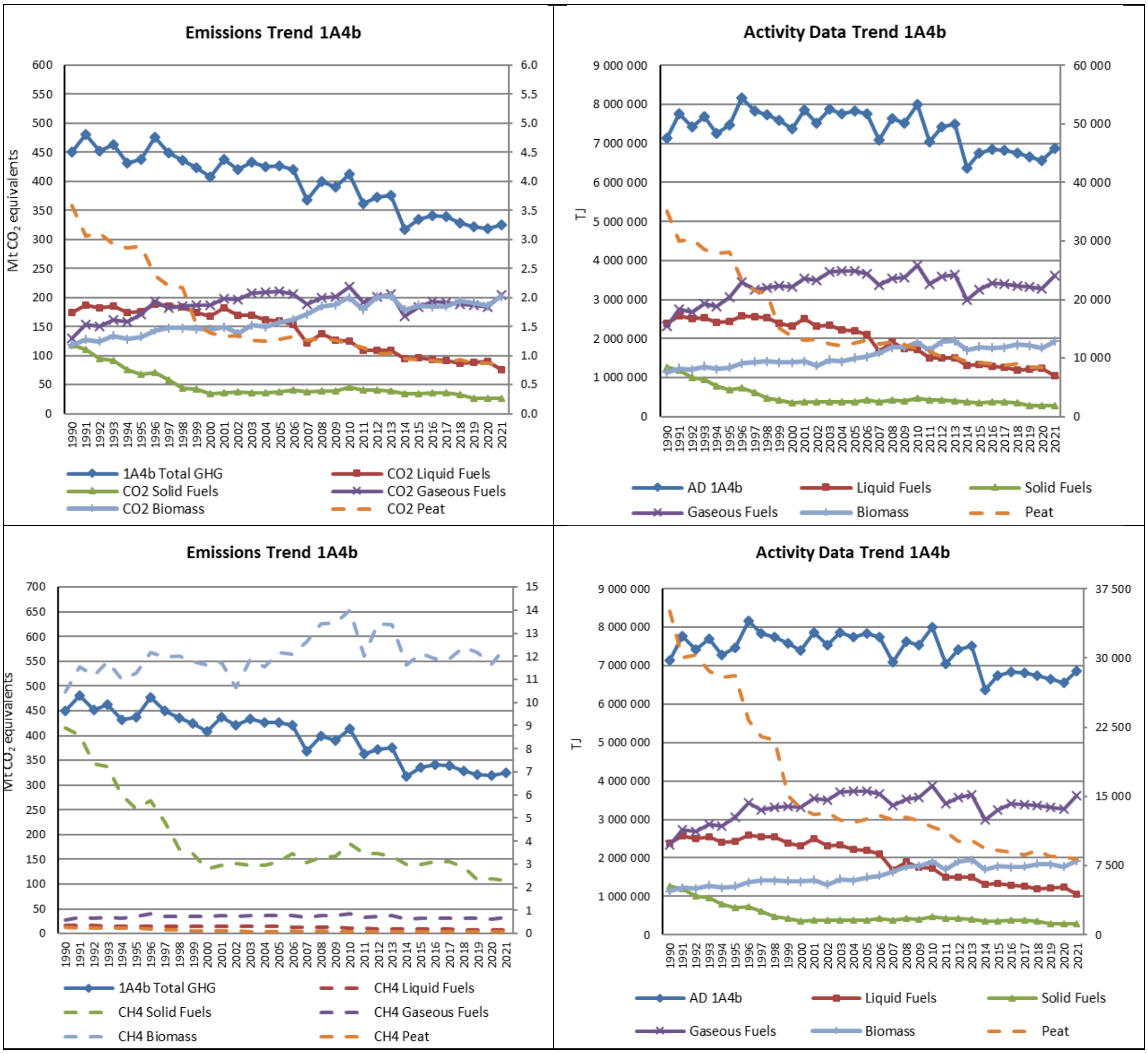
2021 and 1.A.4.b trend in total fuel consumption. presents the (15°/18°) heating degree days in 2020 and 2021 for Member States and trend in 1.A.4.b total fuel consumption.

Table 3.76: EU heating degree days 2020 and 2021 and 1.A.4.b trend in total fuel consumption.

	2020	2021	Trend 2020 – 2021 [%]	Trend fuel consumption 1.A.4.b [%]
Austria	3323	3633	9	5
Belgium	2340	2711	16	7
Bulgaria	2247	2503	11	2
Croatia	2138	2366	11	11
Cyprus	630	610	-3	16
Czechia	3079	3452	12	3
Denmark	2921	3264	12	8
Estonia	3553	4283	21	1
Finland	4871	5623	15	-6
France	2038	2413	18	4
Germany	2741	3114	14	5
Greece	1489	1536	3	28
Hungary	2547	2803	10	8
Ireland	2744	2644	-4	4
Italy	1750	1917	10	9
Latvia	3404	4144	22	-10
Lithuania	3306	4016	21	-5
Luxembourg	2567	3174	24	13
Malta	402	466	16	23
Netherlands	2386	2722	14	6
Poland	3006	3491	16	0
Portugal	1008	1065	6	-2
Romania	2666	2994	12	-1
Slovakia	3047	3383	11	1
Slovenia	2691	2986	11	10
Spain	1554	1663	7	3
Sweden	4593	5201	13	-1
EU (weighted)	2759	3126	13	5

Source: Eurostat and EEA 2023

Figure 3.148 1.A.4.b Residential: Total, CO_2 and CH_4 emission and activity trends



Data displayed as dashed line refers to the secondary axis.

CO_2 emissions from 1.A.4.b Residential

Between 1990 and 2021, CO_2 emissions from households decreased by 28 % in the EU (Table 3.77). Main factors influencing CO_2 emissions from this source category are (1) outdoor temperature, (2) number and size of dwellings, (3) building codes, (4) thermal properties of building stock, (5) fuel split for heating and warm water, (6) use of renewable energy sources, e.g. biomass or solar panels, and (7) the use of district heating. Fuel consumption of households decreased by 4 % between 1990 and 2021, with a fuel shift from coal and oil to natural gas and biomass. Overall, the recently mild winters are apparent on the lower amount of fuel combustion.

Between 1990 and 2021, the largest CO_2 reduction in absolute terms was reported by Germany. One reason for the performance of the Nordic countries is increased use of district heating. As district heating replaces heating boilers in households, an increase in the share of district heating reduces CO_2 emissions from households (but increases emissions from energy industries if fossil fuels are used). In Germany, efficiency improvements and the fuel switch in eastern German households are two reasons for the emission reductions. Still, between 2020 and 2021 the largest absolute increase in the emissions is reported by Germany which contributes to total EU emissions with 26.9 %.

Table 3.77 1.A.4.b Residential: Member States' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Information
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	10 000	6 469	7 185	2.3%	-2 816	-28%	715	11%	T1,T2	CS,D
Belgium	20 483	14 974	16 202	5.3%	-4 281	-21%	1 228	8%	CS,T1,T3	D
Bulgaria	2 887	643	838	0.3%	-2 050	-71%	195	30%	T1,T2	CS,D
Croatia	2 029	1 477	1 518	0.5%	-511	-25%	41	3%	T1	D
Cyprus	300	324	294	0.1%	-6	-2%	-30	-9%	T1	D
Czechia	18 375	7 362	7 848	2.6%	-10 527	-57%	486	7%	T1,T2	CS,D
Denmark	4 996	1 554	1 419	0.5%	-3 578	-72%	-135	-9%	,M,T1,T2,T3	CS,D
Estonia	1 024	158	164	0.1%	-860	-84%	6	3%	T1,T2	CS,D
Finland	3 148	914	841	0.3%	-2 307	-73%	-73	-8%	T1,T2,T3	CS,D
France	53 948	38 229	40 459	13.2%	-13 489	-25%	2 230	6%	T1,T2	CS,D
Germany	128 636	88 625	82 296	26.9%	-46 339	-36%	-6 328	-7%	CS,T1,T2	CS
Greece	4 654	4 999	4 549	1.5%	-105	-2%	-450	-9%	T1,T2	CS,D
Hungary	15 761	7 638	8 315	2.7%	-7 446	-47%	677	9%	T1,T2	CS,D
Ireland	7 050	7 179	6 745	2.2%	-305	-4%	-435	-6%	T2	CS
Italy	55 174	44 063	46 678	15.3%	-8 496	-15%	2 615	6%	T2	CS
Latvia	1 182	419	431	0.1%	-751	-64%	12	3%	T1,T2	CS,D
Lithuania	2 361	704	836	0.3%	-1 525	-65%	133	19%	T2	CS
Luxembourg	670	1 029	986	0.3%	316	47%	-43	-4%	T1,T2	CS,D
Malta	95	41	39	0.0%	-56	-59%	-1	-4%	T1	D
Netherlands	20 811	15 038	17 097	5.6%	-3 714	-18%	2 059	14%	T1,T2	CS,D
Poland	35 222	31 113	31 457	10.3%	-3 765	-11%	344	1%	T1,T2	CS,D
Portugal	1 640	1 905	1 730	0.6%	90	5%	-175	-9%	T1,T2	CS,D
Romania	8 881	7 219	8 328	2.7%	-553	-6%	1 109	15%	T1,T2	CS,D
Slovakia	6 773	2 894	3 173	1.0%	-3 600	-53%	279	10%	T2	CS
Slovenia	896	649	614	0.2%	-282	-31%	-34	-5%	T1,T2	CS,D
Spain	12 802	15 379	15 314	5.0%	2 512	20%	-65	0%	T2	CS,D,OTH
Sweden	6 299	478	525	0.2%	-5 774	-92%	48	10%	T1,T2	CS
EU-27	**426 098**	**301 476**	**305 879**	**100%**	**-120 219**	**-28%**	**4 404**	**1.5%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

1.A.4.b Residential – Liquid Fuels (CO_2)

In 2021 CO_2 from liquid fuels had a share of 25 % CO_2 emissions within source category 1.A.4.b (compared to 36 % in 1990). Between 1990 and 2021, emissions decreased by 57 % (Table 3.78). Germany, Italy and France show the highest absolute decreases. Only two Member States reported increasing emissions since 1990. Between 2020 and 2021 EU CO_2 emissions decreased by 16 %. The strong decrease from 2006 to 2007 for Germany is due to low gasoil sales to end consumers. Many end consumers did not restock their oil tanks in 2007 because of high outdoor temperatures and rising oil prices. Additionally, end consumer gasoil stocks were comparatively high in 2007 due to a mild winter 2006. It is assumed that the circumstances were similar for other MS (e.g. Austria).

According to the methodology as described in chapter 3.2.4 about 83 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.78 1.A.4.b Residential, liquid fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	5 633	3 076	3 332	4%	-2 301	-41%	257	8%	T2,T2	CS
Belgium	12 805	7 554	7 471	10%	-5 334	-42%	-83	-1%	T1,CS,T3	D
Bulgaria	158	56	56	0%	-102	-65%	0	-1%	T1	D
Croatia	1 137	329	279	0%	-858	-75%	-49	-15%	T1	D
Cyprus	300	324	294	0%	-6	-2%	-30	-9%	-	-
Czechia	239	139	139	0%	-100	-42%	0	0%	T1	CS,D
Denmark	3 937	398	365	0%	-3 572	-91%	-33	-8%	T1,T2,CR,M	CS,D
Estonia	247	24	22	0%	-225	-91%	-3	-11%	-	-
Finland	3 024	845	760	1%	-2 263	-75%	-85	-10%	T2,T3	CS
France	30 915	12 952	12 832	17%	-18 083	-58%	-120	-1%	-	-
Germany	56 382	37 274	24 300	32%	-32 082	-57%	-12 974	-35%	CS,T2	CS
Greece	4 565	3 955	3 371	4%	-1 194	-26%	-584	-15%	T2	CS
Hungary	3 540	229	214	0%	-3 326	-94%	-15	-6%	T1,T2	D,CS
Ireland	1 173	4 193	3 817	5%	2 643	225%	-376	-9%	T2	CS
Italy	27 830	5 429	5 431	7%	-22 399	-80%	2	0%	T2	CS
Latvia	332	158	157	0%	-175	-53%	-1	-1%	T2	CS
Lithuania	397	157	153	0%	-244	-62%	-4	-2%	T2	CS
Luxembourg	474	423	418	1%	-56	-12%	-5	-1%	T2	CS
Malta	95	41	39	0%	-56	-59%	-1	-4%	T1	D
Netherlands	856	180	177	0%	-679	-79%	-3	-2%	T2,T1	CS,D
Poland	110	1 662	1 691	2%	1 581	1431%	29	2%	T1,T2	CS,D
Portugal	1 640	1 209	1 050	1%	-590	-36%	-159	-13%	T1	D
Romania	922	744	736	1%	-185	-20%	-8	-1%	T1,T2	CS,D
Slovakia	93	17	23	0%	-70	-75%	6	33%	T2	CS
Slovenia	527	400	349	0%	-178	-34%	-51	-13%	T1	D
Spain	9 855	7 016	7 001	9%	-2 854	-29%	-14	0%	T2	D
Sweden	6 213	426	473	1%	-5 740	-92%	48	11%	T1,T2	CS
EU-27	**173 398**	**89 209**	**74 950**	**100%**	**-98 448**	**-57%**	**-14 258**	**-16%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.149 and Figure 3.150 show CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Germany, France, Belgium and Spain; together they cause 68 % of the CO_2 emissions from liquid fuels in 1.A.4.b. Fuel consumption in the EU decreased by 57 % between 1990 and 2021. The CO_2 implied emission factor for liquid fuels was 71.81 t/TJ in 2021. Within the MS there is variation of specific fuels used, which is causing also the fluctuation of the IEF. Most often Residual fuel oil, LPG and other kerosene are used.

Figure 3.149 1.A.4.b Residential, liquid fuels: Emission trend and share for CO_2

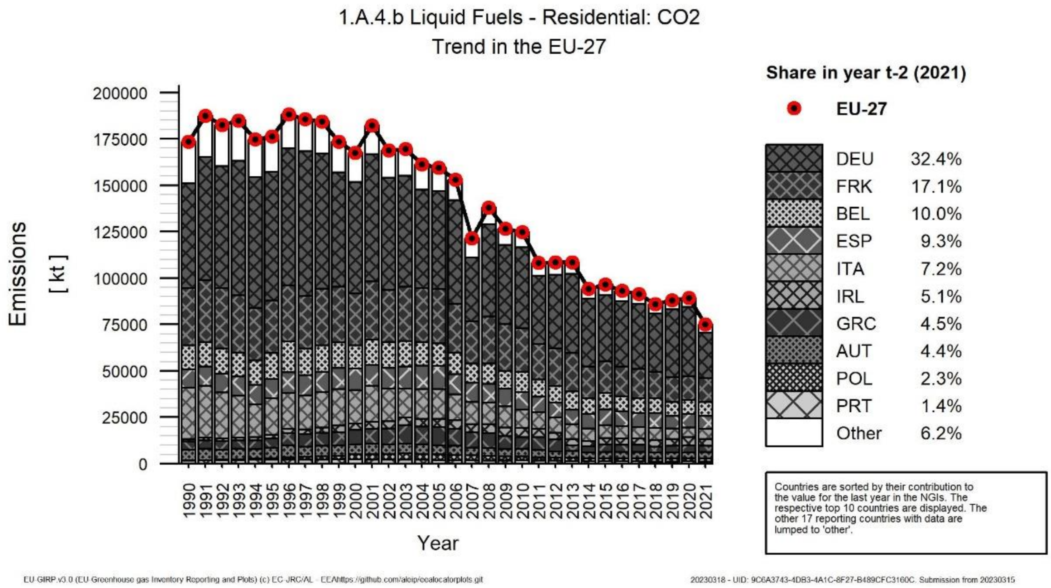
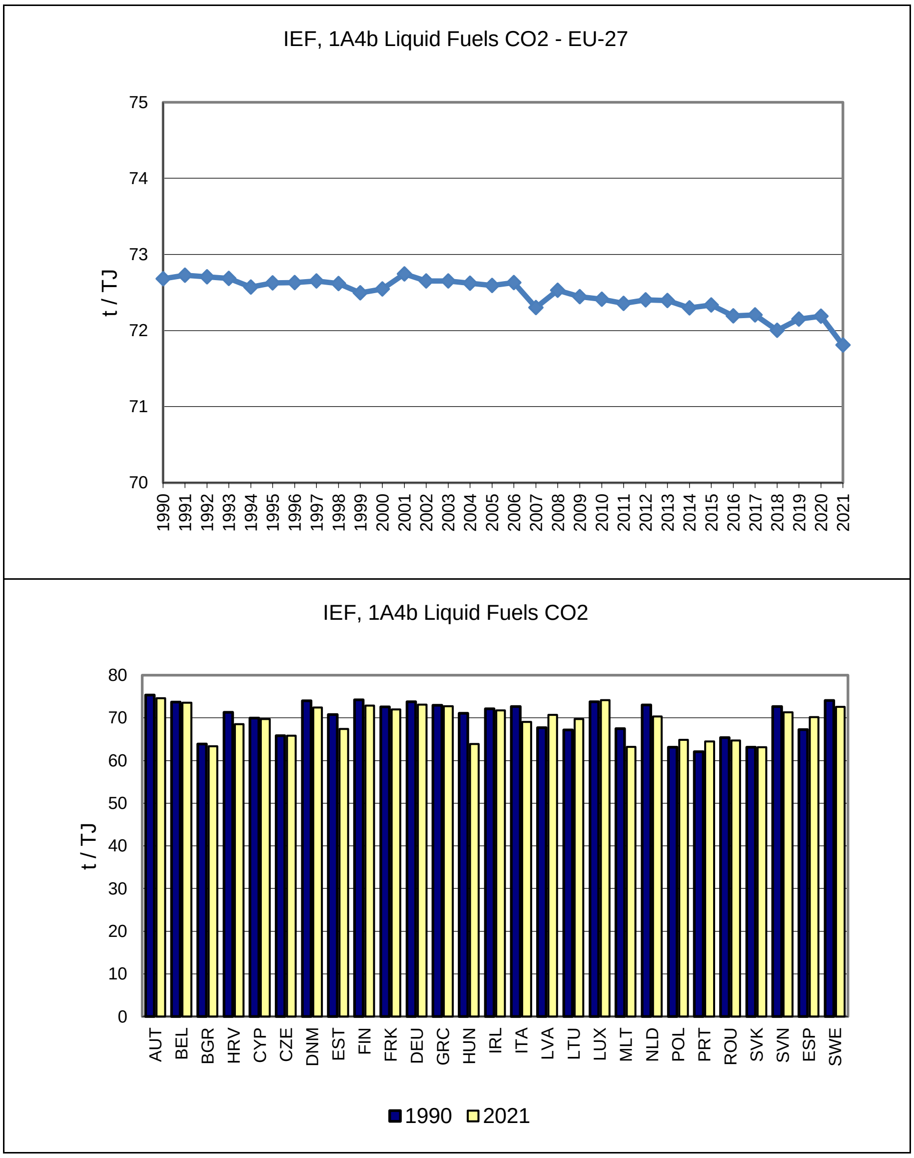


Figure 3.150 1.A.4.b Residential, liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)



1.A.4.b Residential –Solid Fuels (CO_2)

In 2021, CO_2 from solid fuels had a share of 8 % CO_2 emissions within source category 1.A.4.b (compared to 27 % in 1990). Between 1990 and 2021 CO_2 emissions decreased by 78 % (Table 3.79). Between 2020 and 2021 CO_2 emissions decreased by 4 %. Six Member States and Iceland report emissions as 'Not occurring' in 2021. According to the methodology as described in chapter 3.2.4 98 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.79 1.A.4.b Residential, solid fuels: Member States' contributions to CO_2 emissions

Member State	Emissions in kt CO2 equiv.			Share in EU-27	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021	Emissions in 2021	kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	2 511	55	61	0.2%	-2 450	-98%	6	11%	T2	T2
Belgium	1 796	71	80	0.3%	-1 716	-96%	9	13%	T1, T2	D
Bulgaria	2 730	363	518	2.0%	-2 211	-81%	155	43%	T1,T2	T1,T2
Croatia	436	8	8	0.0%	-429	-98%	0	-4%	T1	T1
Cyprus	NO	NO	NO	-	-	-	-	-	-	-
Czechia	16 038	2 904	2 866	11.0%	-13 172	-82%	-38	-1%	T2	CS,D
Denmark	72	NO	NO	-	-72	-100%	-	-	NA	NA
Estonia	337	4	2	0.0%	-334	-99%	-1	-38%	T2	CS
Finland	33	0	NO	-	-33	-100%	0	-100%	T2	T2
France	1 969	82	104	0.4%	-1 865	-95%	22	26%	-	-
Germany	40 661	1 306	1 439	5.5%	-39 221	-96%	134	10%	CS	CS
Greece	89	13	13	0.1%	-75	-85%	1	5%	T2	T2
Hungary	8 107	239	191	0.7%	-7 916	-98%	-48	-20%	T1,T2	T1,T2
Ireland	2 483	788	752	2.9%	-1 732	-70%	-36	-5%	T2	T2
Italy	899	NO	NO	-	-899	-100%	-	-	NA	NA
Latvia	587	5	5	0.0%	-582	-99%	0	-4%	T2	CS
Lithuania	1 440	98	120	0.5%	-1 319	-92%	22	23%	T2	T2
Luxembourg	26	1	1	0.0%	-25	-95%	0	31%	T1	T1
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	61	1	2	0.0%	-60	-97%	0	10%	T2	T2
Poland	28 362	20 542	19 181	74.0%	-9 181	-32%	-1 361	-7%	T1,T2	CS,D
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	2 729	147	144	0.6%	-2 586	-95%	-3	-2%	T1,T2	T1,T2
Slovakia	5 122	244	256	1.0%	-4 866	-95%	12	5%	T2	T2
Slovenia	345	0	0	0.0%	-344	-100%	0	-50%	T1	D
Spain	2 035	234	193	0.7%	-1 841	-91%	-41	-17%	T2	CS
Sweden	NO	NO	NO	-	-	-	-	-	-	-
EU-27	**118 866**	**27 105**	**25 937**	**100%**	**-92 929**	**-78%**	**-1 168**	**-4%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.151 and Figure 3.152 show CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Poland and Czechia; together they cause 86 % of the CO_2 emissions from solid fuels in 1.A.4.b. Fuel consumption in the EU decreased by 74 % between 1990 and 220. The CO_2 implied emission factor for solid fuels was 94.57 t/TJ in 2021. The comparatively low IEFs of Italy and Spain in 1990 are due to a high share of gas works gas consumption in the 1990s.

Figure 3.151 1.A.4.b Residential, solid fuels: Emission trend and share for CO_2

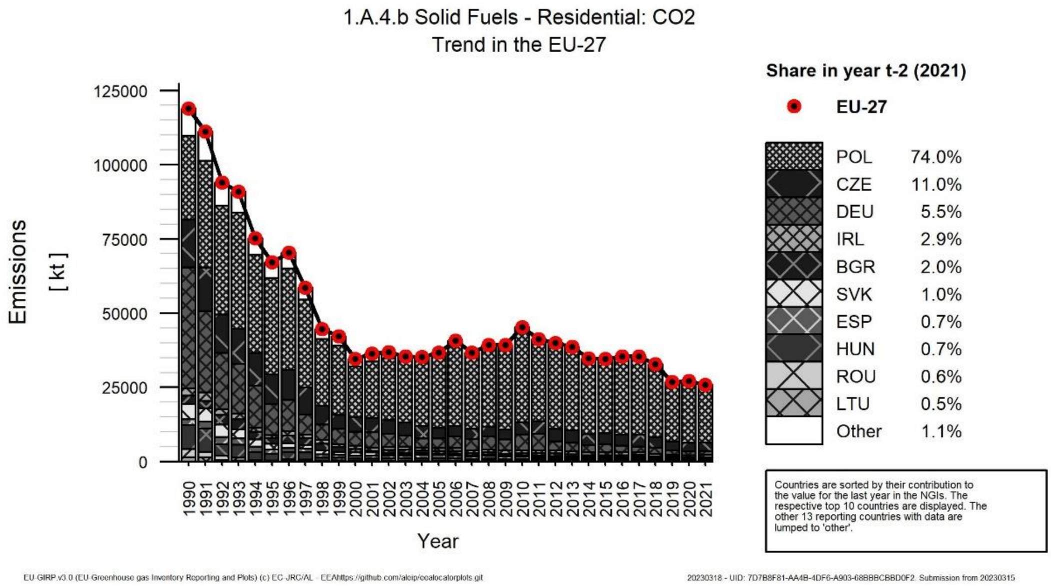
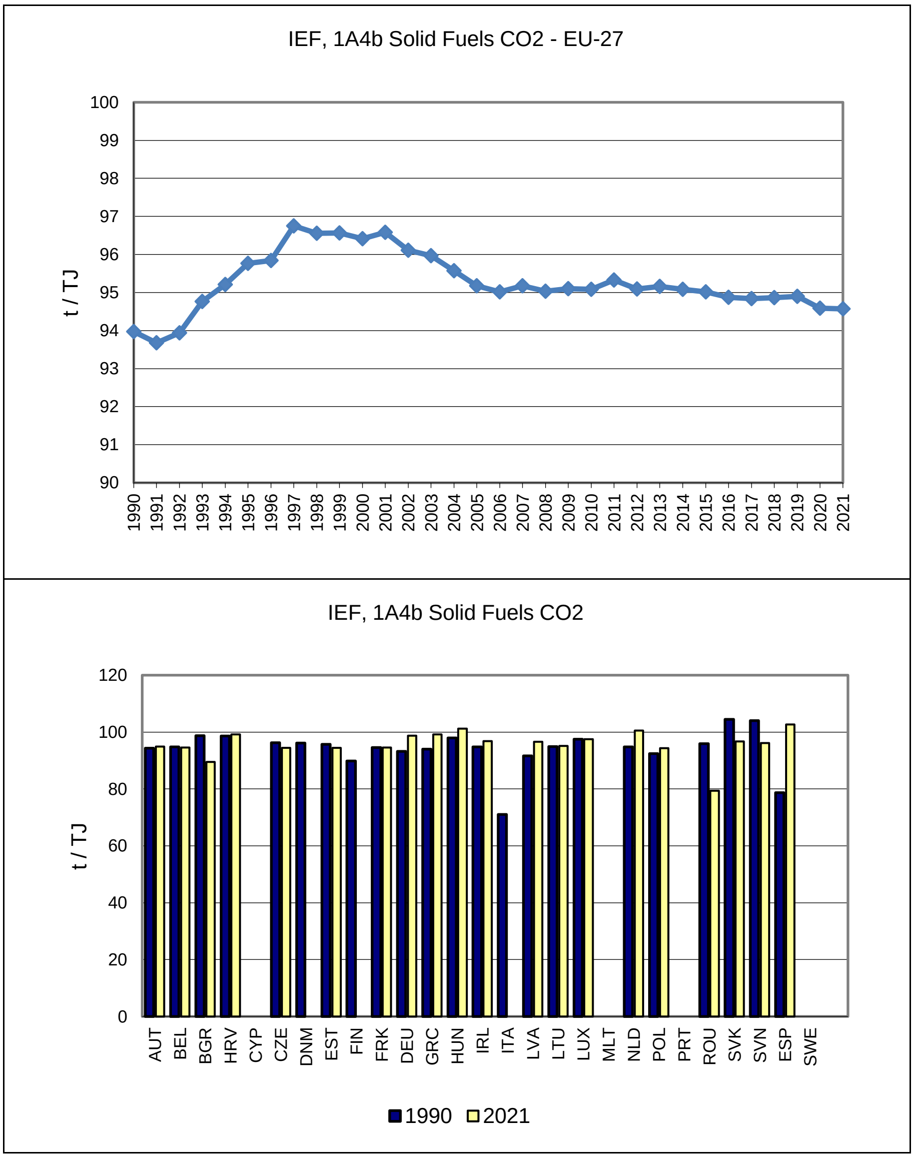


Figure 3.152 1.A.4.b Residential, solid fuels: Implied Emission Factors for CO_2 (in t/TJ)



1.A.4.b Residential – Gaseous Fuels (CO_2)

In 2021, CO_2 from gaseous fuels had a share of 67 % CO_2 emissions within source category 1.A.4.b (compared to 37 % in 1990). Between 1990 and 2021, the emissions increased by 57 % (Table 3.80). All Member States except Lithuania, the Netherlands and Sweden reported increasing emissions from the gaseous fuels combustion. The highest absolute increase occurred in Germany. Between 2020 and 2021 EU emissions increased by 11 %. According to the methodology as described in chapter 3.2.4 about 94 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.80 1.A.4.b Residential, gaseous fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 856	3 339	3 791	2%	1 935	104%	452	14%	T2	CS
Belgium	5 882	7 349	8 651	4%	2 769	47%	1 301	18%	T1	D
Bulgaria	NO	223	263	0%	263	∞	40	18%	T2	CS
Croatia	456	1 141	1 231	1%	775	170%	90	8%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	-	-
Czechia	2 098	4 319	4 842	2%	2 744	131%	524	12%	T2	CS
Denmark	988	1 156	1 054	1%	66	7%	-102	-9%	T3	CS
Estonia	132	130	140	0%	8	6%	10	7%	-	-
Finland	25	55	64	0%	39	153%	9	17%	T2	CS
France	21 064	25 185	27 512	13%	6 448	31%	2 327	9%	-	-
Germany	31 564	50 045	56 557	28%	24 993	79%	6 512	13%	CS	CS
Greece	IE,NO	1 031	1 164	1%	1 164	∞	133	13%	T2	CS
Hungary	4 115	7 170	7 910	4%	3 795	92%	739	10%	T2	CS
Ireland	270	1 387	1 404	1%	1 134	420%	17	1%	T2	CS
Italy	26 444	38 635	41 247	20%	14 803	56%	2 613	7%	T2	CS
Latvia	221	255	269	0%	48	22%	14	5%	T2	CS
Lithuania	509	404	509	0%	0	0%	106	26%	T2	CS
Luxembourg	170	605	567	0%	397	234%	-39	-6%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	19 894	14 856	16 918	8%	-2 976	-15%	2 062	14%	T2	CS
Poland	6 750	8 909	10 585	5%	3 835	57%	1 676	19%	T2	CS
Portugal	NO	696	680	0%	680	∞	-16	-2%	T2	CS
Romania	5 230	6 327	7 448	4%	2 218	42%	1 120	18%	T2	CS
Slovakia	1 559	2 633	2 894	1%	1 336	86%	261	10%	T2	CS
Slovenia	25	248	265	0%	240	948%	17	7%	T2	CS
Spain	912	8 130	8 120	4%	7 207	790%	-10	0%	T2	CS,D
Sweden	86	51	51	0%	-35	-40%	0	0%	T1	CS
EU-27	**130 249**	**184 279**	**204 136**	**100%**	**73 888**	**57%**	**19 857**	**11%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.153 shows CO_2 emissions for EU and the Member States as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to the Germany, Italy, France and the Netherlands; together they cause 70 % of the CO_2 emissions from gaseous fuels in 1.A.4.b. Fuel consumption in the EU increased by 57 % between 1990 and 2021. The CO_2 implied emission factor for gaseous fuels was 56.43 t/TJ in 2021.

Figure 3.153 1.A.4.b Residential, gaseous fuels: Emission trend and share for CO_2

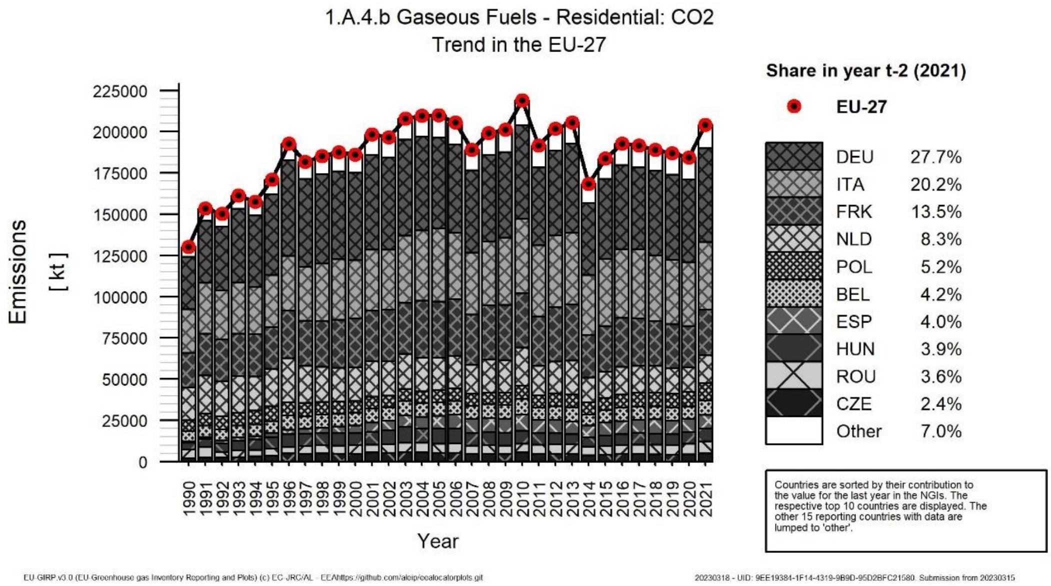
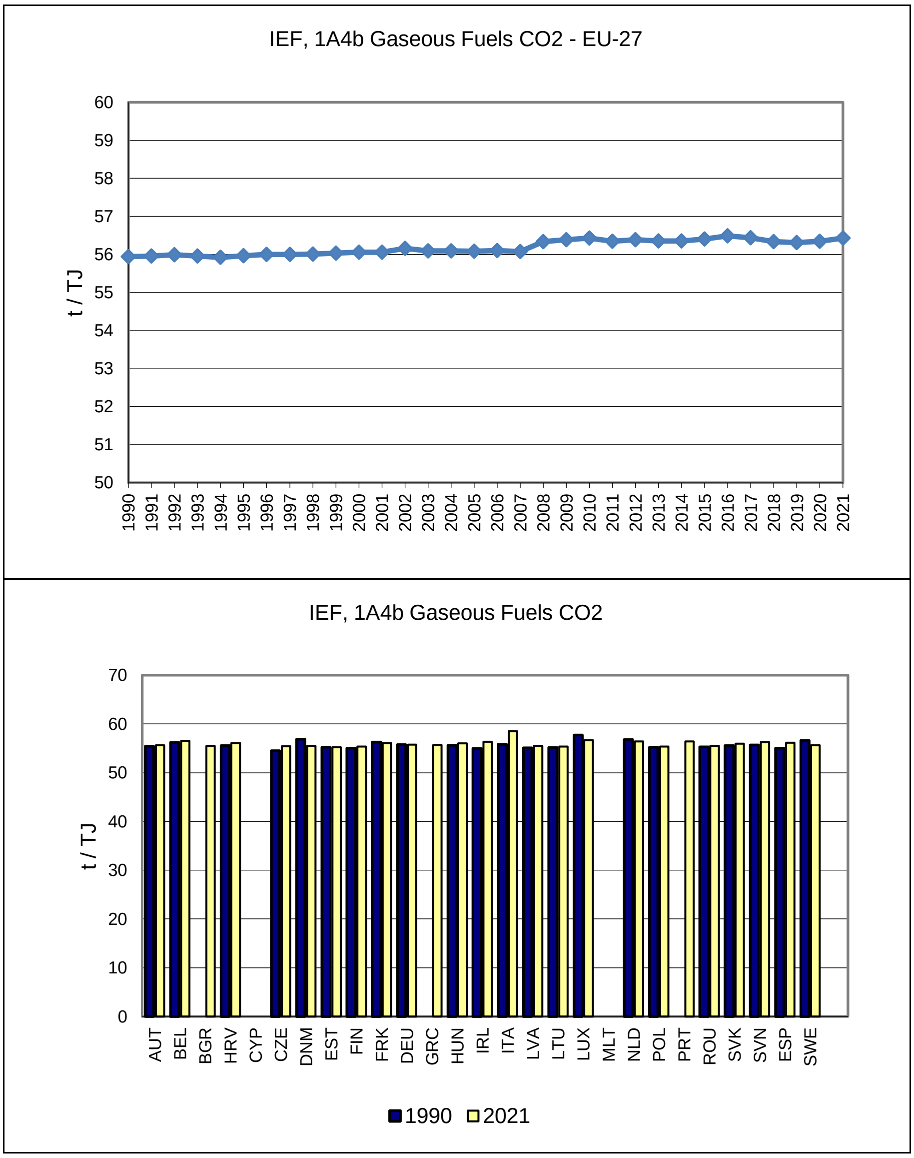


Figure 3.154 1.A.4.b Residential, gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)



CH_4 emissions from 1.A.4.b Residential

CH_4 emissions mainly occur from incomplete biomass and coal combustion. CH_4 emissions from 1.A.4.b Residential accounted for 59 % of total CH_4 emissions in 1.A and 0.6 % of total GHG emissions in 1.A in 2021. Between 1990 and 2021, CH_4 emissions from households decreased by 24 % in the EU (Table 3.81). France and Germany reported the highest decrease in emissions while Italy, Romania and Poland reported the highest increase in emissions. Between 2020 and 2021 CH_4 emissions increased by 5.1 %.

Table 3.81 1.A.4.b Residential: Member States' contributions to CH_4 emissions and information on method applied and emission factor

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	513	230	256	1.6%	-257	-50%	26	11%	T1,T2,T3	CS,D
Belgium	262	261	314	2.0%	51	20%	53	20%	CS,T1,T2,T3	CR,D
Bulgaria	293	334	314	2.0%	20	7%	-20	-6%	T1	D
Croatia	396	364	395	2.5%	-2	0%	31	9%	T1	D
Cyprus	2	8	8	0.0%	5	253%	-1	-8%	T1	D
Czechia	1 697	996	1 077	6.9%	-621	-37%	80	8%	T1	D
Denmark	152	96	93	0.6%	-59	-39%	-2	-2%	,M,T1,T2,T3	CS,D,OTH
Estonia	64	15	14	0.1%	-50	-78%	-1	-3%	T1,T2,T3	CS,D
Finland	166	179	199	1.3%	33	20%	20	11%	T1,T2,T3	CR,CS,D
France	5 113	1 693	1 825	11.7%	-3 288	-64%	132	8%	T1,T2	CS,D
Germany	2 783	869	991	6.3%	-1 792	-64%	122	14%	T2,T3	CS,M
Greece	256	213	230	1.5%	-26	-10%	17	8%	T1	D
Hungary	928	485	501	3.2%	-427	-46%	16	3%	T1	D
Ireland	496	165	157	1.0%	-339	-68%	-8	-5%	T1	D
Italy	1 224	2 310	2 514	16.1%	1 290	105%	203	9%	T2	CR
Latvia	221	126	128	0.8%	-93	-42%	2	2%	T1,T2	CS,D
Lithuania	196	154	158	1.0%	-39	-20%	4	2%	T1,T2	CS,D
Luxembourg	10	9	9	0.1%	-2	-15%	0	2%	T1,T3	D,M
Malta	0	1	1	0.0%	0	113%	0	5%	T1	D
Netherlands	503	368	414	2.6%	-89	-18%	46	13%	T1,T2	CS,D
Poland	2 772	3 562	3 484	22.2%	712	26%	-78	-2%	T1	D
Portugal	479	239	238	1.5%	-241	-50%	-1	0%	T1,T2	D,OTH
Romania	457	1 109	1 179	7.5%	722	158%	70	6%	T1	D
Slovakia	424	234	270	1.7%	-154	-36%	35	15%	T1	D
Slovenia	159	119	134	0.9%	-25	-16%	15	13%	T1,T2	CS,D
Spain	889	704	703	4.5%	-187	-21%	-2	0%	T2	D
Sweden	115	57	57	0.4%	-59	-51%	-1	-1%	M,T1	CS
EU-27	**20 574**	**14 899**	**15 661**	**100%**	**-4 912**	**-24%**	**762**	**5.1%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

1.A.4.b Residential – Biomass (CH_4)

In 2021 CH_4 from biomass had a share of 79 % within source category on the total CH_4 emissions from 1.A.4.b (compared to 47% in 1990). Between 1990 and 2021 CH_4 emissions increased by less than 19 % (Table 3.82). France reported the highest absolute decrease, while CH_4 emissions of Poland and Italy increased significantly. Between 2020 and 2021, CH_4 emissions decreased by 7 %. According to the methodology as described in chapter 3.2.4 about 50 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.82 1.A.4.b Residential, biomass: Member States' contributions to CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	264	211	236	2%	-28	-11%	24	11%	T1,T2,T3	CS,D
Belgium	109	228	280	2%	170	156%	52	23%	T1	D
Bulgaria	61	298	264	2%	203	335%	-34	-11%	T1	D
Croatia	354	359	390	3%	36	10%	31	9%	T1	D
Cyprus	1	7	7	0%	5	474%	-1	-7%	-	-
Czechia	363	727	809	7%	446	123%	82	11%	T1	D
Denmark	124	72	72	1%	-52	-42%	0	0%	T1,T3,CR,M	CS,D,OTH
Estonia	6	14	14	0%	7	112%	0	-3%	-	-
Finland	147	171	192	2%	45	31%	21	12%	T2,T3	CS,CR
France	4 765	1 566	1 692	14%	-3 073	-64%	125	8%	-	-
Germany	313	690	793	6%	480	153%	104	15%	T2,T3	CS,M
Greece	247	211	228	2%	-19	-8%	17	8%	T1	D
Hungary	209	445	463	4%	255	122%	18	4%	T1	D
Ireland	16	10	10	0%	-6	-35%	0	4%	T1	D
Italy	1 115	2 256	2 457	20%	1 342	120%	201	9%	T2	CR
Latvia	162	124	126	1%	-36	-22%	2	2%	T2	CS
Lithuania	66	140	141	1%	75	115%	1	0%	T2	CS
Luxembourg	5	5	6	0%	0	4%	0	4%	T1,T3	D,M
Malta	NO	1	1	0%	1	∞	0	7%	T1	D
Netherlands	99	66	71	1%	-28	-28%	5	7%	T1,T2	D,CS
Poland	327	1 707	1 745	14%	1 419	434%	38	2%	T1	D
Portugal	476	237	236	2%	-240	-50%	-1	0%	T2	OTH
Romania	202	1 076	1 144	9%	941	465%	67	6%	T1	D
Slovakia	40	207	241	2%	201	499%	34	16%	T1	D
Slovenia	129	117	132	1%	3	2%	16	13%	T2	CS
Spain	729	642	644	5%	-86	-12%	2	0%	T2	D
Sweden	107	55	54	0%	-54	-50%	-1	-1%	T1	CS
EU-27	**10 438**	**11 642**	**12 446**	**100%**	**2 008**	**19%**	**803**	**7%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviation'.

Figure 3.155 and Figure 3.156 show CH_4 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CH_4 emissions correspond to Italy followed by Poland, France and Romania; together they cause 57 % of the CH_4 emissions from biomass fuels in 1.A.4.b. Biomass fuel consumption in the EU increased by 70 % between 1990 and 2021. The CH_4 implied emission factor for biomass fuels was 230.75 kg/TJ in 2021.

The trend in implied emission factor is strongly affected by France, whose IEF changed dramatically over the time series; from 497.41 kg/TJ in 1990 to 207.05 kg/TJ in 2021. The decreasing trend of IEF in France (and also other Member States) reflects replacement of old biomass boilers, stoves and open fireplaces by modern technologies (pellets, automatic boilers). These new technologies have lower CH_4 (as well as NMVOC) emissions from incomplete combustion. However, this change in improved technologies is not reflected by the Member States which are using the default emission factor value (300 kg/TJ) for the whole time series.

Figure 3.155 1.A.4.b Residential, biomass: Emission trend and share for CH_4

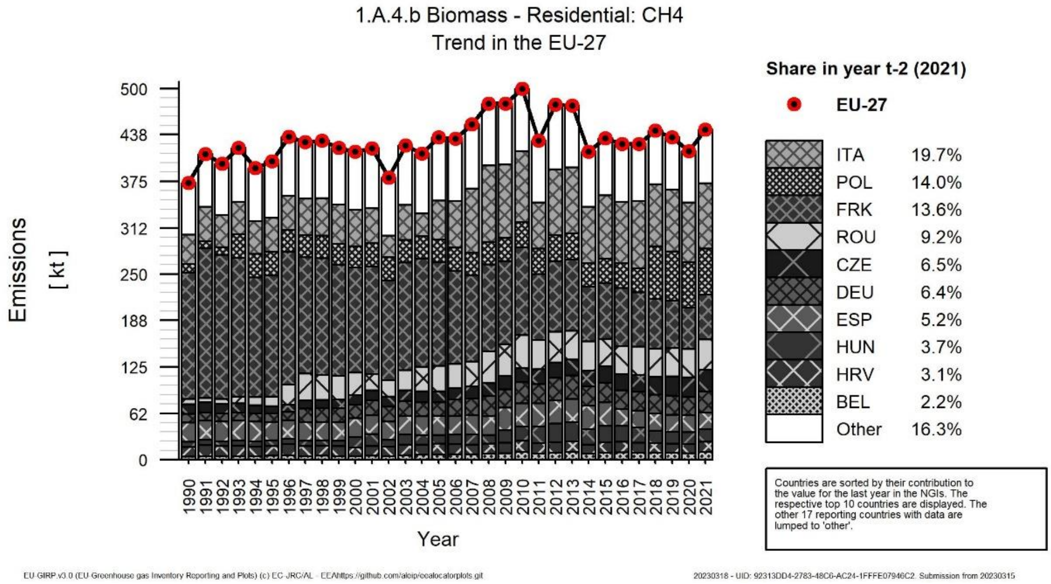
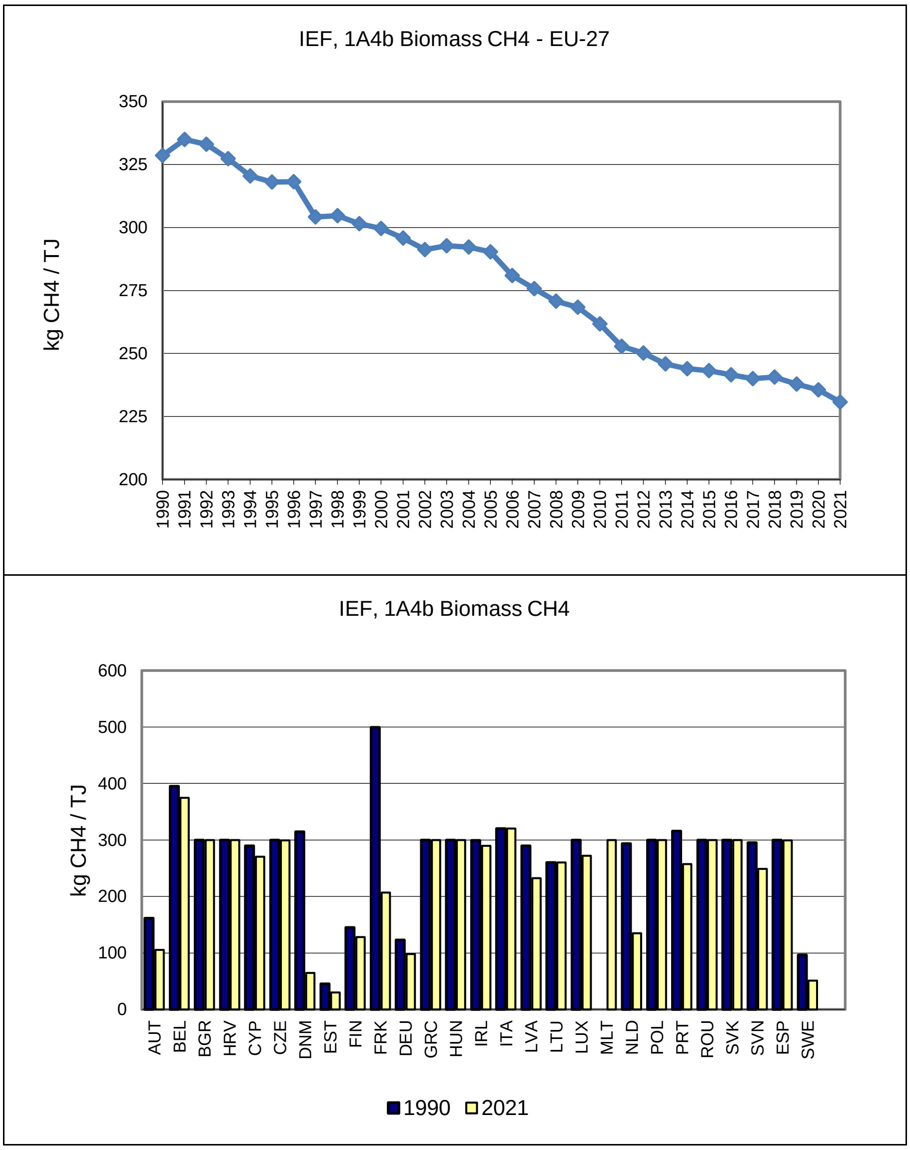


Figure 3.156 1.A.4.b Residential, biomass: Implied Emission Factors for CH_4 (in kg/TJ)



1.A.4.b Residential – Solid Fuels (CH_4)

In 2021, CH_4 from solid fuels had a share of 15 % within source category on the total CH_4 emissions from 1.A.4.b (compared to 46 % in 1990). Between 1990 and 2021 CH_4 emissions decreased by 74 % (Table 3.82). All Member States reported decreasing emissions since 1990 with Germany showing the largest absolute decreases. Between 2020 and 2021 CH_4 emissions increased by 4 %. According to the methodology as described in chapter 3.2.4, about 8 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.83: 1.A.4.b Residential, solid fuels: Member States' contributions to CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	224	5	5	0%	-218	-98%	1	11%	T1	D
Belgium	123	5	6	0%	-117	-95%	1	15%	T1,T2	D
Bulgaria	232	35	49	2%	-184	-79%	14	39%	T1	D
Croatia	37	1	1	0%	-37	-98%	0	-5%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	-	-
Czechia	1 328	258	255	11%	-1 073	-81%	-3	-1%	T1	D
Denmark	6	NO	NO	-	-6	-100%	-	-	NA	NA
Estonia	30	0	0	0%	-29	-99%	0	-38%	-	-
Finland	3	0	NO	-	-3	-100%	0	-100%	NA	NA
France	175	7	9	0%	-166	-95%	2	26%	-	-
Germany	2 429	95	104	5%	-2 324	-96%	9	10%	T2	CS
Greece	8	1	1	0%	-7	-86%	0	5%	T1	D
Hungary	695	20	16	1%	-680	-98%	-4	-20%	T1	D
Ireland	220	69	65	3%	-155	-70%	-3	-5%	T1	D
Italy	11	NO	NO	-	-11	-100%	-	-	NA	NA
Latvia	54	0	0	0%	-53	-99%	0	-4%	T1	D
Lithuania	127	9	11	0%	-117	-92%	2	23%	T1	D
Luxembourg	2	0	0	0%	-2	-95%	0	31%	T1	D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	0	0	0	0%	0	-82%	0	15%	T2	CS
Poland	2 428	1 829	1 708	75%	-720	-30%	-121	-7%	T1	D
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	239	15	15	1%	-224	-94%	0	0%	T1	D
Slovakia	379	21	22	1%	-358	-94%	1	6%	T1	D
Slovenia	28	0	0	0%	-28	-100%	0	-50%	T1	D
Spain	130	19	16	1%	-114	-88%	-3	-17%	T2	D
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**8 908**	**2 389**	**2 284**	**100%**	**-6 624**	**-74%**	**-105**	**-4%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.155 and Figure 3.156 show CH_4 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CH_4 emissions (above the average share calculated for EU) correspond to Poland and Czechia with a share of 86 % of total CH_4 emissions from solid fuels in 1.A.4.b. Solid fuel consumption in the EU decreased by 78 % between 1990 and 2021. The CH_4 implied emission factor for solid fuels was 297401 kg/TJ in 2021.

Figure 3.157: 1.A.4.b Residential, solid fuels: Emission trend and share for CH_4

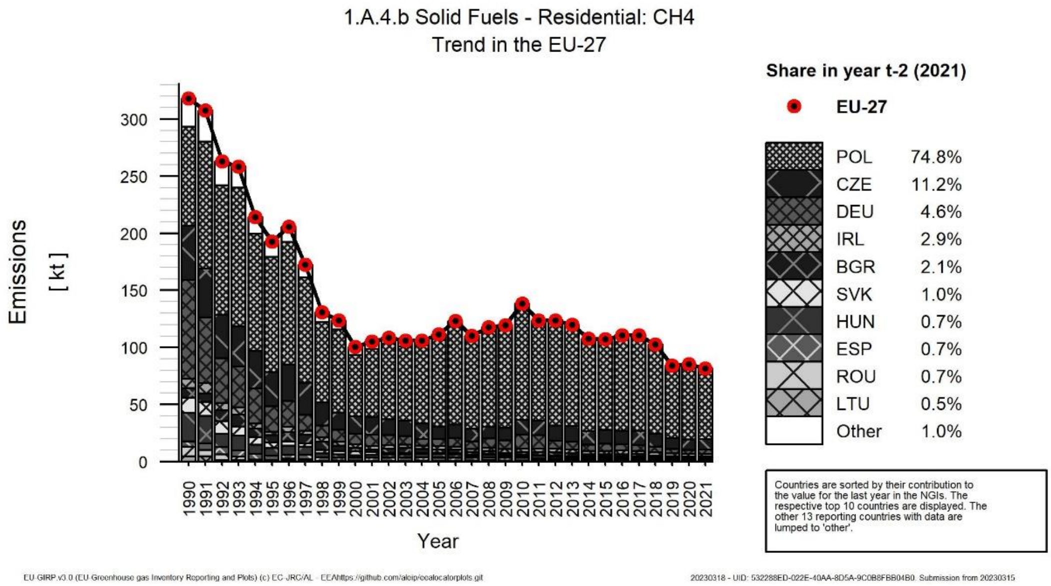
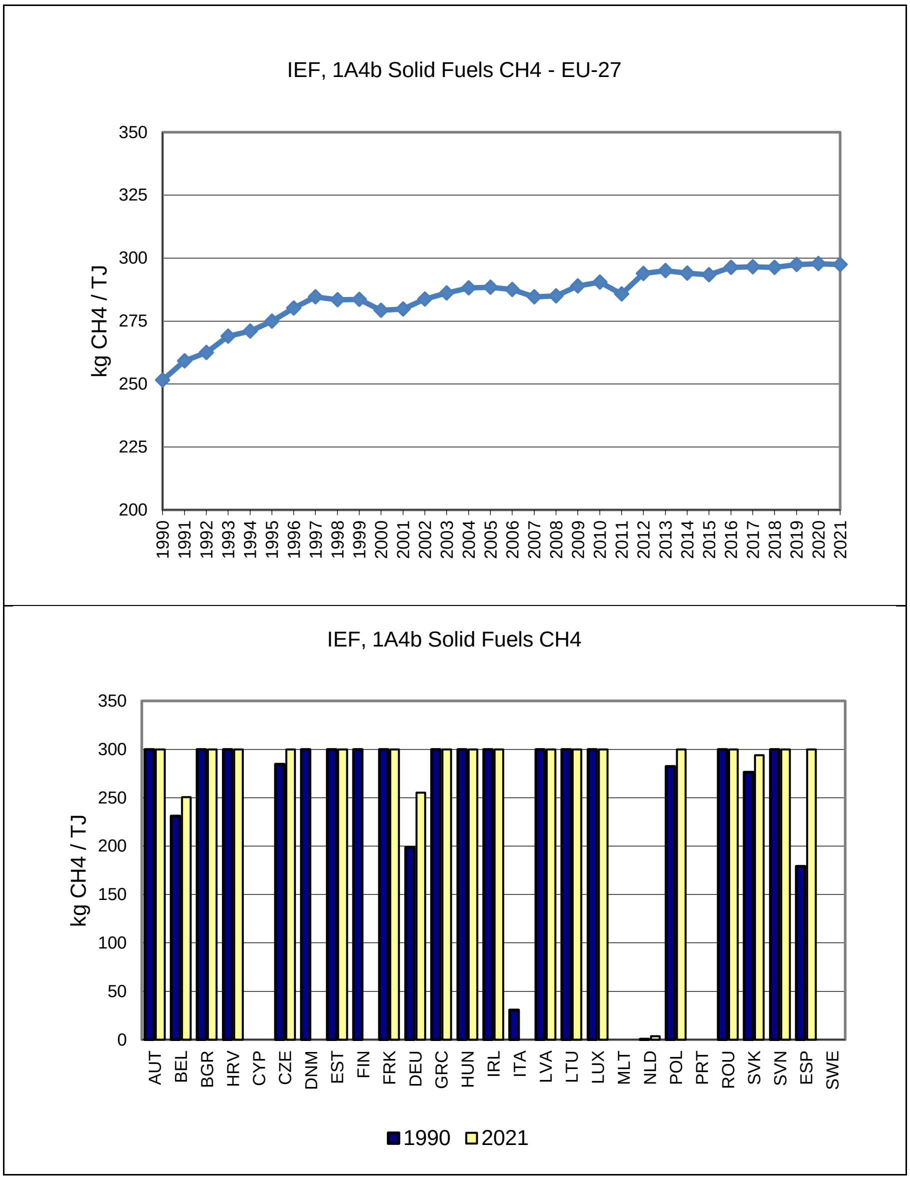


Table 3.84: 1.A.4.b Residential, solid fuels: Implied Emission Factors for CH_4 (in kg/TJ)

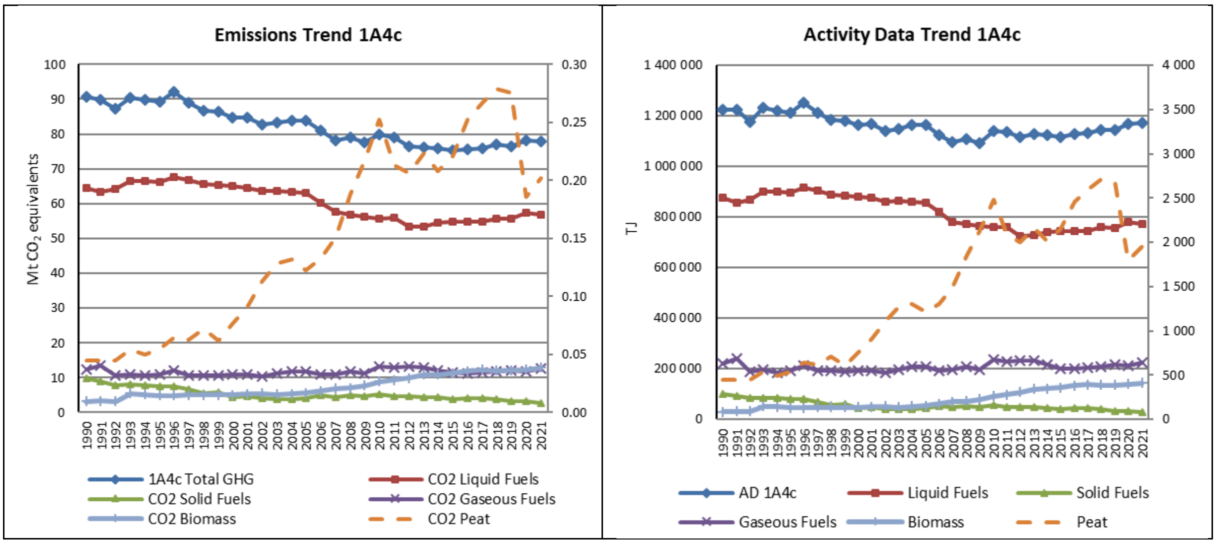


3.2.4.3 Agriculture/Forestry/Fisheries (1.A.4.c)

In this chapter information about emission trends, Member States' contribution and activity data is provided for category 1.A.4.c by fuels. CO_2 emissions from 1.A.4.c Agriculture/Forestry/Fisheries accounted for 2.8 % of total EU GHG emissions from 1.A Fuel Combustion in 2021. Between 1990 and 2021, CO_2 emissions from 1.A.4.c Agriculture/Forestry/Fisheries decreased by 16 % in the EU (Table 3.85).

Figure 3.158 shows the emission trend within source category 1.A.4.c, which is mainly dominated by CO_2 emissions from liquid fuels. Total GHG emissions decreased by 12 % between 1990 and 2021, mainly due to decreases in CO_2 emissions from liquid fuels.

Figure 3.158 1.A.4.c Agriculture/Forestry/Fisheries: Total and CO_2 emission trends



Data displayed as dashed line refers to the secondary axis.

Five Member States; Spain, France, Poland, the Netherlands and Italy together contributed 68 % to the emissions from this source in 2021. Spain and Poland were the Member States with the highest increase in absolute terms between 1990 and 2021, while the highest decreases were achieved in Germany, Czechia and Greece.

Table 3.85 1.A.4.c Agriculture/Forestry/Fisheries: Member States' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 251	883	865	1.2%	-386	-31%	-17	-2%	IO,T1,T2,T3	CS,D,NO
Belgium	3 037	2 438	2 649	3.7%	-388	-13%	212	9%	CS,T1,T3	D
Bulgaria	1 649	420	455	0.6%	-1 195	-72%	34	8%	T1,T2	CS,D
Croatia	835	679	687	0.9%	-148	-18%	8	1%	T1	D
Cyprus	55	88	85	0.1%	29	53%	-4	-4%	T1	D
Czechia	3 672	1 224	1 208	1.7%	-2 463	-67%	-16	-1%	T1,T2	CS,D
Denmark	2 203	1 255	1 353	1.9%	-851	-39%	98	8%	,M,T1,T2,T3	CS,D
Estonia	601	281	210	0.3%	-391	-65%	-70	-25%	T1,T2	CS,D
Finland	1 870	1 566	1 389	1.9%	-481	-26%	-177	-11%	T1,T2,T3	CS,D
France	11 226	10 913	10 520	14.5%	-706	-6%	-393	-4%	T1,T2	CS,D
Germany	10 172	5 996	6 083	8.4%	-4 089	-40%	87	1%	S,T1,T2,T3	CS,D
Greece	2 893	703	557	0.8%	-2 335	-81%	-146	-21%	T1,T2	CS,D
Hungary	2 652	1 639	1 551	2.1%	-1 101	-42%	-88	-5%	T1,T2	CS,D
Ireland	747	622	619	0.9%	-128	-17%	-3	-1%	T1,T2	CS,D
Italy	8 352	7 065	7 066	9.8%	-1 286	-15%	1	0%	T2	CS
Latvia	1 585	482	473	0.7%	-1 112	-70%	-9	-2%	T1,T2	CS,D
Lithuania	1 483	219	237	0.3%	-1 246	-84%	18	8%	T2	CS
Luxembourg	34	22	22	0.0%	-12	-36%	0	0%	T1,T2	CS,D
Malta	4	21	22	0.0%	18	461%	1	3%	T1	D
Netherlands	9 850	8 962	9 252	12.8%	-598	-6%	290	3%	T1,T2	CS,D
Poland	8 505	10 750	10 239	14.2%	1 734	20%	-511	-5%	T1,T2	CS,D
Portugal	1 119	1 286	1 303	1.8%	184	16%	18	1%	NO,T1,T2	CS,D,NO
Romania	1 996	1 442	1 567	2.2%	-429	-21%	125	9%	T1,T2	CS,D
Slovakia	146	335	345	0.5%	198	135%	10	3%	T1,T2	CS
Slovenia	166	211	212	0.3%	45	27%	0	0%	T1	D
Spain	8 695	12 109	12 267	17.0%	3 572	41%	158	1%	R,T1,T2,T3	R,CS,D,OTH
Sweden	1 801	1 114	1 119	1.5%	-682	-38%	5	0%	NO,T1,T2	CS,NO
EU-27	**86 600**	**72 724**	**72 354**	**100%**	**-14 246**	**-16%**	**-371**	**-0.5%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

1.A.4.c Agriculture/Forestry/Fisheries – Liquid Fuels (CO_2)

In 2021, CO_2 from liquid fuels had a share of 78 % within source category 1.A.4.c (compared to 76 % in 1990). Between 1990 and 2021 CO_2 decreased by 12 % (Table 3.86. Eight Member States reported increasing emissions with the highest increases in absolute terms in Poland and Spain. Between 2020 and 2021 EU emissions decreased by 1 %. According to the methodology as described in chapter 3.2.4 about 77 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.86 1.A.4.c Agriculture/Forestry/Fisheries, liquid fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	1 180	828	808	1%	-372	-32%	-20	-2%	T2	CS
Belgium	2 757	1 107	1 145	2%	-1 613	-58%	38	3%	T1	D
Bulgaria	1 498	359	389	1%	-1 109	-74%	30	8%	T1	D
Croatia	788	620	616	1%	-172	-22%	-4	-1%	T1	D
Cyprus	55	88	85	0%	29	53%	-4	-4%	T1	D
Czechia	1 536	1 066	1 058	2%	-478	-31%	-8	-1%	T1	CS,D
Denmark	1 840	1 160	1 263	2%	-577	-31%	103	9%	T1,T2	CS,D
Estonia	574	272	202	0%	-372	-65%	-70	-26%	T1,T2	CS,D
Finland	1 784	1 440	1 251	2%	-533	-30%	-190	-13%	T1	CS
France	10 905	10 433	9 960	18%	-945	-9%	-473	-5%	T1,T2	CS,D
Germany	6 829	5 432	5 513	10%	-1 316	-19%	81	1%	CS	CS
Greece	2 882	697	552	1%	-2 330	-81%	-146	-21%	T2	CS
Hungary	2 085	1 283	1 215	2%	-870	-42%	-68	-5%	T1	D
Ireland	747	622	619	1%	-128	-17%	-3	-1%	T1,T2	CS,D
Italy	8 300	6 735	6 626	12%	-1 674	-20%	-109	-2%	T2	CS
Latvia	701	459	444	1%	-257	-37%	-15	-3%	T2	CS
Lithuania	1 173	167	178	0%	-995	-85%	11	6%	T2	CS
Luxembourg	34	22	22	0%	-12	-36%	0	0%	NA	NA
Malta	4	21	22	0%	18	461%	1	3%	T1	D
Netherlands	2 521	1 884	1 821	3%	-700	-28%	-63	-3%	T1,T2	CS,D
Poland	4 725	7 668	7 670	14%	2 945	62%	2	0%	T1,T2	CS,D
Portugal	1 119	1 251	1 267	2%	148	13%	16	1%	T1	D
Romania	9	1 061	1 161	2%	1 152	12276%	100	9%	T1,T2	CS,D
Slovakia	104	247	280	0%	175	168%	32	13%	T2	CS
Slovenia	166	211	212	0%	45	27%	0	0%	NA	NA
Spain	8 652	11 169	11 298	20%	2 647	31%	130	1%	T2,T3	D
Sweden	1 610	1 102	1 108	2%	-502	-31%	6	1%	T1	CS
EU-27	**64 579**	**57 406**	**56 783**	**100%**	**-7 796**	**-12%**	**-623**	**-1%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.159 and Figure 3.160 show CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to Spain, France, Poland, Italy and Germany; together they cause 72 % of the CO_2 emissions from liquid fuels in 1.A.4.c. Fuel consumption in the EU decreased by 12 % between 1990 and 2021. The CO_2 implied emission factor for liquid fuels was 73.43 t/TJ in 2021.

Figure 3.159 1.A.4.c Agriculture/Forestry/Fisheries, liquid fuels: Emission trend and share for CO_2

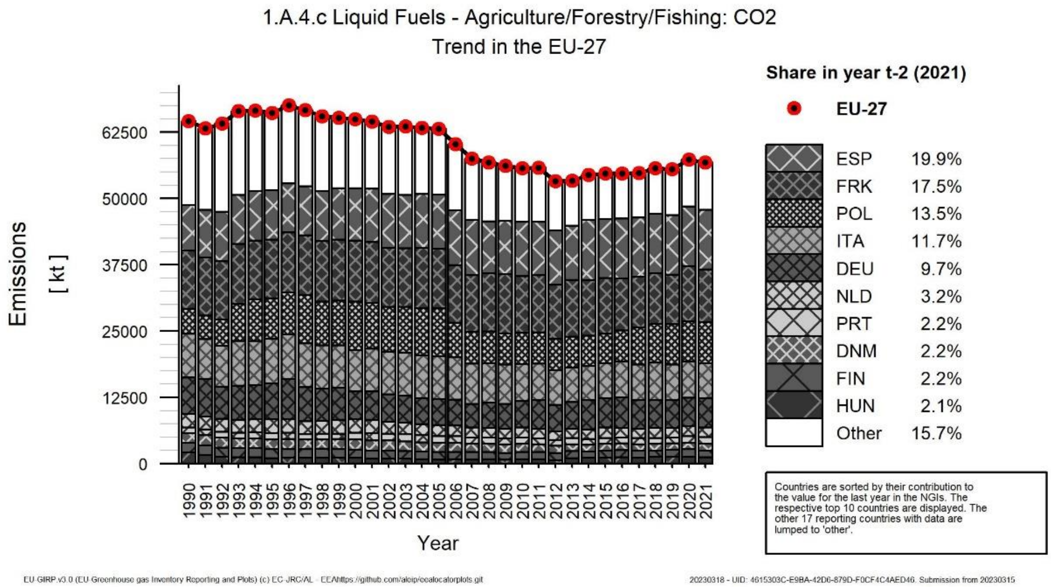
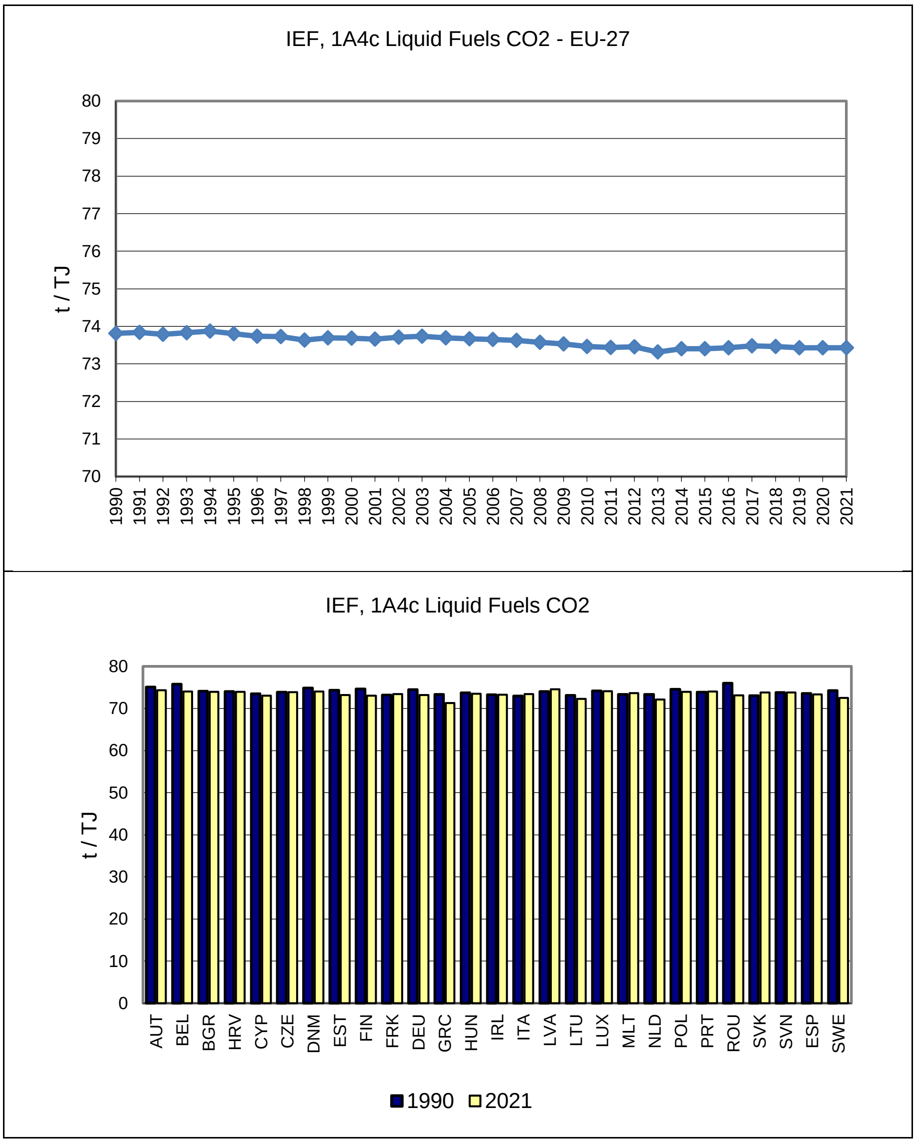


Figure 3.160 1.A.4.c Agriculture/Forestry/Fisheries, liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)



1.A.4.c Agriculture/Forestry/Fisheries – Solid Fuels (CO_2)

In 2021 CO_2 from solid fuels had a share of 4 % within source category 1.A.4.c (compared to 10 % in 1990). Between 1990 and 2021, CO_2 decreased by 72 % (Table 3.87). Fourteen Member States reported CO_2 emissions from this source category as 'Not occurring' in 2021. All Member States except Romania reported decreasing emissions between 1990 and 2021. Between 2020 and 2021, EU emissions decreased by 16 %. The decrease in 1990 to 1992 emissions is due to the strong decrease reported by Germany (which had 29 % share on 1990 emissions). According to the methodology as described in chapter 3.2.4 97 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.87 1.A.4.c Agriculture/Forestry/Fisheries, solid fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	51	2	2	0%	-49	-97%	0	-3%	T2	CS
Belgium	212	41	41	2%	-171	-81%	0	0%	T1	D
Bulgaria	151	36	37	1%	-114	-76%	1	2%	T1,T2	CS,D
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	1 730	20	27	1%	-1 703	-98%	7	33%	T2	CS,D
Denmark	237	13	12	0%	-225	-95%	-1	-6%	T1	D
Estonia	22	1	1	0%	-21	-95%	1	108%	T1,T2	CS,D
Finland	13	7	9	0%	-4	-34%	2	25%	T3	CS
France	NO	NO	NO	-	-	-	-	-	NA	NA
Germany	2 861	NA	NA	-	-2 861	-100%	-	-	NA	NA
Greece	11	6	6	0%	-5	-47%	0	-2%	T2	CS
Hungary	134	6	6	0%	-128	-96%	0	0%	T1,T2	CS,D
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	NO	NO	NO	-	-	-	-	-	NA	NA
Latvia	99	NO	NO	-	-99	-100%	-	-	NA	NA
Lithuania	148	5	3	0%	-144	-98%	-1	-27%	T2	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	3 755	2 982	2 448	92%	-1 307	-35%	-533	-18%	T1,T2	CS,D
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	66	73	78	3%	13	19%	6	8%	T1,T2	CS,D
Slovakia	1	1	1	0%	0	-12%	0	-14%	T2	CS
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	37	NO	NO	-	-37	-100%	-	-	NA	NA
Sweden	157	NO	NO	-	-157	-100%	-	-	NA	NA
EU-27	**9 686**	**3 191**	**2 671**	**100%**	**-7 015**	**-72%**	**-520**	**-16%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.161 and Figure **3.162** show CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. Poland contributes to 92 % of EU emissions in 2021. Fuel consumption in the EU decreased by 72 % between 1990 and 2021. The CO_2 implied emission factor for solid fuels was 94.82 t/TJ in 2021.

Figure 3.161 1.A.4.c Agriculture/Forestry/Fisheries, solid fuels: Emission trend and share for CO_2

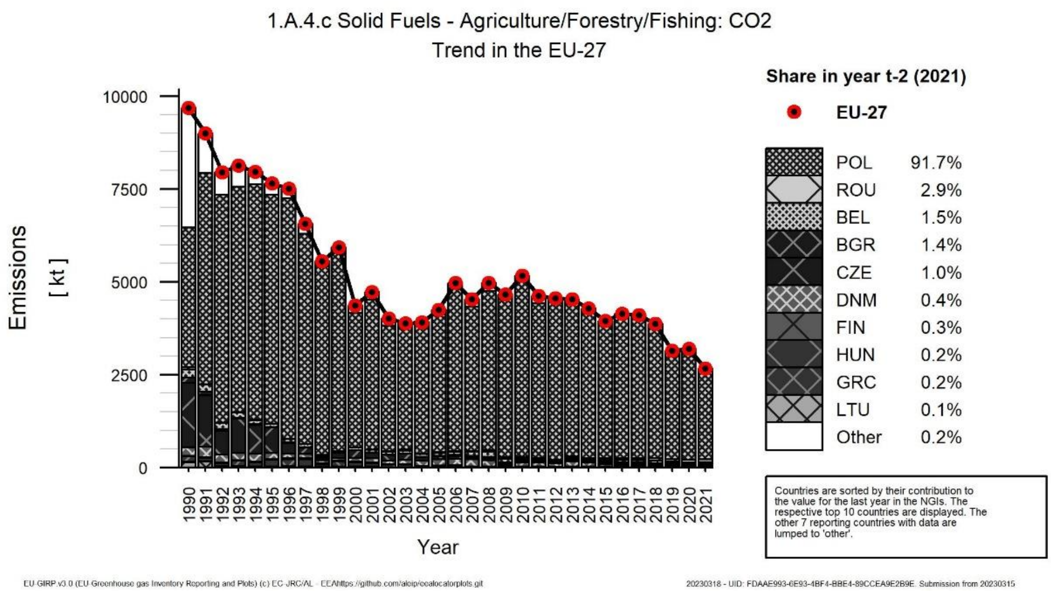
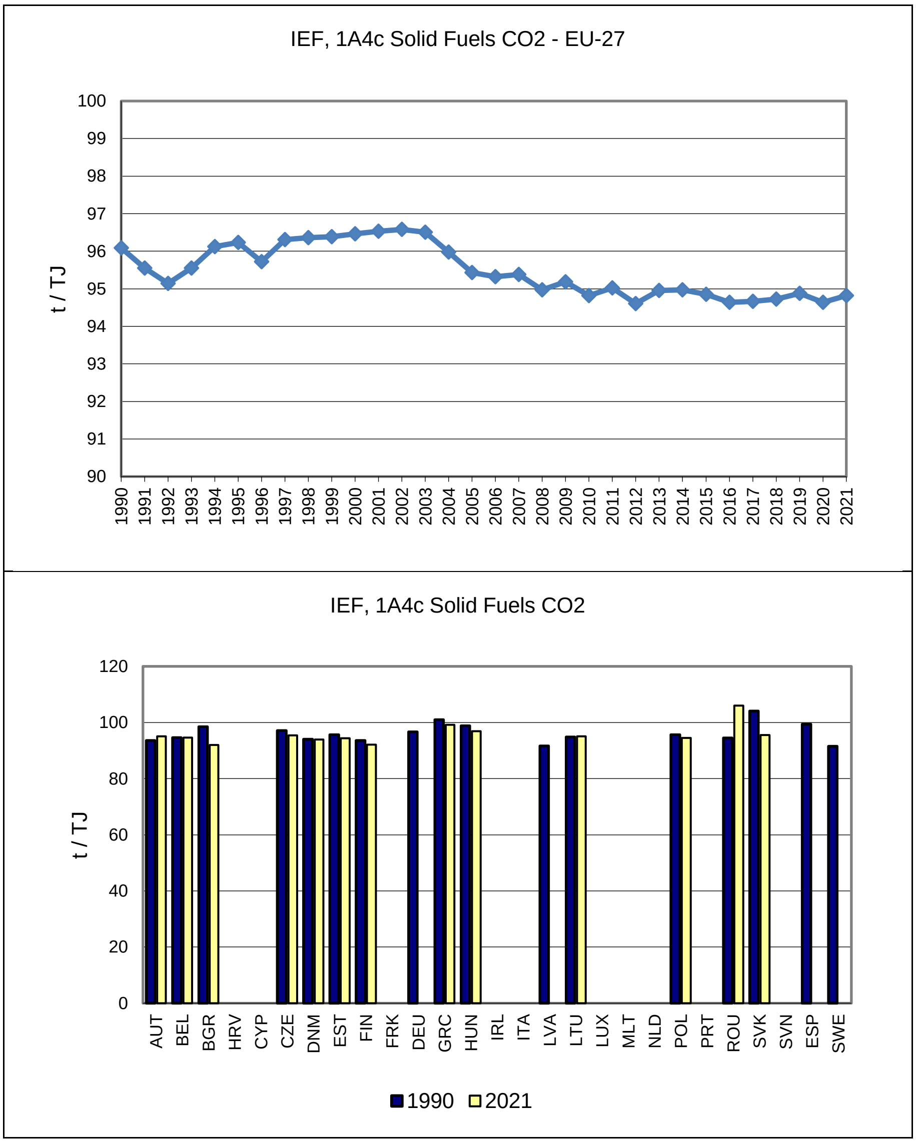


Figure 3.162 1.A.4.c Agriculture/Forestry/Fisheries, solid fuels: Implied Emission Factors for CO_2 (in t/TJ)



1.A.4.c Agriculture/Forestry/Fisheries –Gaseous Fuels (CO_2)

In 2021, CO_2 from gaseous fuels had a share of 17 % within source category 1.A.4.c (compared to 13 % in 1990). Between 1990 and 2021 CO_2 emissions increased by 3 % (Table 3.88). The highest absolute increase occurred in Belgium. Between 2020 and 2021, EU emissions increased by 6 %. This source of emissions is dominated by the Netherlands where natural gas is used for greenhouse horticulture. According to the methodology as described in chapter 3.2.4 about 87 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.88 1.A.4.c Agriculture/Forestry/Fisheries, gaseous fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	20	50	53	0%	33	164%	3	6%	T2	CS
Belgium	67	1 290	1 464	12%	1 396	2070%	174	13%	T1	D
Bulgaria	0	26	29	0%	29	14504%	3	14%	T2	CS
Croatia	48	59	71	1%	24	49%	12	21%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	405	138	123	1%	-282	-70%	-14	-10%	T2	CS
Denmark	126	82	77	1%	-49	-39%	-4	-5%	T3	CS
Estonia	4	8	7	0%	3	87%	-1	-17%	T2	CS
Finland	32	6	6	0%	-26	-80%	1	12%	T2	CS
France	320	442	523	4%	203	63%	81	18%	T1,T2	CS,D
Germany	483	546	554	4%	71	15%	8	2%	CS	CS
Greece	IE,NO	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Hungary	433	350	330	3%	-103	-24%	-20	-6%	T2	CS
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	52	330	439	3%	387	745%	110	33%	T2	CS
Latvia	782	23	29	0%	-754	-96%	6	27%	T2	CS
Lithuania	162	47	55	0%	-108	-66%	8	16%	T2	CS
Luxembourg	NO	0	0	0%	0	∞	0	53%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	7 329	7 074	7 426	59%	97	1%	352	5%	T1,T2	CS,D
Poland	25	100	120	1%	96	387%	20	20%	T2	CS
Portugal	NO	34	36	0%	36	∞	2	6%	T2	CS
Romania	1 921	236	249	2%	-1 672	-87%	14	6%	T2	CS
Slovakia	41	86	64	1%	23	57%	-22	-26%	T2	CS
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	6	940	969	8%	963	15630%	29	3%	T2	CS,D
Sweden	33	8	8	0%	-25	-77%	0	0%	T1	CS
EU-27	**12 291**	**11 874**	**12 634**	**100%**	**343**	**3%**	**760**	**6%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.
Greece reports emissions from stationary combustion and off road machinery as 'NO' and emissions from fishing as 'IE.'

Figure 3.163 and Figure 3.164 show CO_2 emissions and implied emission factors for EU as well as the share of the Member States with the highest contributions. It can be seen that the highest shares on total CO_2 emissions (above the average share calculated for EU) correspond to the Netherlands, Belgium and Spain accounting for 78 % of the CO_2 emissions from gaseous fuels in 1.A.4.c. Fuel consumption in the EU decreased by 3 % between 1990 and 2021. The CO_2 implied emission factor for gaseous fuels was 56.36 t/TJ in 2021. The strong decrease of IEF in 1998 is caused by a decrease of Belgium's IEF.

Figure 3.163 1.A.4.c Agriculture/Forestry/Fisheries, gaseous fuels: Emission trend and share for CO_2

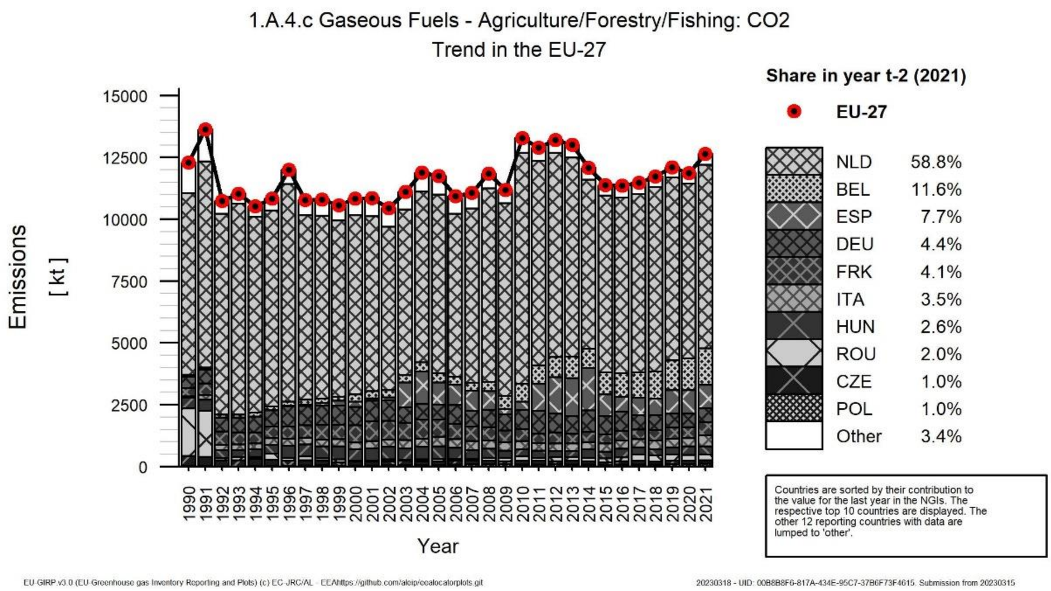
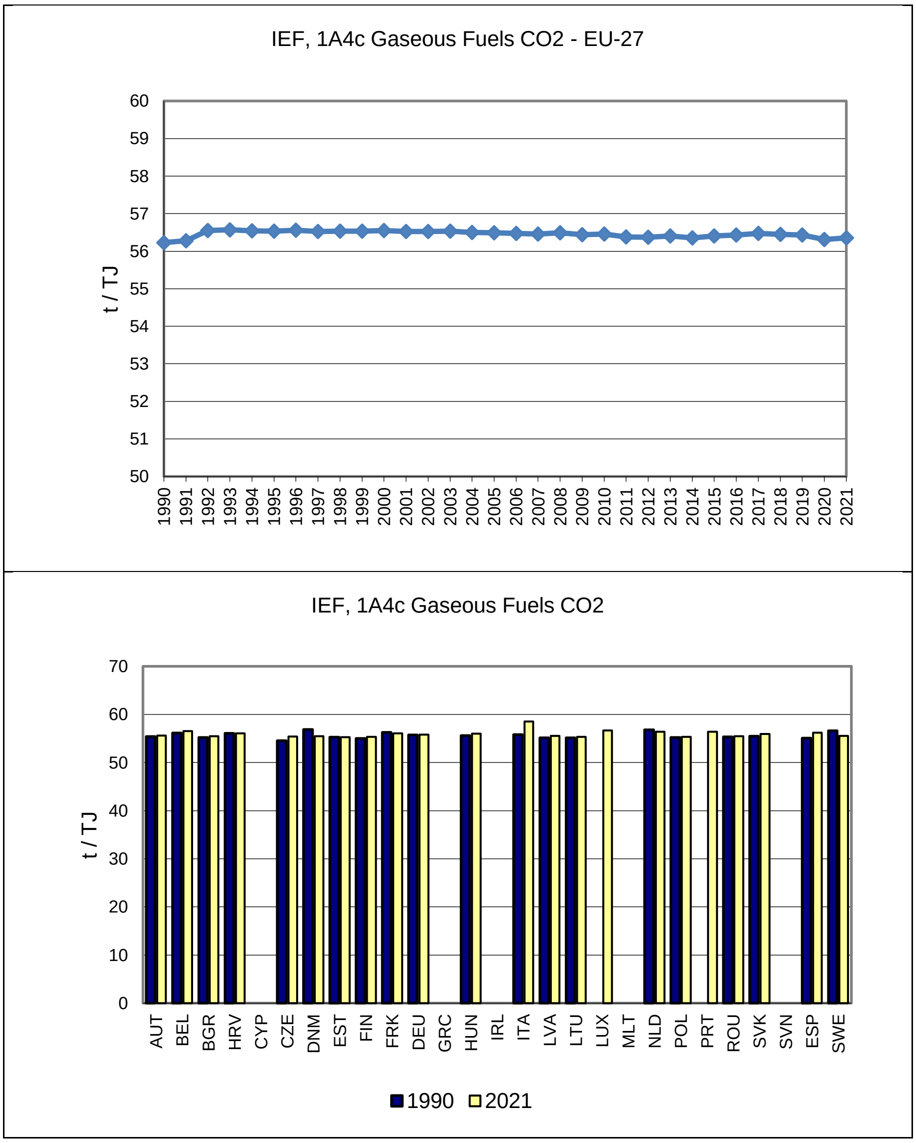


Figure 3.164 1.A.4.c Agriculture/Forestry/Fisheries, gaseous fuels: Implied Emission Factors for CO_2 (in t/TJ)



3.2.5 Other (CRF Source Category 1.A.5.)

Source category 1.A.5. Other includes emissions from stationary and mobile military fuel use including aircraft. In 2021, category 1.A.5 contributed to 6 947 kt CO_2 equivalents of which 99.2 % is CO_2, 0.2 % CH_4 and 0.6 % N_2O.

Table 3.89: Key source categories for level and trend analyses and share of MS emissions using higher tier methods for sector 1.A.5. (Table excerpt)

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
1.A.5.a Other Other Sectors: Solid Fuels (CO_2)	5955	8	T	0	0	99.5 %
1.A.5.b Other Other Sectors: Liquid Fuels (CO_2)	8086	2284	T	L	0	83 %

Table 3.90 provides an overview of Member States' source allocation to Source Category 1.A.5 Other as reported in CRF Table1.A(a)s4.

Table 3.90 1.A.5. Other: Member States' allocation of sources

Member State	Source allocation to 1.A.5 Other
Austria	Stationary: Emissions are 'Not occurring' Mobile: Military use
Belgium	Stationary: Emissions are 'Not occurring' Mobile: Military use
Bulgaria	Stationary: Emissions are 'Not occurring' Mobile: Military aviation
Croatia	Stationary: Emissions are 'Not occurring' Mobile: Emissions are 'Not occurring' or 'Included elsewhere' (emissions from military aviation component and military water-borne component are reported under 1.A.3.b)
Cyprus	Stationary: Emissions reported from Liquid Fuels Mobile: aviation component
Czechia	Stationary: Emissions are 'Not occurring' Mobile: Other mobile sources not included elsewhere, Agriculture and Forestry and Fishing (emissions from aviation besides the public air transport, it is consumption of aviation fuels in the army in the state institutions (aerial vehicles from Integrated rescue system), or private air transport)
Denmark	Stationary: Emissions are 'Not occurring' Mobile: Military use, Recreational crafts
Estonia	Emissions are 'Not occurring'
Finland	Stationary: Includes emissions from non-specified consumption of fuels, military use and statistical corrections of fuel consumption Mobile: Emissions are 'Not occurring' or 'Included elsewhere' (emissions and fuel consumptions of all fuels from category 1A5b is reported in 1A5a due to confidentiality)
France	Stationary: Other non specified Mobile: Emissions are 'Not occurring' or 'Included elsewhere' (under 1.A.5.a)
Germany	Stationary: Military use Mobile: Military use
Greece	Stationary: Emissions are 'Not occurring' Mobile: Other (not specified elsewhere)
Hungary	Stationary: Military use – Emissions from Gaseous Fuels Mobile: Military use – Emissions from Liquid Fuels
Ireland	Stationary: Emissions are 'Included elsewhere' (under 1.A.4.a) Mobile: Emissions are 'Included elsewhere' (under 1.A.3)
Iceland	Stationary: Other (not specified elsewhere) Mobile: Emissions are 'Not occurring'
Italy	Stationary: Emissions are 'Not occurring' Mobile: Military use
Latvia	Stationary: Emissions are 'Not occurring' Mobile: Aviation gasoline, diesel oil and jet kerosene, used in aircrafts and ships
Lithuania	Stationary: Emissions are 'Not occurring' Mobile: Military use
Luxembourg	Stationary: Building and Plant Site Fuel Powered Machinery. Emissions are reported for 1990-2003 and 'Not occurring' from 2004 on. Mobile: Military Vehicles
Malta	Stationary: Emissions are 'Not occurring' Mobile: Military use
Netherlands	Stationary: Emissions are 'Not occurring' Mobile: military use
Poland	Stationary: Emissions are 'Included elsewhere' (without specification of allocation) Mobile: Emissions are 'Not occurring'

Member State	Source allocation to 1.A.5 Other
Portugal	Stationary: Emissions are ‘Not occurring’ Mobile: Military aviation
Romania	Stationary: Other sectors - Not elsewhere specified Mobile: Emissions are ‘Included elsewhere’ (under 1.A.5.a)
Slovakia	Stationary: Other, emissions from fuel combustion in stationary sources that are not specified elsewhere Mobile: Military use Jet Kerosene, Gasoline, Diesel Oil
Slovenia	Stationary: Emissions are ‘Not occurring’ Mobile: Military use
Spain	Stationary: Emissions are ‘Not occurring’ or ‘Included elsewhere’ (Included in 1.A.4.a.i - Military reference activity data are not separated from civil data, and their emissions are estimated together with the same methodology) Mobile: Military use
Sweden	Stationary: Emissions are ‘Not occurring’ Mobile: Emissions are ‘Included elsewhere’

Figure 3.165 shows the total trend within source category 1.A.5 and the dominating emission sources: CO_2 emissions from 1.A.5.b Mobile and from 1.A.5.a Stationary. Total GHG emissions of source category 1.A.5 decreased by 68 % between 1990 and 2021. Germany has the biggest influence on the overall trend; it reports minus 92 % of CO_2 emissions since 1990 and contributes to 45 % in 1990. The German NIR states that only military sources (incl. aircraft) are included in its inventory. Since 2014, the main contributor is France; contributing together 31 % of CO_2 emissions in 2021. France includes in this category other non-specified sources from its national energy balance.

Figure 3.165 1.A.5 Other: Total and CO_2 emission and activity trends

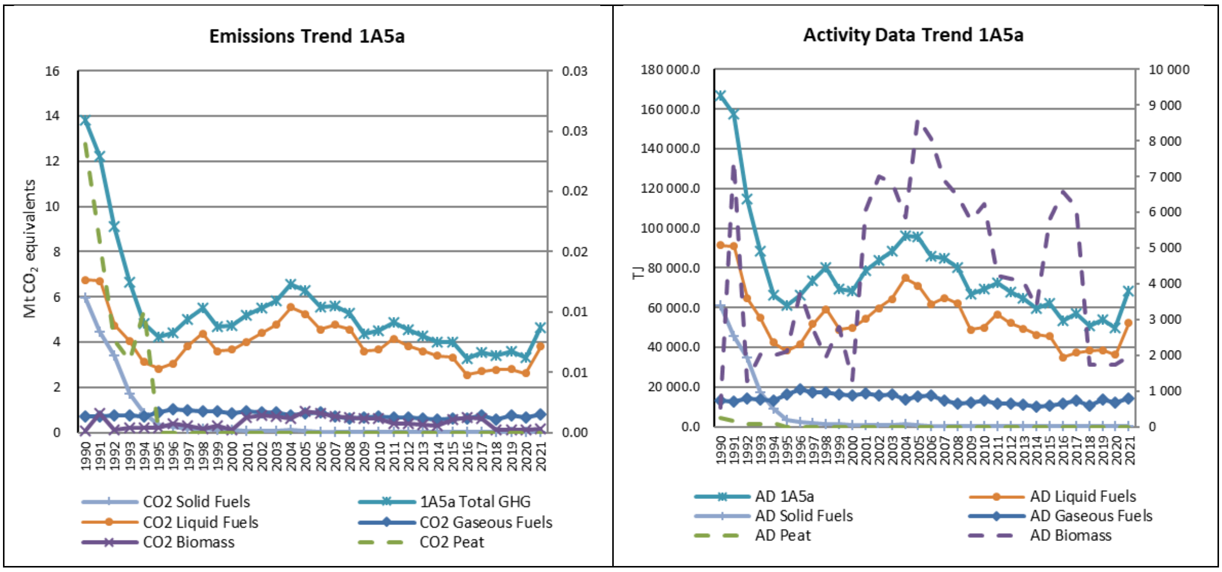


Table 3.91 shows total GHG and CO_2 emissions by Member State from 1.A.5. CO_2 emissions from 1.A.5 Other accounted for 0.3 % of total EU GHG emissions in 1.A in 2021. Between 1990 and 2021, CO_2 emissions from this source decreased by 68 % in the EU. Between 1990 and 2021, the largest reduction in absolute terms was reported by Germany, which was partly due to reduced military operations after German reunification.

Table 3.91 1.A.5. Other: Member States' contributions to CO_2 emissions

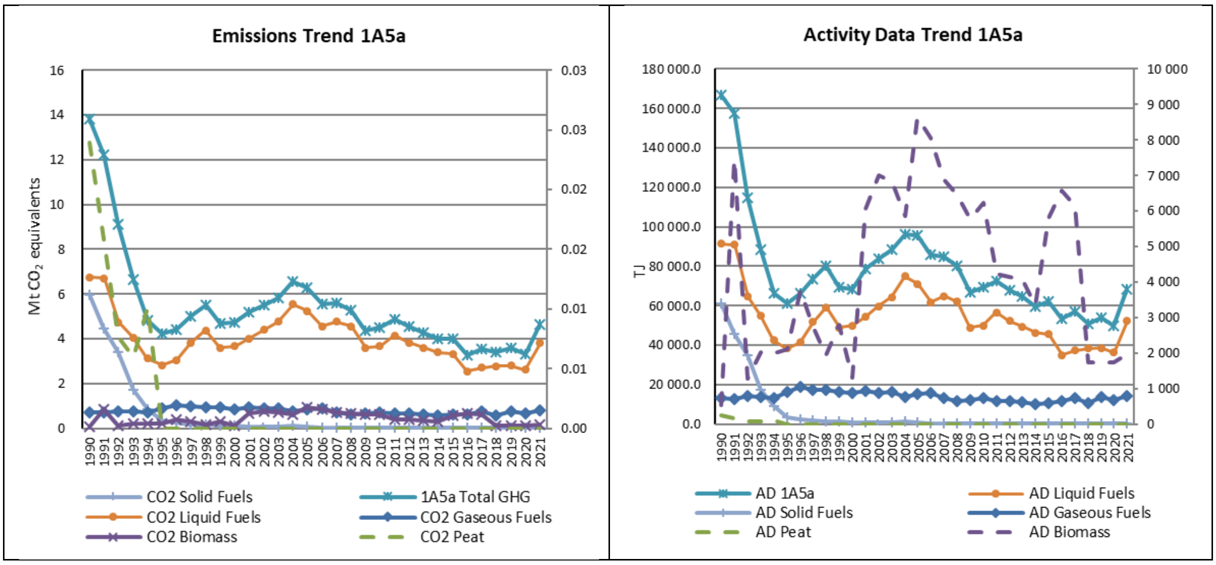
Member State	GHG emissions in kt CO2 equivalents		CO2 emissions in kt	
	1990	2021	1990	2021
Austria	36	30	35	30
Belgium	173	106	172	104
Bulgaria	86	1	86	1
Croatia	IE,NO	IE,NO	NO,IE	NO,IE
Cyprus	11	23	11	23
Czechia	194	319	192	316
Denmark	171	221	167	219
Estonia	NO	NO	NO	NO
Finland	1 138	799	1 126	792
France	4 499	2 145	4 464	2 131
Germany	12 132	986	11 765	980
Greece	IE,NO	36	NO,IE	36
Hungary	15	106	15	106
Ireland	IE	IE	IE	IE
Italy	1 136	307	1 071	299
Latvia	NE,NO	24	NO,NE	24
Lithuania	0	27	0	27
Luxembourg	3	0	3	0
Malta	1	3	1	3
Netherlands	320	167	314	164
Poland	IE,NO	IE,NO	NO,IE	NO,IE
Portugal	97	73	96	73
Romania	1 230	1 103	1 222	1 100
Slovakia	479	64	476	63
Slovenia	32	5	32	5
Spain	300	400	298	397
Sweden	IE,NO	IE,NO	NO,IE	NO,IE
EU-27	**22 053**	**6 947**	**21 545**	**6 891**

Croatia reports that 'military aviation component and military water-borne component' are included in 1.A.3.b.
Ireland reports that emissions of military use stationary combustion are included in 1.A.4.a and that emissions from 1.A.5.b military are included in 1.A.3
Poland reports emissions from stationary combustion as 'IE' without specification of the allocation.
Abbreviations explained in the Chapter 'Units and abbreviations'.

3.2.5.1 Stationary (1.A.5.a)

In this chapter information about emission trends, Member States' contribution, activity data, and emission factors is provided for category 1.A.5.a by fuels. CO_2 emissions from 1.A.5.a Stationary accounted for 0.2 % of total GHG emissions in 1.A in 2021. Figure 3.166 shows the emission trend within the categories 1.A.5.a, which is mainly dominated by CO_2 emissions from solid and liquid fuels for 1990 to 1993 and dominated by liquid fuels from 1994 on. The reduction in the early 1990s was driven by CO_2 from solid fuels. Total emissions decreased by 66 %, mainly due to decreases in emissions from solid fuels (-99.9 %) and liquid fuels (-44 %).

Figure 3.166 1.A.5.a Stationary: Total and CO_2 emission and activity trends



Data displayed as dashed line refers to the secondary axis.

Only seven Member States and Iceland reported emissions from this key source in 2021 (Table 3.92). Luxembourg reported emissions for 1990 - 2003. Hungary reports emissions since 2015. Between 1990 and 2021, Germany reported the highest absolute decrease which also affected overall decreasing trend. Between 2020 and 2021 CO_2 emissions increased by 40 %, mainly because of the increase of emissions in France and Romania.

Table 3.92 1.A.5.a Stationary: Member States' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	NO	NO	NO	-	-	-	-	-	NA	NA
Belgium	NO	NO	NO	-	-	-	-	-	NA	NA
Bulgaria	NO	NO	NO	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	11	22	19	0%	8	71%	-3	-13%	T1	D
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	1 126	709	792	17%	-335	-30%	83	12%	T2	CS
France	4 464	1 475	2 131	46%	-2 334	-52%	656	44%	CS,T1	CS,D
Germany	6 227	373	464	10%	-5 763	-93%	92	25%	CS	CS
Greece	NO	NO	NO	-	-	-	-	-	NA	NA
Hungary	NO,IE	42	49	1%	49	∞	7	16%	T1,T2	CS,D
Ireland	IE	IE	IE	-	-	-	-	-	NA	NA
Italy	NO	NO	NO	-	-	-	-	-	NA	NA
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	3	NO	NO	-	-3	-100%	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	IE	IE	IE	-	-	-	-	-	NA	NA
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	1 222	620	1 100	24%	-122	-10%	480	77%	T1,T2	CS,D
Slovakia	406	57	52	1%	-354	-87%	-5	-9%	T2	CS
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**13 459**	**3 298**	**4 606**	**100%**	**-8 853**	**-66%**	**1 309**	**40%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.
Spain reports, that military reference activity data are not separated from civil data and that those emissions are estimated together in 1.A.4.a.i by applying the same methodology.
Ireland reports that emissions of military use stationary combustion are included in 1.A.4.a.
Poland reports the emissions under category 1.A.4.c.

1.A.5.a Stationary – Solid Fuels (CO_2)

In 2021 CO_2 from solid fuels had a share of 0.1 % within source category 1.A.5.a (compared to 44 % in 1990). Between 1990 and 2021, CO_2 emissions decreased by nearly 100 % (Table 3.93). In 2021, only Germany, Slovakia and Hungary reported emissions for this key category. The main reason for the strong decline of emissions in the early 1990s was the closure of military barracks after the German reunification and the phase out of coal use for combustion in buildings.

Ireland reports that emissions of military use stationary combustion are included in 1.A.4.a. Spain reports, that military reference activity data are not separated from civil data and that those emissions are estimated together in 1.A.4.a.i by applying the same methodology.

According to the methodology as described in chapter 3.2.1 99.5 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.93 1.A.5.a Stationary, solid fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	NO	NO	NO	-	-	-	-	-
Belgium	NO	NO	NO	-	-	-	-	-
Bulgaria	NO	NO	NO	-	-	-	-	-
Croatia	NO	NO	NO	-	-	-	-	-
Cyprus	NO	NO	NO	-	-	-	-	-
Czechia	NO	NO	NO	-	-	-	-	-
Denmark	NO	NO	NO	-	-	-	-	-
Estonia	NO	NO	NO	-	-	-	-	-
Finland	1	NO	NO	-	-1	-100%	-	-
France	NO	NO	NO	-	-	-	-	-
Germany	4 553	4	5	58.7%	-4 548	-100%	1	38%
Greece	NO	NO	NO	-	-	-	-	-
Hungary	NO	2	2	28.1%	2	∞	0	0%
Ireland	IE	IE	IE	-	-	-	-	-
Italy	NO	NO	NO	-	-	-	-	-
Latvia	NO	NO	NO	-	-	-	-	-
Lithuania	NO	NO	NO	-	-	-	-	-
Luxembourg	NO	NO	NO	-	-	-	-	-
Malta	NO	NO	NO	-	-	-	-	-
Netherlands	NO	NO	NO	-	-	-	-	-
Poland	IE	IE	IE	-	-	-	-	-
Portugal	NO	NO	NO	-	-	-	-	-
Romania	1 184	NO	NO	-	-1 184	-100%	-	-
Slovakia	216	1	1	13.2%	-215	-99%	0	-26%
Slovenia	NO	NO	NO	-	-	-	-	-
Spain	IE	IE	IE	-	-	-	-	-
Sweden	NO	NO	NO	-	-	-	-	-
EU-27	**5 955**	**7**	**8**	**100%**	**-5 946**	**-100%**	**1**	**13.2%**

Abbreviations explained in the Chapter 'Units and abbreviations'.
Note: The information on methodologies and emission factors is not available from the CRF/XML on fuels level.

Figure 3.167 shows CO_2 emissions for EU. Germany accounts for 59 % of EU CO_2 emissions from this source category. Fuel consumption in the EU decreased by 43 % between 1990 and 2021. The CO_2 implied emission factor for solid fuels was 97.48 t/TJ in 2021.

Figure 3.167 1.A.5.a Stationary, solid fuels: Emission trend and share for CO_2

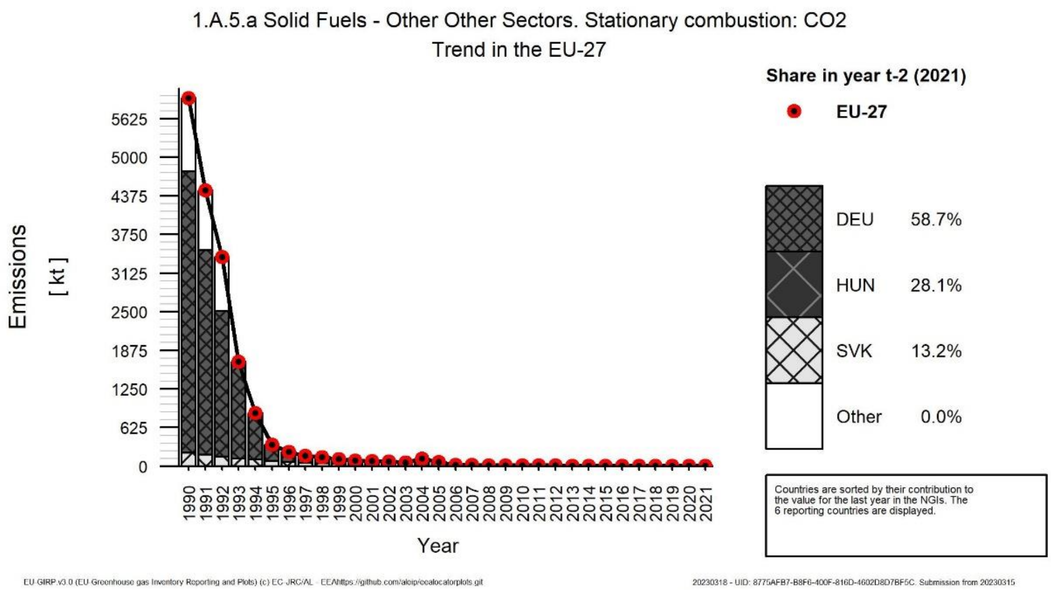
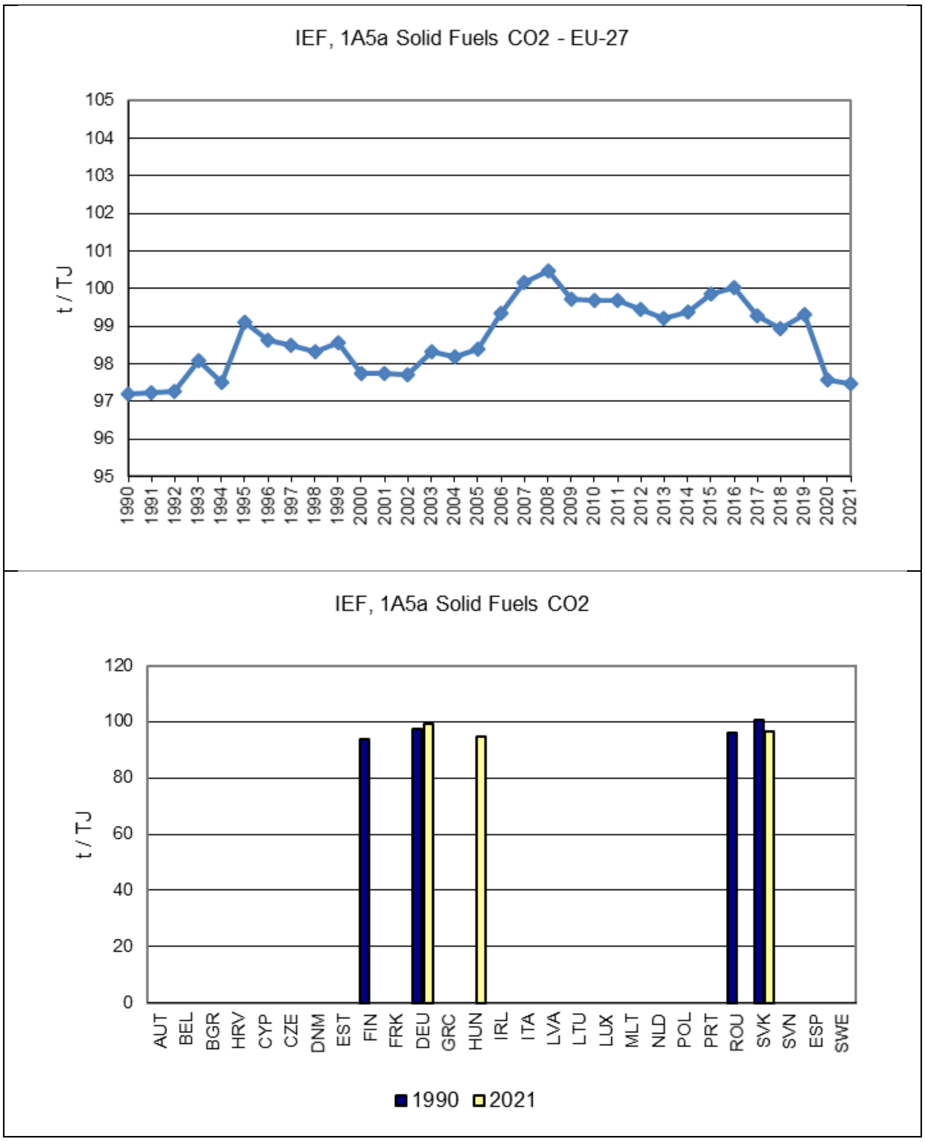


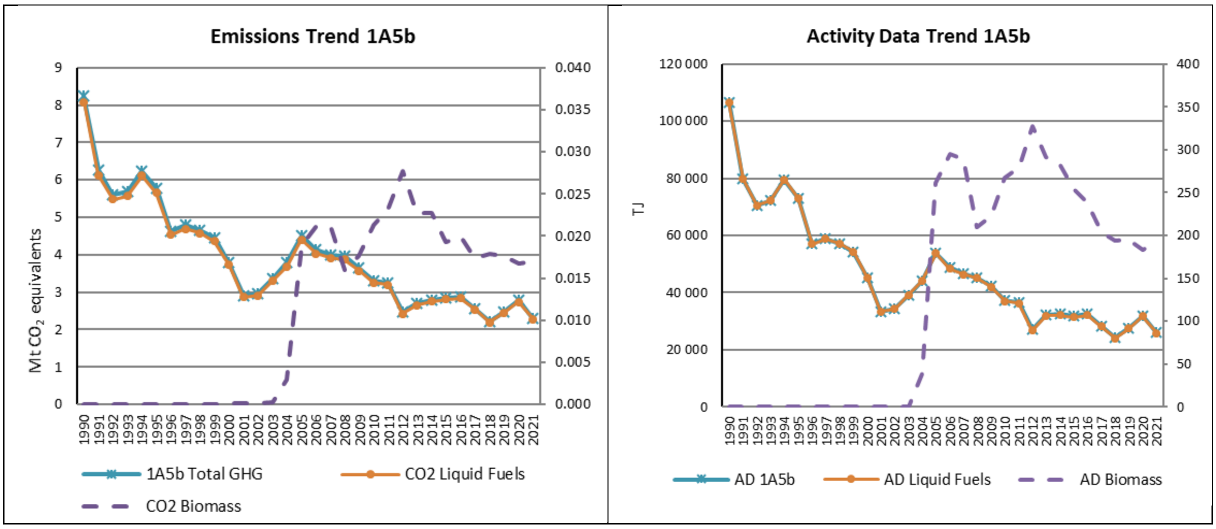
Figure 3.168 1.A.5.a Stationary, solid fuels: Implied Emission Factors for CO_2 (in t/TJ)



3.2.5.2 Mobile (1.A.5.b)

In this chapter information about emission trends, Member States' contribution and activity data is provided for category 1.A.5.b by fuels. CO_2 emissions from 1.A.5.b Mobile accounted for 0.1 % of total EU GHG emissions in 1.A in 2021. Figure 3.169 shows the emission trend within the category 1.A.5.b, which is dominated by CO_2 emissions from liquid fuels. Total CO_2 emissions decreased by 72 %.

Figure 3.169 1.A.5.b Mobile: Total and CO_2 emission trends



Data displayed as dashed line refers to the secondary axis.

Eight Member States reported emissions as ‘Not occurring’ or ’Included elsewhere‘. Germany had the highest share on emissions in 2021 and – together with Italy decreased the most in absolute terms between 1990 and 2021. The EU emissions decreased by 17 % between 2020 and 2021.

“Included elsewhere” often indicates, that the country reports these emissions under 1.A.3 Transport or 1.A.5.a.

Table 3.94 1.A.5.b Mobile: Member States’ contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	35	33	30	1.3%	-5	-15%	-3	-10%	T1,T2	CS,D
Belgium	172	104	104	4.6%	-68	-39%	0	0%	CS,T1,T3	D
Bulgaria	86	1	1	0.0%	-85	-99%	0	-8%	T1	D
Croatia	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Cyprus	NO	5	4	0.2%	4	∞	-1	-14%	T1	D
Czechia	192	312	316	13.8%	124	64%	4	1%	T1	D
Denmark	167	238	219	9.6%	52	31%	-19	-8%	CR,M,T2	CS
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
France	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Germany	5 538	370	516	22.6%	-5 022	-91%	146	39%	CS,D,M	CS,D
Greece	NO,IE	296	36	1.6%	36	∞	-260	-88%	T1	D
Hungary	15	31	57	2.5%	42	291%	25	80%	T2	CS
Ireland	IE	IE	IE	-	-	-	-	-	NA	NA
Italy	1 071	625	299	13.1%	-772	-72%	-326	-52%	T2	CS
Latvia	NO,NE	15	24	1.0%	24	∞	9	62%	T1	D
Lithuania	0	28	27	1.2%	27	7420%	-1	-2%	T2	CS
Luxembourg	0	0	0	0.0%	0	-13%	0	1%	T1,T2	CS,D
Malta	1	4	3	0.1%	2	300%	-1	-22%	T1	D
Netherlands	314	161	164	7.2%	-150	-48%	4	2%	T2	CS
Poland	NO	NO	NO	-	-	-	-	-	NA	NA
Portugal	96	66	73	3.2%	-23	-24%	7	10%	T1	D
Romania	IE	IE	IE	-	-	-	-	-	NA	NA
Slovakia	70	11	11	0.5%	-59	-84%	0	1%	T1	CS,D
Slovenia	32	3	5	0.2%	-27	-86%	1	45%	T1	D
Spain	298	435	397	17.4%	99	33%	-39	-9%	CR,T1,T2	CS,D
Sweden	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
EU-27	**8 086**	**2 739**	**2 285**	**100%**	**-5 801**	**-72%**	**-454**	**-16.6%**	**-**	**-**

Croatia reports emissions from military aviation and navy in category 1.A.3.b.
Finland reports emissions from military activities as 'IE' for reasons of confidentiality.
France and Romania report emissions in category 1.A.5.a
Ireland reports emission from military activities in category 1.A.3.
Abbreviations explained in the Chapter 'Units and abbreviations'.

1.A.5.b Mobile – Liquid Fuels (CO_2)

In 2021, CO_2 from liquid fuels had a share of 99.9 % within source category 1.A.5.b (compared to 100 % in 1990). Between 1990 and 2021 CO_2 decreased by 72 % (Table 3.95 **1.A.5.b Mobile, liquid** fuels: Member States' contributions to CO2 emissions). Eight Member States and Iceland reported emissions as 'Not occurring' or 'Included Elsewhere' in 2021. The highest decrease in absolute terms was achieved in Germany while Czechia and Spain had the largest increases.

According to the methodology as described in chapter 3.2.1 about 83 % of EU emissions are calculated by using higher tier methods in 2021.

Table 3.95 1.A.5.b Mobile, liquid fuels: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	35	33	30	1.3%	-5	-15%	-3	-10%
Belgium	172	104	104	4.6%	-68	-39%	0	0%
Bulgaria	86	1	1	0.0%	-85	-99%	0	-8%
Croatia	IE	IE	IE	-	-	-	-	-
Cyprus	NO	5	4	0.2%	4	∞	-1	-14%
Czechia	192	312	316	13.8%	124	64%	4	1%
Denmark	167	238	219	9.6%	52	31%	-19	-8%
Estonia	NO	NO	NO	-	-	-	-	-
Finland	IE	IE	IE	-	-	-	-	-
France	IE	IE	IE	-	-	-	-	-
Germany	5 538	370	515	22.6%	-5 022	-91%	146	39%
Greece	IE	296	36	1.6%	36	∞	-260	-88%
Hungary	15	31	57	2.5%	42	291%	25	80%
Ireland	IE	IE	IE	-	-	-	-	-
Italy	1 071	625	299	13.1%	-772	-72%	-326	-52%
Latvia	NE	15	24	1.0%	24	∞	9	62%
Lithuania	0	28	27	1.2%	27	7420%	-1	-2%
Luxembourg	0	0	0	0.0%	0	-13%	0	1%
Malta	1	4	3	0.1%	2	300%	-1	-22%
Netherlands	314	161	164	7.2%	-150	-48%	4	2%
Poland	NO	NO	NO	-	-	-	-	-
Portugal	96	66	73	3.2%	-23	-24%	7	10%
Romania	IE	IE	IE	-	-	-	-	-
Slovakia	70	11	11	0.5%	-59	-84%	0	1%
Slovenia	32	3	5	0.2%	-27	-86%	1	45%
Spain	298	435	397	17.4%	99	33%	-39	-9%
Sweden	IE	IE	IE	-	-	-	-	-
EU-27	**8 086**	**2 738**	**2 284**	**100%**	**-5 802**	**-72%**	**-454**	**-16.6%**

*Information on methods and emission factors are identical with those described in Table **3.94** as emissions from this source only occur in liquid fuels*
Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.170 shows CO_2 emissions for EU and the Member States. It can be seen that the highest share on total CO_2 emissions (above the average share calculated for EU) correspond to Germany, Spain, Czechia, Italy and Denmark; together they cause 77 % of the CO_2 emissions from liquid fuels in 1.A.5.b. Fuel consumption in the EU decreased by 76 % between 1990 and 2021. The CO_2 implied emission factor for liquid fuels was 88.26 t/TJ in 2021. The IEF is comparably high because Spain reports activity data as confidential. This also explains the increasing trend of the EU IEF because the share of Spain in EU emissions increased from 2 % in 1990 to 17 % in 2021.

Figure 3.170 1.A.5.b Mobile, liquid fuels: Emission trend and share for CO_2

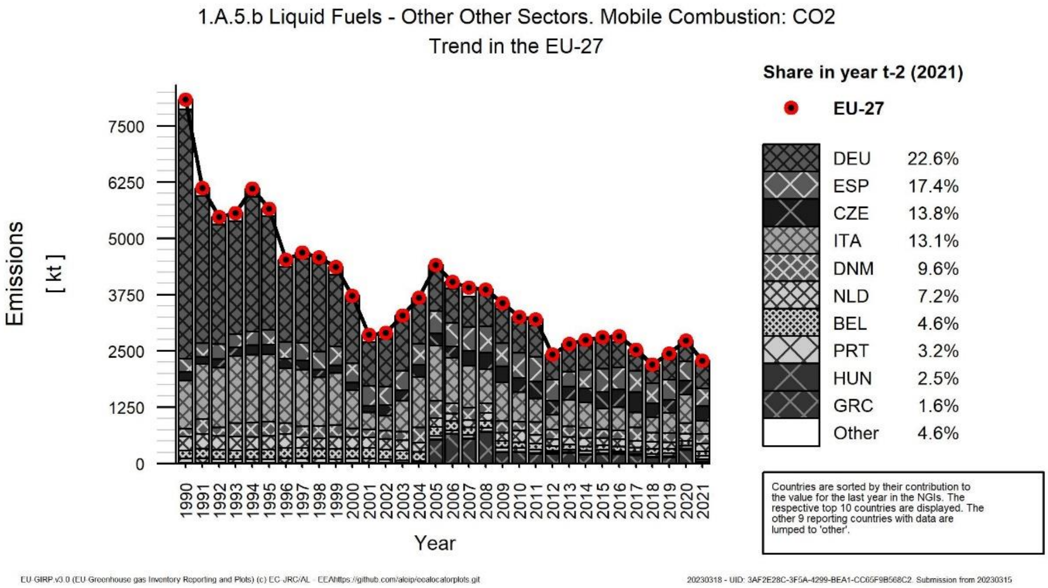
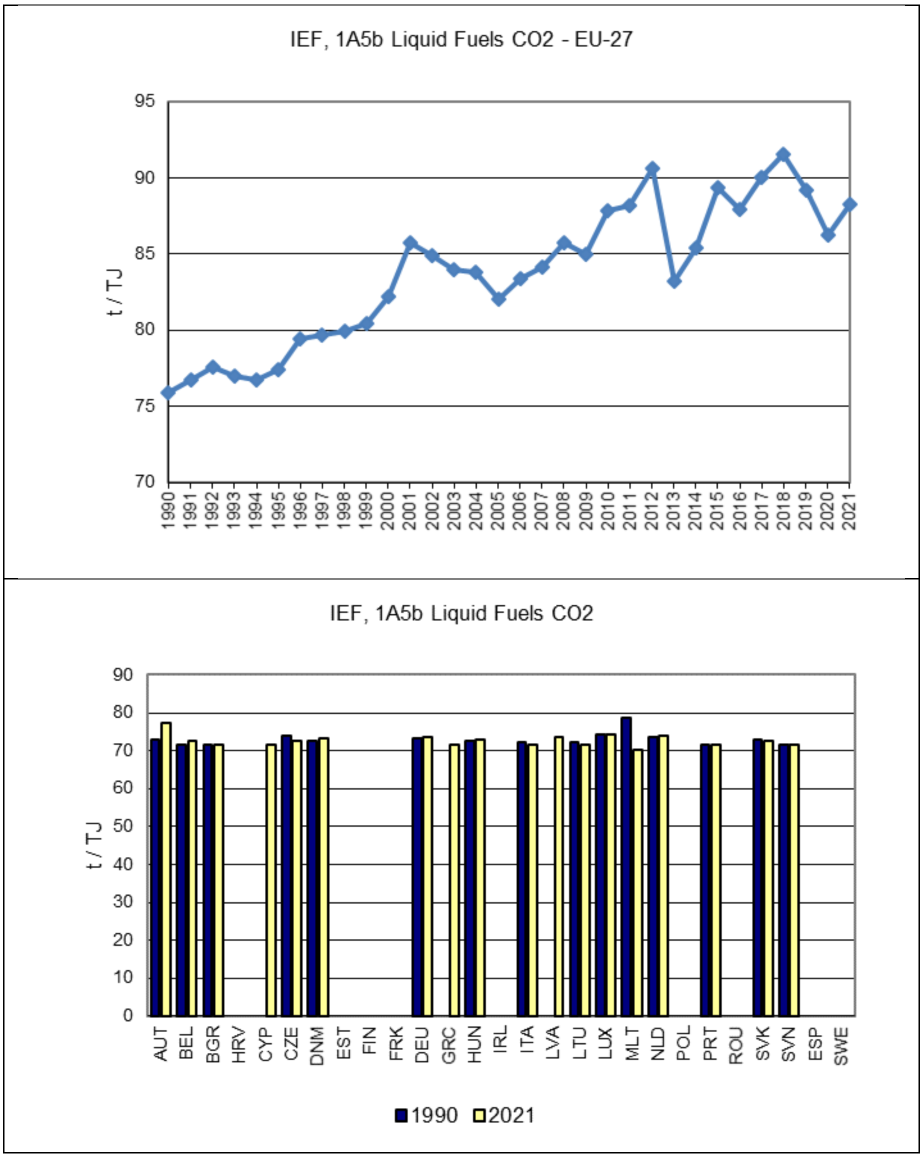


Figure 3.171 1.A.5.b Mobile, liquid fuels: Implied Emission Factors for CO_2 (in t/TJ)

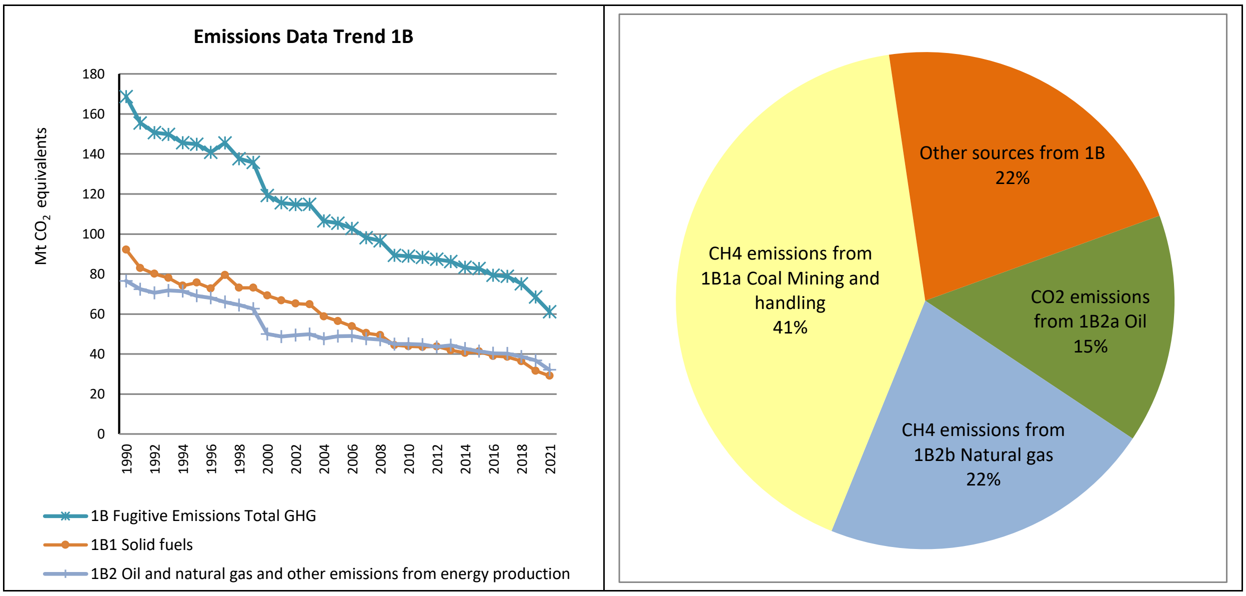


3.2.6 Fugitive emissions from fuels (CRF Source Category 1.B)

This chapter describes gaseous or volatile emissions, which occur during extraction, handling and consumption of fossil fuels. In the 2006 IPCC Guidelines fugitive emissions are defined as intentional or unintentional releases of gases from anthropogenic activities that in particular may arise from the production, processing, transmission, storage and use of fuels. Emissions from combustion are only included where it does not support a productive activity (e.g., flaring of natural gases at oil and gas production facilities). Evaporative emissions from vehicles are included under Road Transport as Subsection 1A3b v (2006 IPCC Guidelines).

In 2021, in terms of CO_2 equivalents, about 71 % of emissions from source category 1.B were fugitive CH_4 emissions while 29 % were fugitive CO_2 emissions. Together, they represent 1.8 % of total GHG emissions in the EU. Fugitive GHG emissions have been steadily declining (Figure 3.172). Between 1990 and 2021, the total fugitive GHG emissions decreased by 64 %. This was mainly due to the decrease in underground mining activities: CH_4 emissions from underground mining activities have decreased by 72 % since 1990 (Figure 3.175) and decreases in CH_4 emissions from category 1B1a1i underground mines are responsible for 45 % of the total decrease of fugitive emissions. Between 1990 and 2021, GHG emissions from 1.B.1 Solid Fuels decreased by 68 % Figure 3.173), while emissions from 1.B.2 Oil and Natural Gas decreased only by 58 % (Figure 3.173). While emissions from 1.B.1 Solid Fuels and 1.B.2 Oil and Natural Gas each were responsible for roughly 55 % (1.B.1) and 45 % (1.B.2) of total fugitive emissions in 1990, fugitive emissions from 1.B.1 Solid Fuels represented only 48 % of total fugitive emissions in 2021 (Figure 3.172).

Figure 3.172 1.B Fugitive Emission from Fuel: GHG Emissions trend and proportion of fugitive emissions within source category in 2021



Fugitive emissions include four key sources:

Table 3.96: Key source categories for level and trend analyses and share of countries emissions using higher tier methods in sector 1.B (table excerpt)

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
1.B.1.a Coal Mining and Handling: Operation (CH_4)	84944	25414	T	L	L	71 %
1.B.2.a Oil: Operation (CH_4)	6901	777	T	L	0	39 %
1.B.2.a Oil: Operation (CO_2)	8593	9126	T	L	L	74 %
1.B.2.b Natural Gas: Operation (CH_4)	46325	13321	T	L	L	72 %

The two largest key sources (CH_4 emissions from 1.B.1.a Coal Mining and Handling and 1.B.2.b Natural Gas) account together for 63 % of total fugitive GHG emissions (Figure 3.172).

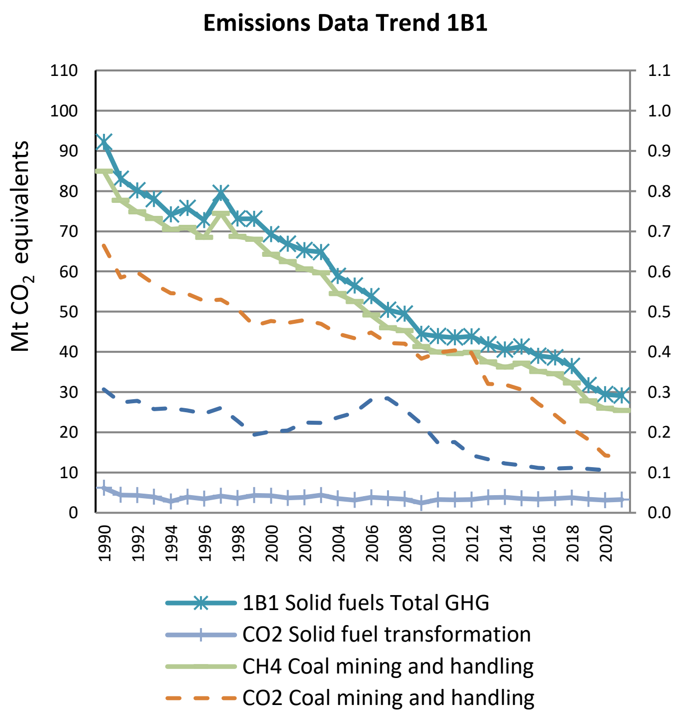
3.2.6.1 Fugitive emissions from Solid Fuels (1.B.1)

In the 2006 IPCC Guidelines fugitive emissions from solid fuels are defined as the intentional or unintentional release of greenhouse gases that may occur during the extraction, processing and delivery of fossil fuels to the point of final use. Combustion emissions from colliery methane recovered and used are excluded here and reported under Fuel Combustion Emissions. Coal mining data reported to the IEA include also peat extraction, which is not included in the CRF. Five countries (Denmark, Estonia, Finland, Latvia and Lithuania) have peat extraction but no coal mining.

In 2021 fugitive emissions from solid fuels accounted for 0.9 % of the total GHG emissions in the EUand 48 % of total fugitive emissions:

- 88 % of fugitive emissions from solid fuels were CH_4 emissions from coal mining. The emissions arise due to the natural production of methane when coal is formed. Methane is partly stored within the coal seam and escapes when mined. Most CH_4 emissions resulted from underground mines; surface mines were a smaller source,
- 12 % of fugitive emissions from solid fuels were emissions due to solid fuel transformation,
- Since 1990 fugitive CH_4 emissions from 1.B.1 Solid fuels have been steadily decreasing, caused by the reduction of coal mining activities.

Figure 3.173 1.B.1 Fugitive Emissions from Solid Fuels: Trend



Note: Data displayed as dashed line refers to the secondary axis.

In 2021 three countries, Poland, Czechia and Romania represented 90 % of total fugitive GHG emissions from solid fuels (Table 3.97).

Table 3.97 1.B.1 Fugitive Emissions from Solid Fuels: Countries Contribution

Member State	GHG emissions in kt CO_2 equivalents		CO2 emissions in kt		CH_4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021
Austria	373	NA,IE,NO	NO,IE,NA	NO,IE,NA	373	NO,IE,NA
Belgium	485	44	0	NO,NA	484	44
Bulgaria	2 244	906	64	23	2 180	883
Croatia	67	NA,NO	NO	NO	67	NO
Cyprus	NO	NO	NO	NO	NO	NO
Czechia	12 638	1 933	456	51	12 181	1 882
Denmark	NO	NO	NO	NO	NO	NO
Estonia	NO	NO	NO	NO	NO	NO
Finland	NO	NO	NO	NO	NO	NO
France	5 387	10	NO,NA	NO,NA	5 387	10
Germany	30 453	794	1 833	634	28 620	159
Greece	1 266	302	NO	NO	1 266	302
Hungary	1 188	39	7	7	1 181	32
Ireland	62	20	NO	NO	62	20
Italy	148	28	0	NO,NA	148	28
Latvia	NA,NO	NA,NO	NO	NO	NO	NO
Lithuania	NO	NO	NO	NO	NO	NO
Luxembourg	NO	NO	NO	NO	NO	NO
Malta	NO	NO	NO	NO	NO	NO
Netherlands	123	76	110	71	12	5
Poland	27 896	18 290	4 188	2 449	23 707	15 841
Portugal	160	17	3	NO	157	17
Romania	6 571	5 955	NA,NO	NO,NA	6 571	5 955
Slovakia	781	229	19	13	762	216
Slovenia	505	313	101	113	404	200
Spain	1 832	124	18	98	1 815	27
Sweden	5	9	5	9	0.003	0.005
EU-27	**92 183**	**29 090**	**6 805**	**3 469**	**85 378**	**25 622**

Abbreviations explained in the Chapter 'Units and abbreviations'
Austria includes emissions from 1.B.1.b – production of coke oven coke – in 1.A.2.a Iron and Steel
Hungary reports fugitive methane emissions released during coal mining and handling under sector 1.A.2. Fugitive emissions from solid fuel transformation are included in sector 1.A.1.c.

Nearly all fugitive CH_4 emissions from solid fuels originate from coal mining and handling (1B1a). Between 1990 and 2021 these emissions decreased by 70 % (Table 3.98). Large reductions (in absolute terms) were observed in Germany, Czechia and Poland (Table 3.97).

CH_4 recovery from coal mining

Romania is the only country that reports CH_4 recovery in category 1.B.1.a.1i (Mining activities) in the EU in 2021. The recovered CH_4 from Lupeni and Vulcan mines are used for energy purposes for the housework of the workers colonies and this information is included in '1.B.1.a Coal Mining and Handling, 1.B. 1.a.1 Underground Mines, 1.B.1.a.1.i Mining Activities, Recovery / Flaring CH_4' category. [ROU NIR, 2023]

Slovakia has reported CH_4 recovery in category 1.B.1.a.1 only for the reporting years 2007-2014. Emissions from cogeneration of mine gas are reported as other biogas from one facility in the category 1.A.1.c – Manufactured of Solid Fuels and Other Energy Industries. [SVK NIR 2023]

CH_4 from Coal Mining (1.B.1.a)

Fugitive emissions from coal mining correspond to the total emissions from:

- underground mining (emissions from underground mines, brought to the surface by ventilation systems),
- surface mining (emissions primarily from the exposed coal surfaces and coal rubble, but also emissions associated with the release of pressure on the coal),
- post-mining (emissions from coal after extraction from the ground, which occur during preparation, transportation, storage, or final crushing prior to combustion),
- abandoned underground mines.

CH_4 emissions from 1.B.1.a coal-mining accounted for 0.8 % of total GHG emissions in 2021 and for 42 % of all fugitive emissions in the EU-27. CH_4 emissions from this source decreased by 70 % in the EU-27 between 1990 and 2021 and also a decrease by -2 % between 2020 and 2021 due to decreases in Poland, Romania, Slovenia and Greece (Table 3.98). In 2021 Bulgaria, Czechia, Poland, Romania and Greece accounted together for 96 % of CH_4 emissions from 1.B.1.a. They had substantially reduced their emissions between 1990 and 2021 due to the decline of coal mining (Figure 3.90).

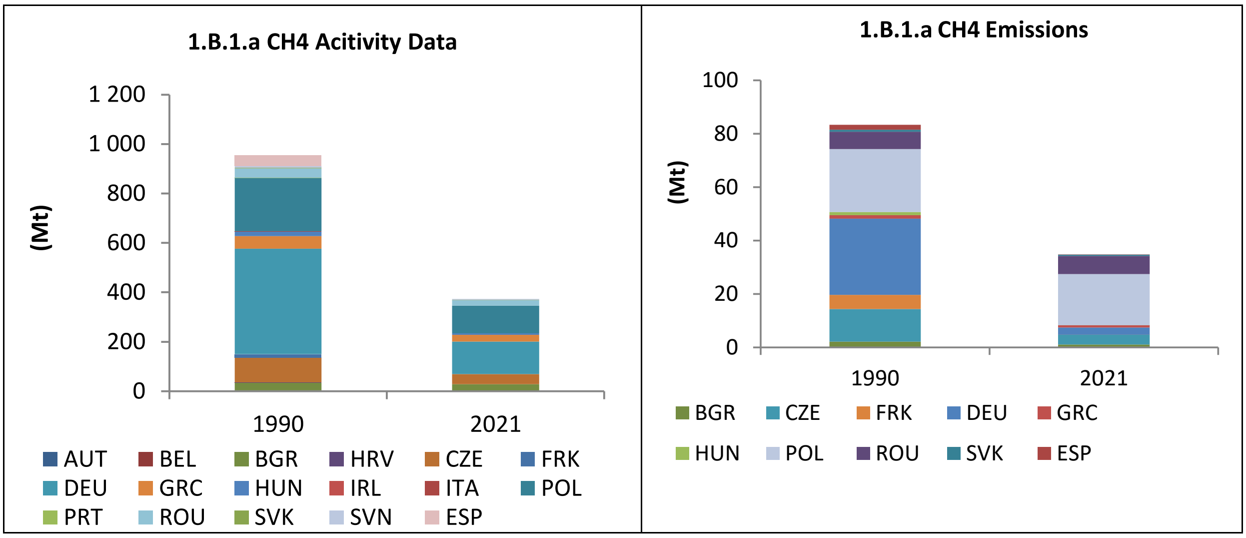
Table **3.98** shows that 71 % of EU emissions are calculated using higher tier methods. In cases where countries report a mix of Tier 1 and higher Tier methods (BRG, CZE, HUN, POL, ROU) only emissions from subcategories of sector 1.B.1.a were taken into account, where the countries actually apply a higher tier method, according to the IPCC 2006 Guidelines.

Table 3.98 1.B.1.a Coal Mining: Countries contribution to CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27	Change 1990-2021		Change 2020-2021		Method	Emission factor
	1990	2020	2021	Emissions in 2021	kt CO2 equiv.	%	kt CO2 equiv.	%		Informa-tion
Austria	373	NO,NA	NO,NA	-	-373	-100%	-	-	NA	NA
Belgium	443	45	44	0.2%	-399	-90%	0	-1%	D	D
Bulgaria	2 163	751	881	3.5%	-1 282	-59%	130	17%	T1,T2	CS,D
Croatia	67	NO	NO	-	-67	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	12 181	1 884	1 877	7.4%	-10 304	-85%	-7	0%	T1,T2	CS,D
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	5 354	11	1	0.0%	-5 353	-100%	-10	-88%	T2,T3	CS,PS
Germany	28 554	103	105	0.4%	-28 449	-100%	2	2%	T2,T3	CS
Greece	1 266	343	302	1.2%	-963	-76%	-40	-12%	T1	D
Hungary	1 181	32	31	0.1%	-1 150	-97%	-1	-3%	T1,T2	CS,D
Ireland	62	20	20	0.1%	-43	-69%	0	-1%	T1	D
Italy	59	9	8	0.0%	-51	-87%	-1	-8%	T2	D
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	23 581	16 122	15 733	61.9%	-7 848	-33%	-390	-2%	T1,T2	D
Portugal	157	17	17	0.1%	-140	-89%	0	-1%	NO	NO
Romania	6 524	6 117	5 955	23.4%	-569	-9%	-162	-3%	T1,T2	D
Slovakia	762	197	213	0.8%	-549	-72%	16	8%	T2	CS
Slovenia	404	242	200	0.8%	-204	-51%	-42	-18%	T2,T3	CS,D,PS
Spain	1 815	30	27	0.1%	-1 788	-99%	-3	-11%	CS,T2	CS
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**84 944**	**25 923**	**25 414**	**100%**	**-59 531**	**-70%**	**-510**	**-2%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.174 1.B.1.a Coal Mining and Handling: Contribution of countries to CH_4 emission and activity data



CH_4 from Underground mines (1.B.1.a.1)

In 2021, 85% of fugitive emissions from coal mines were due to underground mines. Within the EU coal mining in underground mines decreased substantially between 1990 and 2021 (-77 %) (Table **3.99** and Figure 3.175). Largest decreases of CH_4 emissions in absolute terms were observed in Germany (-99.8 %). In Germany, emissions from this source have been decreasing due to decreases in utilizable extracted quantities and increases in pit-gas utilization since 2001 (DEU NIR 2023).

Poland contributing to 67.2 % of methane emissions from this source applies a Tier 2 method based on direct measurements and calculations (POL NIR 2023). Romania has a share of 25.7 % of CH_4 emissions from this source. 99% of CH_4 emissions from this category arise from subcategory 1B1aiii (abandoned coalmines), which is calculated with a Tier 2 methodology of the 2006 IPCC Guidelines (ROU NIR 2023). A Tier 2 method including country specific emission factors is applied by the Czechia, which is contributing 3.4 % of methane emissions to this source (CZE NIR 2023) (Table **3.99**). For detailed information on countries methodologies please see Annex III.

Table 3.99 1.B.1.a.1 Coal Mining – underground mining: Countries contribution to CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	335	NO,NA	NO,NA	-	-335	-100%	-	-	NA	NA
Belgium	443	45	44	0.2%	-399	-90%	0	-1%	D	D
Bulgaria	1 484	208	191	0.9%	-1 293	-87%	-16	-8%	T2	CS
Croatia	67	NO	NO	-	-67	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	9 140	727	723	3.4%	-8 417	-92%	-3	0%	T1,T2	CS,D
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	5 302	11	1	0.0%	-5 300	-100%	-10	-88%	T2,T3	CS,PS
Germany	28 444	70	66	0.3%	-28 378	-100%	-4	-6%	T3	CS
Greece	NO	NO	NO	-	-	-	-	-	NA	NA
Hungary	1 181	31	31	0.1%	-1 150	-97%	0	-1%	T1	D
Ireland	62	20	20	0.1%	-43	-69%	0	-1%	T1	D
Italy	22	9	8	0.0%	-14	-65%	-1	-8%	T2	D
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	21 933	15 001	14 456	67.2%	-7 477	-34%	-545	-4%	T1,T2	D
Portugal	157	17	17	0.1%	-140	-89%	0	-1%	NO	NO
Romania	5 915	5 761	5 529	25.7%	-386	-7%	-232	-4%	T1,T2	D
Slovakia	762	197	213	1.0%	-549	-72%	16	8%	T2	CS
Slovenia	404	242	200	0.9%	-204	-51%	-42	-18%	T2,T3	CS,D,PS
Spain	1 814	30	27	0.1%	-1 787	-99%	-3	-11%	CS,T2	CS
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**77 464**	**22 368**	**21 526**	**100%**	**-55 939**	**-72%**	**-843**	**-4%**	**-**	**-**

Figure 3.175 1.B.1.a.1.i Mining activities - Underground Mines: Emission trend and share for EU-28 and the emitting countries of CH_4

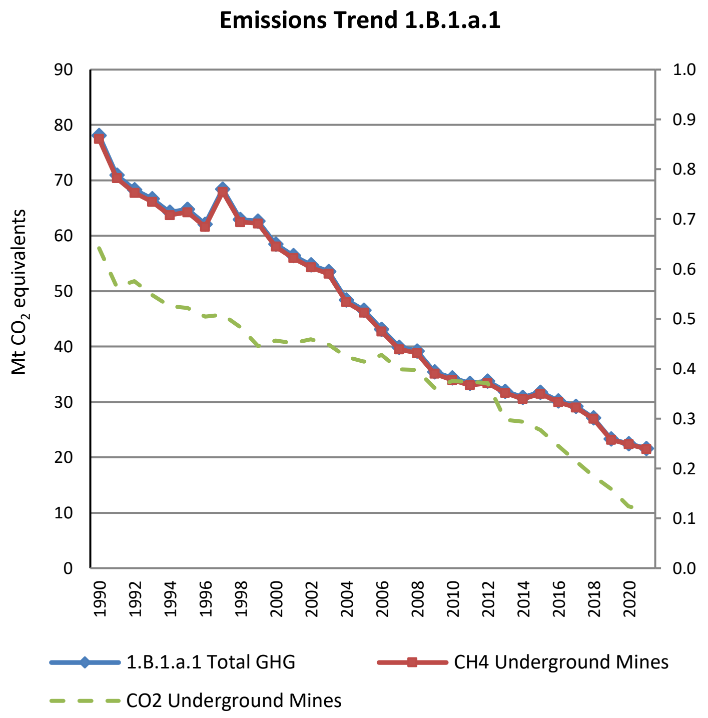


Figure 3.176 shows the implied emission factor of the EU and also the implied emission factor for each Member State for CH_4 emissions in 1B1a1i – underground mines, mining activities, which are responsible for 56 % of total GHG emissions from 1.B.1.a.1. The decrease of the implied emission factor is caused by the closure of underground mining in Germany. Between 1990 and 2018, Germany is calculating emissions from this source applying a Tier 3 methodology, which results in a higher emission factor, compared to the IEF of other countries; from 2019 onwards, Germany reports CH_4 emissions from this source as not occurring, which results in a decrease of the EU implied emission factor (see DEU NIR 2023).

Figure 3.176: 1.B.1.a.1.i Mining activities – Underground mines - Implied Emission Factors for CH_4 (in kg/t)

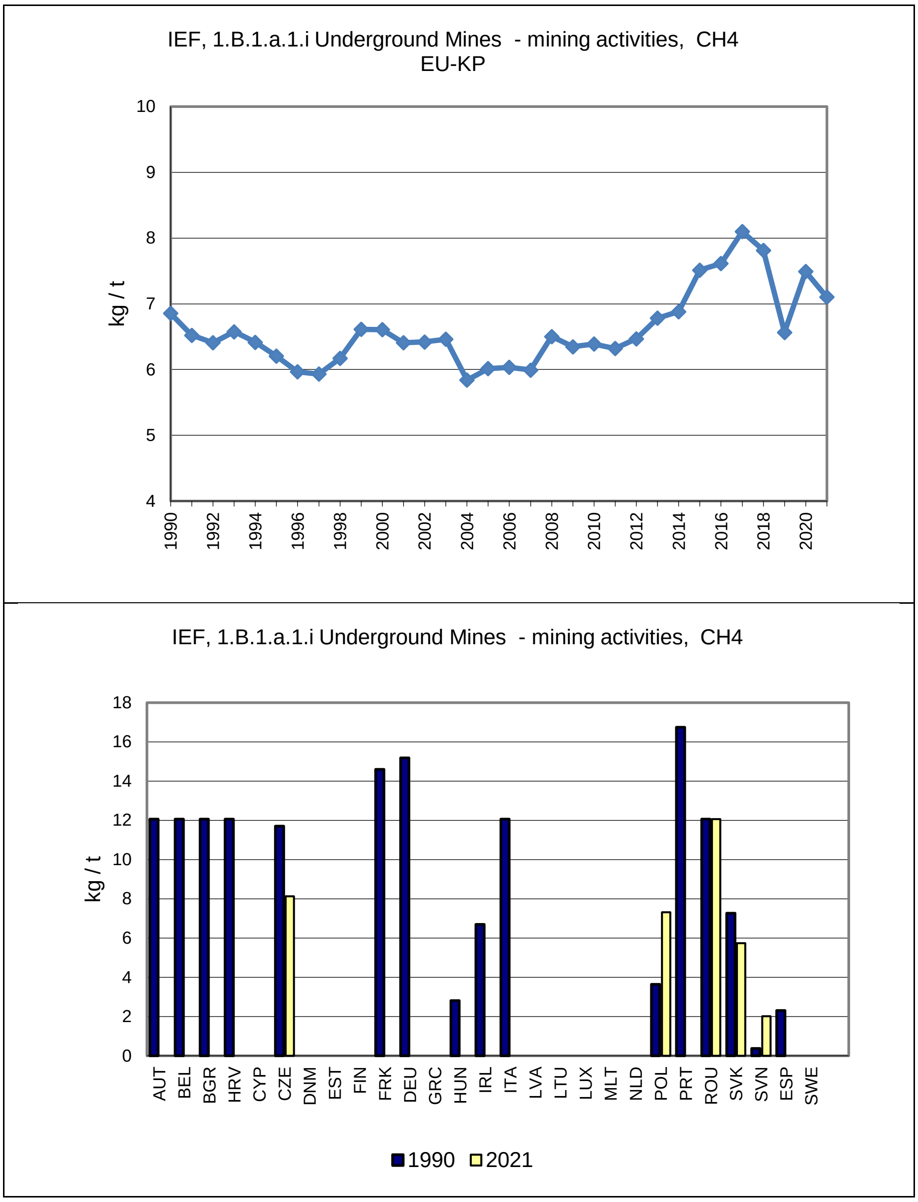
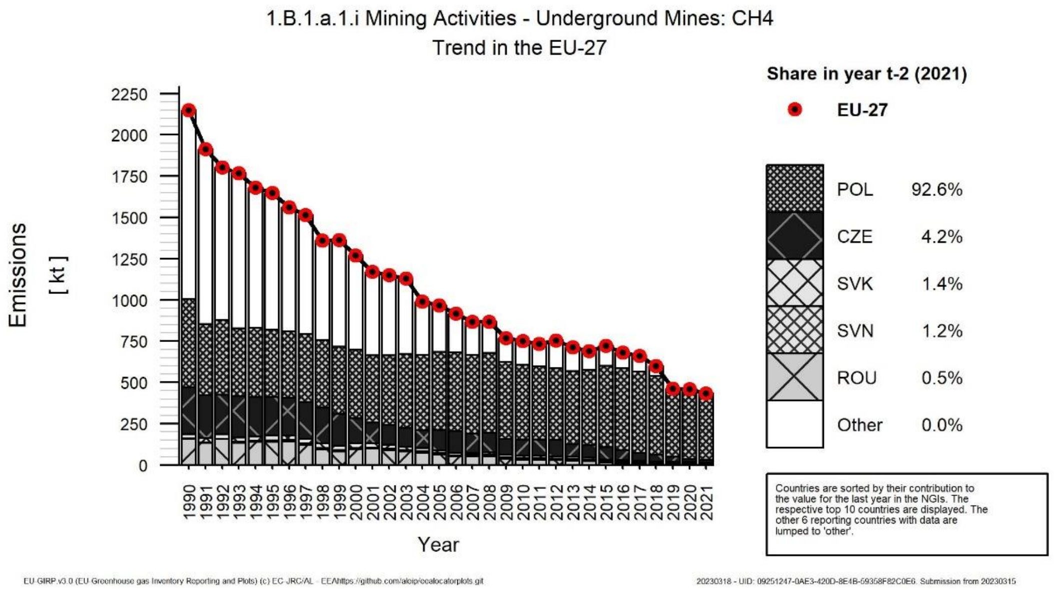


Figure 3.177 1.B.1.a.1.i Mining activities - Surface Mines: Emission trend and share for the emitting countries of CH_4



CH_4 from Surface mines (1.B.1.a.2)

In 2021, only 15% of emissions from coal mining originate from surface mining. Overall, CH_4 emissions from the coal production of surface mines decreased by 48 % between 1990 and 2021 (Table **3.100** and Figure 3.178).

Czechia shows the largest decrease of methane emissions in absolute terms between 1990 and 2021 (- 1 887 kt CO_2 equ.), which is caused by the closure of mines (CZE NIR 2023).

Together, Czechia and Poland account for 62.5% of emissions from this source. Both apply a Tier 1 methodology with a default emission factor as methane emissions from surface mining represents only a minor source of methane emissions from coal mining in Poland - 8 % of total emissions from coal mining arise from category 1.B.1.a.2, whereas the share in Czechia is 61 %. For detailed information on countries methodologies please see Annex III. (Table **3.100**).

Table 3.100 1.B.1.a.2 Coal Mining – surface mining: Countries contribution to CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	38	NO	NO	-	-38	-100%	-	-	NA	NA
Belgium	NO	NO	NO	-	-	-	-	-	NA	NA
Bulgaria	679	544	690	17.7%	11	2%	146	27%	T1,T2	D
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	3 040	1 157	1 153	29.7%	-1 887	-62%	-4	0%	T1	D
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	53	NO	NO	-	-53	-100%	-	-	NA	NA
Germany	110	33	39	1.0%	-71	-65%	6	18%	T2	CS
Greece	1 266	343	302	7.8%	-963	-76%	-40	-12%	T1	D
Hungary	NO	1	0	0.0%	0	∞	-1	-83%	T2	CS
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	37	NO	NO	-	-37	-100%	-	-	NA	NA
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	1 648	1 121	1 277	32.8%	-371	-23%	155	14%	T1	D
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	609	356	426	11.0%	-182	-30%	70	20%	T1	D
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	1	NO	NO	-	-1	-100%	-	-	NA	NA
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**7 480**	**3 555**	**3 888**	**100%**	**-3 592**	**-48%**	**333**	**9%**	**-**	**-**

Figure 3.178 1.B.1.a.2.i Mining activities - Surface Mines: Emission trend and share for the emitting countries of CH_4

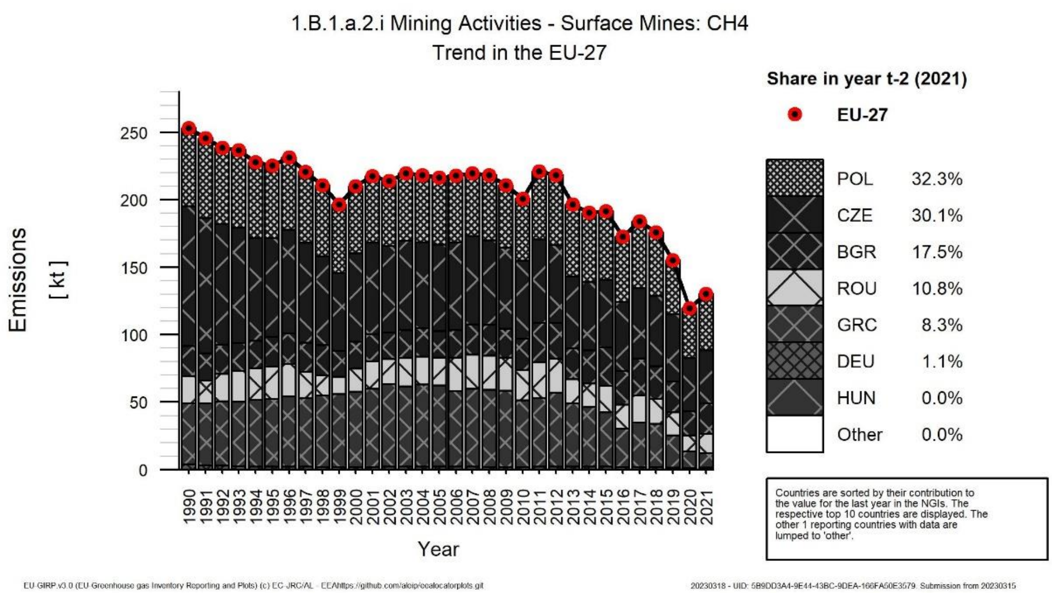
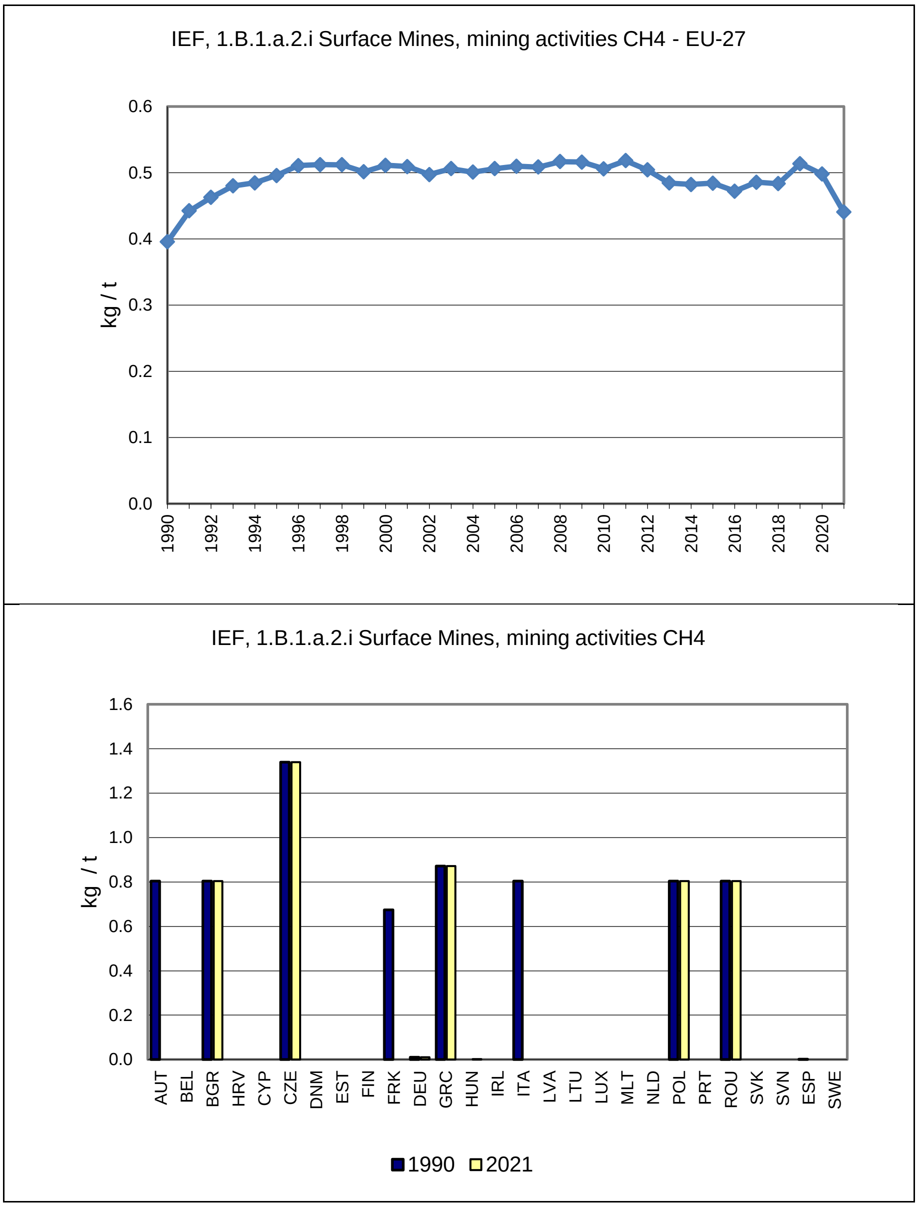


Figure **3.172** shows the Implied Emission factor of the EU and also the implied Emission factor for each Member State for CH_4 emissions in 1.B.1.a.2.i – mining activities from surface mines, which are responsible for 94 % of total GHG emissions from 1.B.1.a.2.

Czechia applies the upper default emission factor from the IPCC 2006 Guidelines, which explains the outlier in Figure 3.179 (lower figure). Germany's low emission factor is caused by the application of a

Tier 2 method with a country specific emission factor for CH_4 from this source (0.015m³ CH_4/t). According to the German NIR, emission factors from the IPCC 2006 Guidelines cannot be applied to German lignite, as it does not exceed a temperature of 50°C during the coalification process, while significant methane releases occur only at temperatures higher than 80°C (for detailed information see Annex III of the EU GHG inventory and German NIR, 2023).

Figure 3.179: 1.B.1.a.2.i Mining activities – Surface mines - Overview of outliers of Implied Emission Factors for CH_4 (in kg/t)



Emissions from Other (1.B.1.c)

Poland and Sweden both report CH_4 and CO_2 emissions in this sector. Sweden additionally reports N_2O emissions. Slovenia reports CO_2 emissions in this subcategory. The description of the subcategories is presented inTable 3.101.

Table 3.101 Description of subcategories in sector 1.B.1c for CO_2- and CH_4-emissions for reporting countries

Member state	Emission	Subcategory
Poland	CO_2, CH_4	Emissions from Coke Oven Gas Subsystem
Slovenia	CO_2	SO_2 scrubbing

Sweden	CO_2, CH_4, N_2O	Flaring of gas

3.2.6.2 Fugitive emissions from oil and natural gas (1.B.2)

Fugitive emissions from oil and natural gas correspond to the total fugitive emissions from oil and natural gas activities. Fugitive emissions may arise from equipment leaks, evaporation losses, venting, flaring and accidental releases (2006 IPCC Guidelines).

Fugitive emissions from 1.B.2 Oil and natural gas include all emissions from exploration, production, processing, transport, and handling of oil and natural gas. They account for 1 % of the total GHG emissions in 2021 and for 52 % (Figure 3.180) of all fugitive emissions in the EU.

Of all fugitive emissions from oil and natural gas, in 2021:

- 42 % were CH_4 emissions from natural gas (exploration, production, processing, transport and distribution)
- 28 % were CO_2 emissions from oil (exploration, production, transport, refining and storage and distribution)
- 9 % were CO_2 emissions from venting and flaring
- 7 % were CH_4 emissions from venting and flaring
- 6 % were CO_2 emissions due to Other emissions

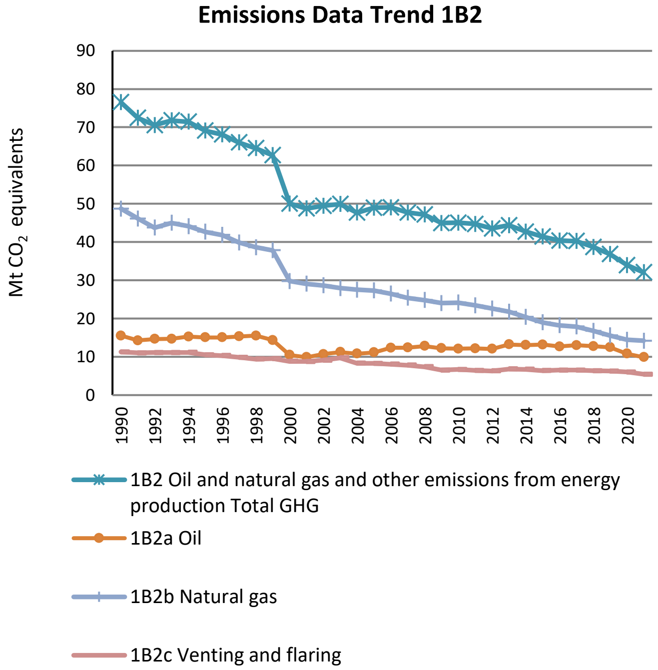
This source category includes three key categories:

Table 3.102: Key source categories for level and trend analyses and share of countries emissions using higher tier methods in sector 1.B.2 (table excerpt)

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
1.B.2.a Oil: Operation (CH_4)	6901	777	T	L	0	39 %
1.B.2.a Oil: Operation (CO_2)	8593	9126	T	L	L	74 %
1.B.2.b Natural Gas: Operation (CH_4)	46325	13321	T	L	L	72 %

Fugitive emissions from oil and natural gas occur in all countries but Malta (Table 3.103). Total greenhouse gas emissions from 1.B.2 decreased by 58 % between 1990 and 2021 (Figure **3.180**). This trend was mainly due to the reduction of fugitive CH_4 emissions from natural gas activities, which decreased by 71 % over that period.

Figure 3.180 1.B.2-Fugitive Emissions Oil and Natural Gas: Trend



In 2021, 55% of all fugitive GHG emissions from oil and natural gas were emitted by four countries: Italy, Poland, Romania and Spain (Table 3.103). The largest reductions (in absolute terms) were observed in Romania and Germany (mainly CH_4 emissions), while emissions increased most in Poland (mainly CH_4 emissions) (Table 3.103).

Table 3.103 1.B.2 Fugitive emissions from oil and natural gas: Countries' contributions

Member State	GHG emissions in kt CO_2 equivalents		CO2 emissions in kt		CH_4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021
Austria	401	331	102	84	299	247
Belgium	892	614	85	99	807	515
Bulgaria	238	844	60	540	177	304
Croatia	986	449	583	284	403	165
Cyprus	0.5	NE,NO	NO,NE	NO,NE	0.5	NO,NE
Czechia	1 198	682	2	4	1 195	679
Denmark	490	172	341	111	149	61
Estonia	72	23	0.1	0.03	72	23
Finland	125	95	111	68	12	27
France	6 402	2 681	4 362	1 755	2 017	919
Germany	12 071	3 032	2 008	1 197	10 061	1 834
Greece	84	163	43	4	41	159
Hungary	2 623	1 921	478	132	2 143	1 789
Ireland	56	82	0.01	0.4	56	82
Italy	14 055	5 680	4 047	1 816	9 997	3 857
Latvia	277	110	0.01	0.01	277	110
Lithuania	321	488	24	218	297	271
Luxembourg	22	34	0.03	0.04	22	34
Malta	NO	NO	NO	NO	NO	NO
Netherlands	2 939	1 464	775	1 052	2 164	413
Poland	1 267	4 779	47	1 834	1 219	2 944
Portugal	58	1 008	54	945	2	62
Romania	27 620	3 484	1 177	753	26 441	2 731
Slovakia	1 919	260	5	1	1 913	259
Slovenia	56	46	0.3	0.1	56	46
Spain	1 934	3 602	1 751	3 413	183	189
Sweden	421	42	331	0.04	89	42
EU-27	**76 527**	**32 088**	**16 386**	**14 307**	**60 095**	**17 760**

Abbreviations explained in the Chapter 'Units and abbreviations'.
AUT: N_2O emissions from venting and flaring are included in 1.A.1.b (petroleum refining)
BEL: N_2O emissions are reported in 1.A.1.b (petroleum refining)
NLD: N_2O emissions from gas transmission are included in 1.A.3.e.i (pipeline transport gaseous fuels)

CH_4 recovery from Oil and Gas

Germany is the only country that describes the recovery of CH_4 emissions in subcategory 1.B.2. These emissions occur in category 1.B.2.c (Venting and Flaring). Gas recovery systems liquify most recovered CH_4 emissions and return them to refining processes or to refinery combustion systems. These emissions are reported under category 1.A.1.b. (DEU NIR 2023)

CO_2 from Oil (1.B.2.a)

Fugitive emissions from oil correspond to fugitive emissions from all sources associated with the exploration, production, transmission, upgrading and refining of crude oil and the distribution of crude oil products (2006 IPCC Guidelines).

CO_2 emissions from 1.B.2.a 'Fugitive emissions from oil' account for 0.3 % of total EU GHG emissions in 2021 and for 15 % of all fugitive emissions. Between 1990 and 2021, CO_2 emissions from this source increased by 6 % in the EU (Table 3.104). By contrast, during the same period 1990-2021, CH_4 emissions of this source category were reduced by 89 %.

Together France, Italy and Spain accounted for 64 % of the EU total CO_2 emissions of 1.B.2.a 'Fugitive CO_2 emissions from oil' (Table 3.104, Figure 3.181). Main contributor to these emissions in all countries is subcategory 1.B.2.a.4 (Oil – Refining/Storage). Spain is applying a Tier 2 methodology with a plant specific emission factor in this subcategory. Italy also applies a Tier 2 methodology for CO_2 emissions from oil refining and storage, while the emission factor is country specific. France uses specific emission factors provided by the plant operator, for other processes, emissions are derived directly from annual emission reports (FRK NIR 2023). For detailed information on countries methodologies please see Annex III. Table **3.104** shows that 74 % of EU CO_2 emissions from this source are calculated using higher tier methods. In cases where countries report a mix of Tier 1 and higher Tier methods (DNM, FRK, DEU, ITA, LTA, NLD, POL, ROU, ESP) only emissions from subcategories of sector 1.B.2.a were considered for the calculation, where the countries actually apply a higher tier method. Countries that report a Tier 1 method but a country specific or plant specific emission factor (HUN, SVK) were calculated as a higher method, according to the IPCC 2006 Guidelines.

During the period 1990-2021, the largest decreases in CO_2 emissions (in absolute terms) were observed in Italy and France. (Table 3.104). Decreasing CO_2 emissions in Italy are mainly driven by the reduction in crude oil losses in refineries (ITA NIR 2023).

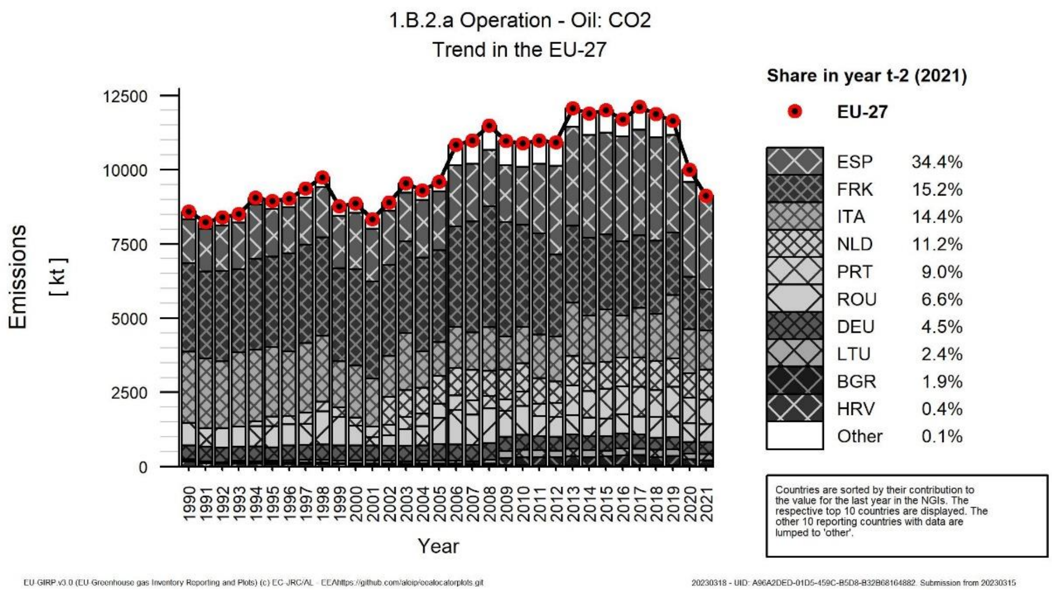
Largest increases between 1990-2021 are reported in the Netherlands, Portugal and Spain (Table 3.104). In all three countries, increases are mainly driven by increases in CO_2 emissions from subcategory 1.B.2.a.4 (Oil – Refining/Storage).

Table 3.104 1.B.2.a Fugitive CO_2 emissions from oil: Countries' contributions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	0.005	0.01	0.005	0.0%	0	5%	0	-3%	T1	D
Belgium	0.01	0.02	0.02	0.0%	0	14%	0	5%	T1	D
Bulgaria	60	211	169	1.9%	110	183%	-42	-20%	T1	D
Croatia	158	37	35	0.4%	-122	-78%	-2	-4%	T1	D
Cyprus	NO,NE	NO,NE	NO,NE	-	-	-	-	-	NA	NA
Czechia	0.02	0.03	0.03	0.0%	0	57%	0	-6%	T1	D
Denmark	5	0.1	0.1	0.0%	-5	-99%	0	-58%	T1,T3	D,PS
Estonia	NO,NE	NO,NE	NO,NE	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	2 983	1 765	1 387	15.2%	-1 596	-54%	-378	-21%	T1,T2,T3	CS,D,PS
Germany	478	393	406	4.5%	-71	-15%	13	3%	T1,T2	CS,D
Greece	0.00004	0.000005	0.000003	0.0%	0	-92%	0	-36%	T1	D
Hungary	5	1	1	0.0%	-5	-89%	0	7%	T1	CS
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	2 402	1 486	1 316	14.4%	-1 086	-45%	-170	-11%	T1,T2	CS,D
Latvia	NO,NA	NO,NA	NO,NA	-	-	-	-	-	NA	NA
Lithuania	23	180	216	2.4%	193	828%	36	20%	T1,T3	D,PS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	0.02	826	1 022	11.2%	1 022	5681062%	196	24%	CS,T1	D,PS
Poland	2	10	10	0.1%	8	449%	-1	-5%	T1	CS,D
Portugal	0	859	819	9.0%	819	192486%	-39	-5%	D	D
Romania	746	636	601	6.6%	-146	-20%	-36	-6%	T1,T3	D,PS
Slovakia	0.03	0.01	0.01	0.0%	0	-79%	0	1%	T1	CS,PS
Slovenia	0.03	0.1	0.1	0.0%	0	143%	0	1%	T1	D
Spain	1 477	3 190	3 144	34.4%	1 667	113%	-46	-1%	T1,T2	D,PS
Sweden	255	402	O,NE,IE,NA	-	-255	-100%	-402	-100%	NA	NA
EU-27	**8 593**	**9 996**	**9 126**	**100%**	**533**	**6%**	**-870**	**-9%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.181 1.B.2.a Oil: Emission trend and share for the emitting countries of CO_2



CH_4 from Oil (1.B.2.a)

CH_4 emissions from 1.B.2.a ‘Fugitive emissions from oil’ account for 0.02 % of total EU GHG emissions in 2021 and for 1.3 % of all fugitive emissions. Between 1990 and 2021, CH_4 emissions from this source decreased by 89 % in the EU (Table 3.104).

Together Romania, Italy and Poland accounted for 62 % of the EU total CH_4 emissions of 1.B.2.a ‘Fugitive CH_4 emissions from oil’ (Table 3.105). In Romania main contributions to CH_4 emissions come from subcategory 1.B.2.a.2 (Oil – Production). From 1990 to 2000 CH_4 emissions are estimated using a Tier 1 methodology with a default emission factor for developing countries of the 2006 IPCC Guidelines. From 2000 on the country applies a Tier 1 methodology with a default emission factor for developed countries, due to change of technology (ROU NIR 2022). This also explains the outlier in ***Figure 3.182***. For detailed information on countries methodologies please see Annex III.

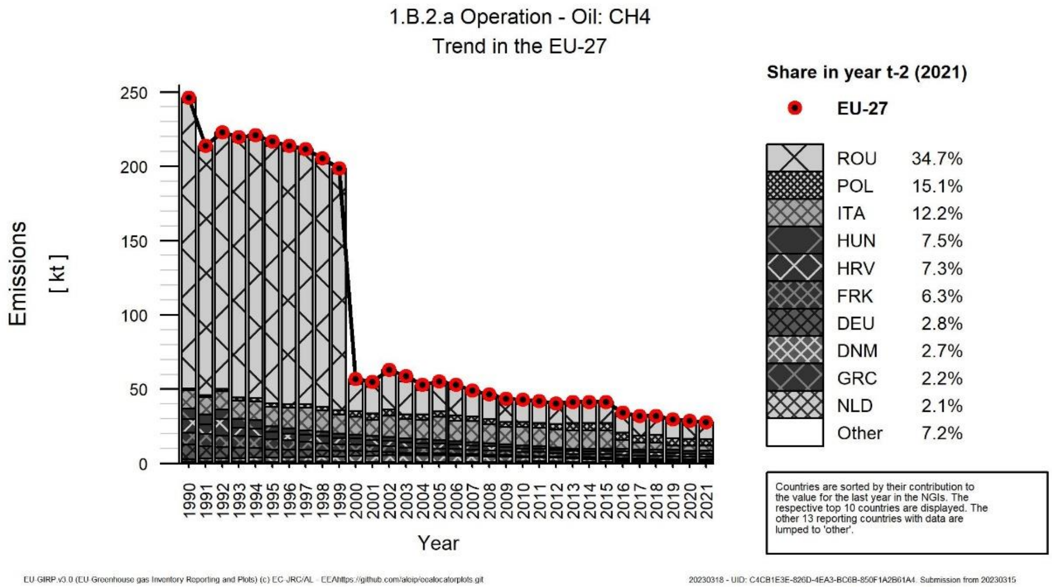
During the period 1990-2021, the largest decreases in CH_4 emissions (in absolute terms) were observed in Romania, caused by significant decreases in oil production (-95% in Romania). In the same period of time, emissions increased most in Poland due to an increase of 297 % in 1.B.2.a.2 - oil production (Table 3.105).

Table 3.105 1.B.2.a Fugitive CH_4 emissions from oil: Countries' contributions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	8	9	9	1.1%	0	4%	0	0%	T1	D
Belgium	13	8	8	1.0%	-5	-37%	0	-4%	CS,D	CS,D
Bulgaria	14	7	6	0.8%	-8	-56%	-1	-11%	T1	D
Croatia	247	59	56	7.3%	-190	-77%	-3	-4%	T1	D
Cyprus	0.5	NO,NE	NO,NE	-	0	-100%	-	-	NA	NA
Czechia	11	6	7	0.9%	-5	-42%	1	15%	T1,T2	CS,D
Denmark	48	21	21	2.7%	-27	-57%	0	-2%	T1,T2,T3	S,D,OTH,PS
Estonia	NO,NE	NO,NE	NO,NE	-	-	-	-	-	NA	NA
Finland	7	9	9	1.2%	2	34%	0	0%	T1	D
France	230	49	49	6.3%	-181	-79%	0	1%	T1,T2,T3	CS,D,PS
Germany	271	19	22	2.8%	-249	-92%	3	16%	T1,T2	CS,D
Greece	11	16	17	2.2%	6	56%	1	6%	T1	D
Hungary	200	56	58	7.5%	-142	-71%	2	4%	T1	CS
Ireland	0.2	0.4	0.4	0.1%	0	68%	0	7%	T1	D
Italy	347	97	95	12.2%	-252	-73%	-2	-3%	T1,T2	CS,D
Latvia	NO,NA	NO,NA	NO,NA	-	-	-	-	-	NA	NA
Lithuania	5	3	2	0.3%	-2	-50%	0	-6%	T1	D
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	23	18	16	2.1%	-6	-29%	-1	-8%	T1,T1b	D
Poland	39	127	117	15.1%	78	199%	-10	-8%	T1	CS,D
Portugal	2	2	2	0.2%	0	-9%	0	-12%	CR,OTH	CR,OTH
Romania	5 389	280	269	34.7%	-5 119	-95%	-11	-4%	T1	D
Slovakia	17	9	8	1.0%	-8	-51%	-1	-11%	T1,T3	CS,PS
Slovenia	0.4	0.000005	0.000003	0.0%	0	-100%	0	-42%	T1	D
Spain	4	3	3	0.4%	-1	-28%	0	-1%	T1	D
Sweden	14	11	1	0.2%	-12	-91%	-10	-89%	T1	D
EU-27	**6 901**	**809**	**777**	**100%**	**-6 123**	**-89%**	**-32**	**-4%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.182: 1.B.2.a Oil: Emission trend and share for the emitting countries of CH_4



CH_4 from Natural gas (1.B.2.b)

Fugitive emissions from natural gas correspond to emissions from all fugitive sources associated with the exploration, production, processing, transmission, storage and distribution of natural gas (associated and non-associated gas) (2006 IPCC Guidelines).

CH_4 emissions from 1.B.2.b 'Fugitive emissions from natural gas' account for 0.4 % of total EU-27 GHG emissions in 2021 and for 22 % of all fugitive emissions in the EU. Between 1990 and 2021, CH_4 emissions from this source decreased by 71 % (Table 3.106).

In 2021, 59 % of the EU CH_4 emissions from 1.B.2.b were emitted by four countries: Germany, Italy, Poland and Romania (Table 3.106, Figure 3.183).In Germany, CH_4 emissions from this source mainly occur in subcategory 1.B.2.b.6 (other operations on natural gas). The country applies a Tier 2 methodology and a country specific emission factor. In Italy, Poland and Romania, methane emissions are mainly due to natural gas distribution (1.B.2.b.5). Italy applies a Tier 2 methodology with country specific emission factors in this subcategory, while Poland and Romania use a Tier 1 methodology and a default emission factor to estimate emissions from this sourceAdditionally, emissions from natural gas production (1.B.2.b.2) and other operations on natural gas (1.B.2.b.6) are the main sources of CH_4 emissions in Romania in this category. From 1990 to 2000, CH_4 emissions are estimated using a Tier 1 methodology with a default emission factor for developing countries of the 2006 IPCC Guidelines. From 2000 on the country applies a Tier 1 methodology with a default emission factor for developed countries, due to change of technology (ROU NIR 2023). This also explains the outlier in Figure **3.183**. For detailed information on countries methodologies, please see Annex III. Table **3.106** shows that 72 % of EU-27 emissions are calculated using higher tier methods. In cases where countries report a mix of Tier 1 and higher Tier methods (AUT, DNM, FIN, ESP) only emissions from subcategories of sector 1.B.2.b were considered for the calculation, where the countries actually apply a higher tier method. Countries that report a Tier 1 method but a country specific or plant specific emission factor (CZE, HUN, SVK) were counted as a higher Tier method, according to the IPCC 2006 Guidelines.

Emission decreases between 1990 and 2021 observed in Romania (-92 %), Germany (-81 %) and in Italy (-66 %) contributed most significantly to the overall reduction in the EU. The decrease was mainly caused by the improvement of pipeline network (Germany), the reduction of losses in gas distribution (Italy) and the decrease in production and the change of methodology (Romania).

Table 3.106 1.B.2.b Fugitive CH_4 emissions from natural gas: Countries' contributions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	290	237	238	1.8%	-52	-18%	1	0%	T1,T2	CS,D
Belgium	795	520	506	3.8%	-289	-36%	-15	-3%	CS	CS
Bulgaria	164	289	298	2.2%	134	82%	8	3%	T1	D
Croatia	155	113	108	0.8%	-47	-30%	-5	-4%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	1 170	648	648	4.9%	-522	-45%	0	0%	T1,T2	CS
Denmark	67	26	28	0.2%	-39	-58%	1	5%	T1,T2	CS,D
Estonia	63	18	20	0.2%	-42	-68%	2	13%	T1	D
Finland	5	15	17	0.1%	12	260%	2	16%	T1,T2	CS,D,PS
France	1 703	856	848	6.4%	-854	-50%	-7	-1%	T2,T3	CS,PS
Germany	9 789	2 001	1 811	13.6%	-7 977	-81%	-190	-9%	T2,T3	CS
Greece	10	98	108	0.8%	98	945%	10	10%	T1	D
Hungary	1 403	1 474	1 444	10.8%	41	3%	-31	-2%	T1,T2	CS
Ireland	25	76	71	0.5%	46	187%	-5	-7%	T3	CS,PS
Italy	9 225	3 263	3 104	23.3%	-6 121	-66%	-159	-5%	T2	CS
Latvia	199	93	91	0.7%	-107	-54%	-2	-2%	T3	CS
Lithuania	292	278	268	2.0%	-24	-8%	-11	-4%	T2	CS
Luxembourg	22	31	33	0.3%	12	54%	2	8%	T1	D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	472	264	264	2.0%	-208	-44%	0	0%	T3	CS
Poland	844	1 422	1 459	11.0%	615	73%	36	3%	T1	D
Portugal	NO	56	59	0.4%	59	∞	2	4%	CR,NO,OTH	CR,NO,OTH
Romania	18 126	1 353	1 467	11.0%	-16 659	-92%	113	8%	T1	D
Slovakia	1 236	196	212	1.6%	-1 024	-83%	16	8%	T1,T3	CS,PS
Slovenia	48	37	39	0.3%	-8	-17%	2	5%	T1	D
Spain	152	156	141	1.1%	-11	-7%	-15	-10%	CS,T1	CS,D
Sweden	75	39	40	0.3%	-35	-47%	2	4%	T2,T3	CS,PS
EU-27	**46 325**	**13 562**	**13 321**	**100%**	**-33 004**	**-71%**	**-241**	**-2%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 3.183 1.B.2.b Natural Gas: Emission trend and share for the emitting countries of CH_4

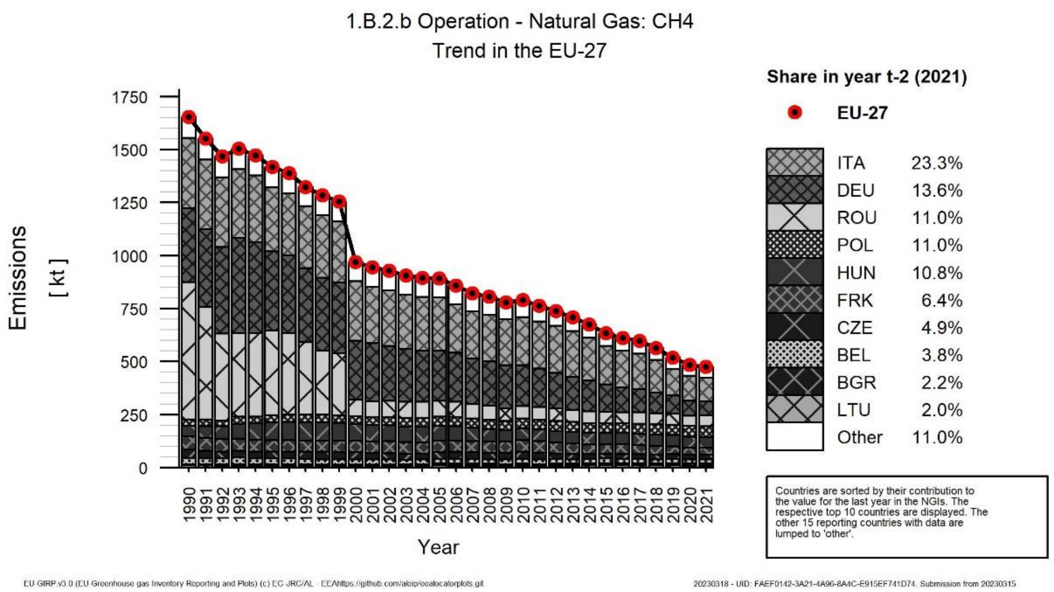


Table 3.107 and Table 3.108 provide an overview on activity data description and emission factors for all countries for sector 1.B.2.a and 1.B.2.b. CRF Tables do not include activity data for sector 1.B.2 because countries use different types of activity data which cannot be aggregated.

Table 3.107: 1.B.2.a Fugitive CO_2- and CH_4 emissions from natural gas: Information on activity data, emission factors by Member State

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990							2021							
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
Austria	**Oil**						**0**	**0.30**						**0**	**0.31**
	1. Exploration	Mt crude oil	Mt	1	NO,IE	IE	IE	IE	Mt crude oil	Mt	0.56	NO,IE	IE	IE	IE
	2. Production	Mt crude oil	Mt	1	NO,IE	IE	IE	IE	Mt crude oil	Mt	0.56	NO,IE	IE	IE	IE
	3. Transport	1000 m^3 crude oil	Mt	9 404	0.5	5	0.005	0.05	1000 m^3 crude oil	Mt	9 882	0.49	5	0	0.05
	4. Refining and storage	Mt crude oil Input	Mt	8	NA,NO	31 663	NA	0.25	Mt crude oil Input	Mt	8	NO,NA	31663	NA	0.26
	5. Distribution of oil products	Mt gasoline	Mt	3	NA,NO	NA	NA	NA	Mt gasoline	Mt	1	NO,NA	NA	NA	NA
	6. Other		Mt	NO	NO	NO	NO	NO		Mt	NO	NO	NO	NO	NO
Belgium	**Oil**						**0**	**0.46**						**0.02**	**0.29**
	1. Exploration	Not occuring	PJ	NO	NO	NO	NO	NO	Not occuring	PJ	NO	NO	NO	NO	NO
	2. Production	Not occuring	PJ	NO	NO	NO	NO	NO	Not occuring	PJ	NO	NO	NO	NO	NO
	3. Transport	Oil transported	PJ	1 051	14	150	0.01	0.16	Oil transported	PJ	1 201	14	150	0.02	0.18
	4. Refining and storage	Oil refined	PJ	1 251	NA,NO	238	NA	0.30	Oil refined	PJ	1 312	NO,NA	83	NA	0.11
	5. Distribution of oil products	Not occuring	PJ	NO	NO	NO	NO	NO	Not occuring	PJ	NO	NO	NO	NO	NO
	6. Other	Not occuring	PJ	NO	NO	NO	NO	NO	Not occuring	PJ	NO	NO	NO	NO	NO
Bulgaria	**Oil**						**60**	**0.50**						**169**	**0.22**
	1. Exploration	Indigenous production	10^3m^3	C	4 400	20	0	0.00	Indigenous production	10^3m^3	C	4400	20	0	0.00
	2. Production	Indigenous production	10^3m^3	C	44 990	2 910	3.15	0.20	Indigenous production	10^3m^3	C	44990	2910	1	0.07
	3. Transport	Indigenous production	10^3m^3	C	2	25	0.0002	0.002	Indigenous production	10^3m^3	C	2	25	0	0.00
	4. Refining and storage	Refinery intake	10^3m^3	9 667	5 850	30	57	0.29	Refinery intake	10^3m^3	4 858	34623	31	168	0.15

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990							2021						
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
	5. Distribution of oil products		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	6. Other		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
Cyprus	**Oil**						**NO,NE**	**0.02**						**NO,NE**	**NO,NE**
	1. Exploration		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	2. Production		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	3. Transport			NE	NO,NE	NE	NE	NE			NO	NO	NO	NO	NO
	4. Refining and storage	Crude Oil refined (10^3 m^3)	NO	743	NO,NE	22	NE	0.02	Crude Oil refined (10^3 m^3)	NO	NO	NO	NO	NO	NO
	5. Distribution of oil products	Liquid Fuels (TJ)	NE	54 141	NO,NE	NE	NE	NE	Liquid Fuels (TJ)	NE	75 094	NO,NE	NE	NE	NE
	6. Other		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
Czechia	**Oil**						**0.02**	**0.41**						**0.03**	**0.24**
	1. Exploration	(e.g. number of wells drilled)	PJ	NE	NE	NE	NE	NE	(e.g. number of wells drilled)	PJ	NE	NE	NE	NE	NE
	2. Production	(e.g. PJ of oil produced)	PJ	2	7 576	5 978	0.02	0.01	(e.g. PJ of oil produced)	PJ	4	7576	4735	0.03	0.02
	3. Transport	(e.g. PJ oil loaded in tankers)	PJ	304	13	146	0.004	0.04	(e.g. PJ oil loaded in tankers)	PJ	302	13	146	0.004	0.04
	4. Refining and storage	(e.g. PJ oil refined)	PJ	304	NE,NO	1 150	NE	0.35	(e.g. PJ oil refined)	PJ	302	NO,NE	585	NE	0.18
	5. Distribution of oil products	(e.g. PJ oil refined)	PJ	304	NE,NO	NE	NE	NE	(e.g. PJ oil refined)	PJ	302	NO,NE	NE	NE	NE
	6. Other	(NO)	PJ	NO	NO	NO	NO	NO	(NO)	PJ	NO	NO	NO	NO	NO
Germany	**Oil**						**478**	**9.67**						**406**	**0.79**
	1. Exploration	Number of wells drilled	number	12	0.5	64	0.00001	0.00	Number of wells drilled	number	8	0.48	64	0.00000	0.00
	2. Production	oil produced	t	3 605 667	0.1	0.3	0.5	1.08	oil produced	t	1 804 427	0.11	0.11	0.19	0.20

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990								2021							
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
	3. Transport	oil transported	t	84 042 887	NO,NA	0.01	NA	0.59	oil transported	t	81 402 657	NO,NA	0.01	NA	0.55
	4. Refining and storage	oil refined	t	214 116 000	2	0.0	477	8.00	oil refined	t	84 138 618	5	0.00	406	0.04
	5. Distribution of oil products	oil products distributed	t	89 461 000	NO,NA	NA	NA	NA	oil products distributed	t	68 743 809	NO,NA	NA	NA	NA
	6. Other	other emissions	m^3	NO	NO	NO	NO	NO	other emissions	m^3	NO	NO	NO	NO	NO
Denmark	**Oil**						**5**	**1.72**						**0.060**	**0.74**
Denmark	1. Exploration	Oil explored	m^3	1 930	2 433	0	5	0.00	Oil explored	m^3	NO	NO	NO	NO	NO
Denmark	2. Production	Oil produced	$10^3 m^3$	6 999	0	1	0	0.00	Oil produced	$10^3 m^3$	3 819	0.04	1	0.0002	0.00
Denmark	3. Transport	Oil loaded	Mg	3 370 410	NO,NA	0	NA	0.49	Oil loaded	Mg	1 436 050	NO,NA	0	NA	0.03
Denmark	4. Refining and storage	Oil refined	Mg	7 263 000	0	0	0	1.23	Oil refined	Mg	7 459 438	0.0081	0.09	0.060	0.71
Denmark	5. Distribution of oil products	Gasoline distribution	Mg	1 734 295	NA	NA	NA	NA	Gasoline distribution	Mg	1 207 319	NA	NA	NA	NA
Denmark	6. Other	Other	m^3	NO	NO	NO	NO	NO	Other	m^3	NO	NO	NO	NO	NO
Spain	**Oil**						**1477**	**0.16**						**3144**	**0.11**
Spain	1. Exploration	Crude oil produced	Tg	NA	NO,NA	NA	NA	NA	Crude oil produced	Tg	NA	NO,NA	NA	NA	NA
Spain	2. Production	Crude oil produced	Tg	1	64	783	0.00005	0.00	Crude oil produced	Tg	0	68.17	857	0.00000	0.00
Spain	3. Transport	Transport of crude oil	Tg	51	75	827	0.004	0.04	Transport of crude oil	Tg	56	47.09	519	0.003	0.03
Spain	4. Refining and storage	Oil refined	Tg	54	27 571 240	2 107	1477	0.11	Oil refined	Tg	61	51818706	1354	3144	0.08
Spain	5. Distribution of oil products	Oil products	Tg	NA	NO,NA	NA	NA	NA	Oil products	Tg	NA	NO,NA	NA	NA	NA
Spain	6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Estoni	**Oil**						**NO,NE**	**NO,NE**						**NO,NE**	**NO,NE**
Estoni	1. Exploration	Exploration	NA	NO	NO	NO	NO	NO	Exploration	NA	NO	NO	NO	NO	NO

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990								2021						
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
	2. Production	Production	NA	NO	NO	NO	NO	NO	Production	NA	NO	NO	NO	NO	NO
	3. Transport	Transport	NA	NO	NO	NO	NO	NO	Transport	NA	NO	NO	NO	NO	NO
	4. Refining and storage	Refining/Storage	NA	NO	NO	NO	NO	NO	Refining/Storage	NA	NO	NO	NO	NO	NO
	5. Distribution of oil products	Distribution of oil products	NE	NE	NE	NE	NE	NE	Distribution of oil products	NE	NE	NE	NE	NE	NE
	6. Other	Other	NA	NO	NO	NO	NO	NO	Other	NA	NO	NO	NO	NO	NO
Finland	**Oil**						**NO**	**0.25**						**NO**	**0.34**
	1. Exploration		NA	NO	NO	NO	NO	NO		NA	NO	NO	NO	NO	NO
	2. Production		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	3. Transport		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	4. Refining and storage	kt oil refined	kt	9 884	NO	25	NO	0.25	kt oil refined	kt	13 207	NO	25	NO	0.34
	5. Distribution of oil products		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	6. Other		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
France	**Oil**						**2983**	**8.23**						**1387**	**1.76**
	1. Exploration	Oil produced	PJ	127	252 097	5 373	32	0.68	Oil produced	PJ	28	252097	5373	7	0.15
	2. Production	Oil produced	PJ	127	7 201	54 578	1	6.93	Oil produced	PJ	28	7201	54578	0.20	1.51
	3. Transport	Oil loaded	PJ	5 189	7	73	0.03	0.38	Oil loaded	PJ	1 537	6	61	0.01	0.09
	4. Refining and storage	Oil refined	PJ	3 194	923 744	75	2950	0.24	Oil refined	PJ	1 451	951028	5	1380	0.01
	5. Distribution of oil products	Oil refined	PJ	3 785	NA	NA	NA	NA	Oil refined	PJ	3 078	NA	NA	NA	NA
	6. Other	NO	PJ	NO	NO	NO	NO	NO	NO	PJ	NO	NO	NO	NO	NO
Greec	**Oil**						**0.00004**	**0.39**						**0.000003**	**0.61**
	1. Exploration			NE	NO,NE	NE	NE	NE			NE	NO,NE	NE	NE	NE

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990							2021						
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
	2. Production		kt	773	0.1	1	0.00004	0.001		kt	59	0.05	1	0.000003	0.00
	3. Transport		kt	773	NO,NE	27	NE	0.02		kt	59	NO,NE	27	NE	0.00
	4. Refining and storage		kt	14 411	IE,NO	26	IE	0.37		kt	23 711	NO,IE	26	IE	0.61
	5. Distribution of oil products		kt	2 450	NA,NO	NA	NA	NA		kt	2 034	NO,NA	NA	NA	NA
	6. Other			NO	NO	NO	NO	NO			NO	NO	NO	NO	NO
Croatia	**Oil**						**158**	**8.82**						**35**	**2.02**
Croatia	1. Exploration	total oil production	1000 m^3	3 135	9 102	194	29	0.61	total oil production	1000 m^3	703	9102	194	6	0.14
Croatia	2. Production	total oil production	1000 m^3	3 135	41 225	2 546	129	7.98	total oil production	1000 m^3	703	41225	2546	29	1.79
Croatia	3. Transport	total oil transported by pipelines	1000 m^3	9 949	0.49	5	0.00	0.05	total oil transported by pipelines	1000 m^3	7 914	0.49	5	0.004	0.04
Croatia	4. Refining and storage	oil refined	1000 m^3	7 978	NO,NA	22	NA	0.17	oil refined	1000 m^3	2 165	NO,NA	22	NA	0.05
Croatia	5. Distribution of oil products	product transported	NA	NA	NO,NA	NA	NA	NA	product transported	NA	NA	NO,NA	NA	NA	NA
Croatia	6. Other		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
Hungary	**Oil**						**5**	**7.14**						**1**	**2.07**
Hungary	1. Exploration		NA	IE	IE,NO	IE	IE	IE		NA	IE	NO,IE	IE	IE	IE
Hungary	2. Production	conventional oil production (thousand m3)	1000 m^3	2 269	2 150	3 000	5	6.81	conventional oil production (thousand m3)	1000 m^3	1 013	130	1801	0.1	1.82
Hungary	3. Transport	Oil transported by pipeline (thousand m3)	1000 m^3	10 432	25	13	0.3	0.13	Oil transported by pipeline (thousand m3)	1000 m^3	8 400	52	9	0.4	0.08

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990							2021						
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
	4. Refining and storage	Oil refined (thousand m3)	1000 m^3	9 357	NA,NO	22	NA	0.20	Oil refined (thousand m3)	1000 m^3	7 728	NO,NA	22	NA	0.17
	5. Distribution of oil products		NA	NA	NA,NO	NA	NA	NA		NA	NA	NO,NA	NA	NA	NA
	6. Other		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
Ireland	**Oil**						**NO**	**0.01**						**NO**	**0.01**
Ireland	1. Exploration		PJ	NE	NO	NE	NO	NE		PJ	NE	NO	NE	NO	NE
Ireland	2. Production		PJ	NO	NO	NO	NO	NO		PJ	NO	NO	NO	NO	NO
Ireland	3. Transport		PJ	NO	NO	NO	NO	NO		PJ	NO	NO	NO	NO	NO
Ireland	4. Refining and storage		PJ	77	NO	110	NO	0.01		PJ	130	NO	110	NO	0.01
Ireland	5. Distribution of oil products		PJ	NO	NO	NO	NO	NO		PJ	NO	NO	NO	NO	NO
Ireland	6. Other		PJ	NO	NO	NO	NO	NO		PJ	NO	NO	NO	NO	NO
Italy	**Oil**						**2402**	**12.39**						**1316**	**3.39**
Italy	1. Exploration	Wells drilled	Number	6	1 900	112	0.01	0.001	Wells drilled	Number	NO	NO	NO	NO	NO
Italy	2. Production	Oil produced	Gg	4 668	320	2 049	1	9.56	Oil produced	Gg	4 914	321	365	2	1.79
Italy	3. Transport	Oil transported	Gg	94 600	1	6	0.1	0.58	Oil transported	Gg	103 824	0.56	6	0.06	0.64
Italy	4. Refining and storage	Oil refined	Gg	93 711	25 615	24	2400	2.24	Oil refined	Gg	70 581	18615	14	1314	0.95
Italy	5. Distribution of oil products	Oil distributed	NA	NA	NA	NA	NA	NA	Oil distributed	NA	NA	NA	NA	NA	NA
Italy	6. Other	Other	NA	NO	NO	NO	NO	NO	Other	NA	NO	NO	NO	NO	NO
Lithuania	**Oil**						**23.3**	**0.17**						**216**	**0.08**
Lithuania	1. Exploration	Oil produced	thous. m^3	14	9 102	194	0.1	0.00	Oil produced	thous. m^3	32	9101.90	194	0	0.01
Lithuania	2. Production	Oil produced, thous. m^3	thous. m^3	14	0.1	2	0.000002	0.00	Oil produced, thous. m^3	thous. m^3	32	0.11	1	0.000004	0.00005

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990							2021						
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
	3. Transport	Oil transported, thous. m^3	thous. m^3	25 577	0.5	5	0.01	0.14	Oil transported, thous. m^3	thous. m^3	10 066	0.49	5	0.00	0.05
	4. Refining and storage	Oil refined	thous. m^3	11 181	NO	3	NO	0.03	Oil refined	thous. m^3	9 325	NO	3	NO	0.02
	5. Distribution of oil products		NA	NA	NO,NA	NA	NA	NA		NA	NA	NO,NA	NA	NA	NA
	6. Other	Refinery gas	kt	8	2 870 000	NO	23	NO	Refinery gas	kt	75	2889430.00	NO	216	NO
Luxembourg	**Oil**						**NO**	**NO**						**NO**	**NO**
	1. Exploration	number of wells drilled	NA	NO	NO	NO	NO	NO	number of wells drilled	NA	NO	NO	NO	NO	NO
	2. Production	oil produced	NA	NO	NO	NO	NO	NO	oil produced	NA	NO	NO	NO	NO	NO
	3. Transport	oil loaded in tankers	NA	NO	NO	NO	NO	NO	oil loaded in tankers	NA	NO	NO	NO	NO	NO
	4. Refining and storage	oil refined	NA	NO	NO	NO	NO	NO	oil refined	NA	NO	NO	NO	NO	NO
	5. Distribution of oil products	oil refined	TJ	66 031	NO	NO	NO	NO	oil refined	TJ	107 272	NO	NO	NO	NO
	6. Other	other n.i.e.	NA	NO	NO	NO	NO	NO	other n.i.e.	NA	NO	NO	NO	NO	NO
Latvia	**Oil**						**NO,NA**	**NO,NA**						**NO,NA**	**NO,NA**
	1. Exploration	Exploration	kt	NO	NO	NO	NO	NO	Exploration	kt	NO	NO	NO	NO	NO
	2. Production	Production	kt	NO	NO	NO	NO	NO	Production	kt	NO	NO	NO	NO	NO
	3. Transport	Transport	kt	NO	NO	NO	NO	NO	Transport	kt	NO	NO	NO	NO	NO
	4. Refining and storage	Refining/Storage	kt	NO	NO	NO	NO	NO	Refining/Storage	kt	NO	NO	NO	NO	NO
	5. Distribution of oil products	Distribution of Oil Products	kt	609	NO,NA	NA	NA	NA	Distribution of Oil Products	kt	164	NO,NA	NA	NA	NA
	6. Other	Other	kt	NO	NO	NO	NO	NO	Other	kt	NO	NO	NO	NO	NO
Ma	**Oil**						**NO**	**NO**						**NO**	**NO**

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990							2021							
	GHG source category	Activity data: Description	Unit	Value	CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data: Description	Unit	Value	CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
	1. Exploration	number of wells drilled	NO	NO	NO	NO	NO	NO	number of wells drilled	NO	NO	NO	NO	NO	NO
	2. Production	oil produced	NO	NO	NO	NO	NO	NO	oil produced	NO	NO	NO	NO	NO	NO
	3. Transport	oil loaded in tankers	NO	NO	NO	NO	NO	NO	oil loaded in tankers	NO	NO	NO	NO	NO	NO
	4. Refining and storage	oil refined	NO	NO	NO	NO	NO	NO	oil refined	NO	NO	NO	NO	NO	NO
	5. Distribution of oil products	Gasoline	NO	NO	NO	NO	NO	NO	Gasoline	NO	NO	NO	NO	NO	NO
	6. Other	Other Petroleum Product	NO	NO	NO	NO	NO	NO	Other Petroleum Product	NO	NO	NO	NO	NO	NO
Netherlands	**Oil**						**0.02**	**0.81**						**1022**	**0.58**
	1. Exploration		NA	IE	NO,IE	IE	IE	IE		NA	IE	NO,IE	IE	IE	IE
	2. Production		NA	IE	NO,IE	IE	IE	IE		NA	IE	NO,IE	IE	IE	IE
	3. Transport	Amount of oil transported	Gg	33 912	1	6	0.02	0.20	Amount of oil transported	Gg	47 005	0.53	6	0.02	0.27
	4. Refining and storage	Total amount of oil products	PJ	2 077	NO,IE	296	IE	0.61	Total amount of oil products	PJ	2 306	443410	133	1022	0.31
	5. Distribution of oil products		NA	NE	NA	NA	NA	NA		NA	NE	NO,NA	NA	NA	NA
	6. Other		NA	NO	NO	NO	NO	NO		NA	NO	NO	NO	NO	NO
Poland	**Oil**						**2**	**1.40**						**9.59**	**4.19**
	1. Exploration	NA	Gg	160	10 571	225	2	0.04	NA	Gg	888	10571.31	225	9	0.20
	2. Production	Production	PJ	7	7 305	101 149	0	0.67	Production	PJ	41	4644	64297	0.19	2.66
	3. Transport	oil ltransported by pipeline	Gg	13 286	1	6	0	0.08	oil ltransported by pipeline	Gg	24 508	0.57	6	0.01	0.15
	4. Refining and storage	oil refined	Gg	12 846	NA	48	NA	0.61	oil refined	Gg	24 755	NA	48	NA	1.18

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990							2021						
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
	5. Distribution of oil products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	6. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Portugal	**Oil**						**0.4**	**0.07**						**819**	**0.06**
	1. Exploration		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	2. Production		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	3. Transport		Mt	0.00	578 512	6 375 442 739	0.00001	0.07		Mt	0	578512	6375442 739	0.00001	0.06
	4. Refining and storage		Mt	0.04	9 571 940	6	0.4	0.00		Mt	0	4480555 9495	13	819	0.00
	5. Distribution of oil products		Mt	0.001	NO	NO	NO	NO		Mt	0	NO	NO	NO	NO
	6. Other		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
Romania	**Oil**						**746**	**192.45**						**601**	**9.62**
	1. Exploration	oil produced	PJ	322	2 245 932	47 534	724	15.32	oil produced	PJ	135	261396	5571	35	0.75
	2. Production	oil produced	PJ	322	69 542	547 400	22	176.40	oil produced	PJ	135	8041	63182	1	8.55
	3. Transport	oil refined	PJ	975	14	151	0.01	0.15	oil refined	PJ	422	14	150	0.01	0.06
	4. Refining and storage	oil refined	PJ	962	IE,NO	609	IE	0.59	oil refined	PJ	413	NO,IE	615	IE	0.25
	5. Distribution of oil products	oil refined	PJ	NO	NO	NO	NO	NO	oil refined	PJ	NO	NO	NO	NO	NO
	6. Other	oil refined	kt	NO	NO	IE	NO	IE	oil refined	kt	161	3502495	IE	564	IE
Slovakia	**Oil**						**0.03**	**0.59**						**0.01**	**0.29**
	1. Exploration		NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
	2. Production	Production	kt	73	260	3 600	0.02	0.26	Production	kt	5	260	3600	0.001	0.02
	3. Transport	Transfer	kt	13 581	0.5	5	0.01	0.07	Transfer	kt	8 819	0.49	5	0.004	0.05
	4. Refining and storage	Refining/Storage	kt	6 221	NE	41	NE	0.26	Refining/Storage	kt	5 507	NE	41	NE	0.23

1.B.2.a Fugitive CO_2 and CH_4 Emissions from Oil		1990							2021						
	GHG source category	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)	Activity data			CO_2 IEF (kg/unit)	CH_4 IEF (kg/unit)	CO_2 EM (kt)	CH_4 EM (kt)
		Description	Unit	Value					Description	Unit	Value				
	5. Distribution of oil products		NA	NE	NO,NE	NE	NE	NE		NA	NE	NO,NE	NE	NE	NE
	6. Other		NA	NO	NO	NO	NO	NO		NA	NO	NO	NO	NO	NO
Slovenia	**Oil**						**0.03**	**0.01**						**0**	**0.00**
	1. Exploration	NA	1000 m^3	NO	NO	NO	NO	NO	NA	1000 m^3	NO	NO	NO	NO	NO
	2. Production	Conventional oil produced	1000 m^3	3	0.04	1	0.0000001	0.000002	Conventional oil produced	1000 m^3	0	0.04	1	0.00	0.00
	3. Transport	Consumption of LPG	1000 m^3	58	430	NA	0.03	NA	Consumption of LPG	1000 m^3	142	430	NA	0.06	NA
	4. Refining and storage	Oil refined	1000 m^3	626	NO,NA	22	NA	0.01	Oil refined	1000 m^3	NO	NO,NA	NO	NA	NO
	5. Distribution of oil products	NA	1000 m^3	NO	NO	NO	NO	NO	NA	1000 m^3	NO	NO	NO	NO	NO
	6. Other	NA	1000 m^3	NO	NO	NO	NO	NO	NA	1000 m^3	NO	NO	NO	NO	NO
Sweden	**Oil**						**255**	**0.48**						**NO,NE,IE,NA**	**0.04**
	1. Exploration	Consumption of feedstock	TJ	375	101 897	3	38	0.00	Consumption of feedstock	TJ	IE	IE,NA	IE	IE	IE
	2. Production	Oil production		NO	NO	NO	NO	NO	Oil production		NO	NO	NO	NO	NO
	3. Transport	Transported amount of oil	PJ	20 000 046	NE	0	NE	0.04	Transported amount of oil	PJ	21 687 826	NE	0	NE	0.04
	4. Refining and storage	Consumption of crude oil	Mt	17	12 497 656	25 612	217	0.44	Consumption of crude oil	Mt	IE	IE,NA	IE,NA	IE,NA	IE,NA
	5. Distribution of oil products	Distribution of oil products		NE	NA	NA	NA	NA	Distribution of oil products		NE	NA	NA	NA	NA
	6. Other			NO	NO	NO	NO	NO			NO	NO	NO	NO	NO

Table 3.108 1.B.2.b Fugitive CH_4 emissions from natural gas: Information on activity data, emission factors by Member State

1.B.2.b Fugitive CH_4 Emissions from Natural gas		**1990**					**2021**				
	GHG source category	**Activity data**			**CH_4 IEF (kg/unit)**	**CH_4 EM (kt)**	**Activity data**			**CH_4 IEF (kg/unit)**	**CH_4 EM (kt)**
		Description	**Unit**	**Value**			**Description**	**Unit**	**Value**		
Austria	**Natural Gas**					**10.36**					**8.51**
	1. Exploration	Mm^3 natural gas	Mm^3	1288.00	IE	IE	Mm^3 natural gas	Mm^3	655.00	IE	IE
	2. Production	Mm^3 natural gas	Mm^3	1288.00	4478.96	5.77	Mm^3 natural gas	Mm^3	655.00	4431.53	2.90
	3. Processing	Mm^3 natural gas	Mm^3	248.09	NA	NA	Mm^3 natural gas	Mm^3	159.69	NA	NA
	4. Transmission and storage	km pipeline length	km	3628.00	718.43	2.61	km pipeline length	km	7202.51	577.59	4.16
	5. Distribution	km distribution network length	km	11672.00	170.22	1.99	km distribution network length	km	30591.13	47.34	1.45
	6. Other	Mm^3 natural gas stored	Mm^3	NO	NO	NO	Mm^3 natural gas stored	Mm^3	NO	NO	NO
Belgium	**Natural Gas**					**28.38**					**18.06**
	1. Exploration	Not occuring	PJ	NO	NO	NO	Not occuring	PJ	NO	NO	NO
	2. Production	Not occuring	PJ	NO	NO	NO	Not occuring	PJ	NO	NO	NO
	3. Processing	Not occuring	PJ	NO	NO	NO	Not occuring	PJ	NO	NO	NO
	4. Transmission and storage	Gas consumed	PJ	341.98	16693.69	5.71	Gas consumed	PJ	616.04	6082.66	3.75
	5. Distribution	Gas consumed	PJ	341.98	66287.85	22.67	Gas consumed	PJ	616.04	23229.65	14.31
	6. Other	Not occuring	PJ	NO	NO	NO	Not occuring	PJ	NO	NO	NO
Bulgaria	**Natural Gas**					**5.84**					**10.63**
	2. Exploration	Indigenous production	10^6m^3	14.00	60.00	0.00	Indigenous production	10^6m^3	31.85	60.00	0.00
	3. Production	Indigenous production	10^6m^3	14.00	2540.00	0.04	Indigenous production	10^6m^3	31.85	2540.00	0.08
	4. Processing	Indigenous production	10^6m^3	14.00	570.00	0.01	Indigenous production	10^6m^3	31.85	570.00	0.02
	5. Transmission and storage	Pipeline length	km	1469.00	2123.34	3.12	Pipeline length	km	3276.00	2121.63	6.95
	6. Distribution	Pipeline length	km	50.00	230.00	0.01	Pipeline length	km	5461.00	230.00	1.26
	7. Other	Natural gas consumption at energy and industrial plants	106m3	6610.22	403.27	2.67	Natural gas consumption at energy and industrial plants	106m3	2845.20	814.56	2.32
Cy	**Natural Gas**					**NO**					**NO**

1.B.2.b Fugitive CH_4 Emissions from Natural gas		1990					2021				
		Activity data					Activity data				
	GHG source category	Description	Unit	Value	CH_4 IEF (kg/unit)	CH_4 EM (kt)	Description	Unit	Value	CH_4 IEF (kg/unit)	CH_4 EM (kt)
	2. Exploration		NO	NO	NO	NO		NO	NO	NO	NO
	3. Production		NO	NO	NO	NO		NO	NO	NO	NO
	4. Processing		NO	NO	NO	NO		NO	NO	NO	NO
	5. Transmission and storage		NO	NO	NO	NO		NO	NO	NO	NO
	6. Distribution		NO	NO	NO	NO		NO	NO	NO	NO
	7. Other		NO	NO	NO	NO		NO	NO	NO	NO
Czechia	**Natural Gas**					**41.80**					**23.15**
	2. Exploration		PJ	NE	NE	NE		PJ	NE	NE	NE
	3. Production	(e.g. PJ gas produced)	PJ	7.84	39365.45	0.31	(e.g. PJ gas produced)	PJ	6.87	38649.05	0.27
	4. Processing		PJ	NO	NA	NA		PJ	NO	NA	NA
	5. Transmission and storage	(e.g. PJ gas consumed)	PJ	1357.98	9296.21	12.62	(e.g. PJ gas consumed)	PJ	1575.00	4186.49	6.59
	6. Distribution	(e.g. PJ gas consumed)	PJ	55.77	517563.35	28.86	(e.g. PJ gas consumed)	PJ	132.61	122867.41	16.29
	7. Other	(e.g. PJ gas consumed)	PJ	29.68	IE	IE	(e.g. PJ gas consumed)	PJ	191.76	IE	IE
Germany	**Natural Gas**					**349.59**					**64.69**
	3. Exploration	number of wells drilled	number	IE	IE	IE	number of wells drilled	number	IE	IE	IE
	4. Production	gas produced	1000 m^3	15262000.00	0.38	5.80	gas produced	1000 m^3	5160108.23	0.02	0.10
	5. Processing	gas produced	1000 m^3	15262000.00	0.35	5.34	gas produced	1000 m^3	5160108.23	0.02	0.12
	6. Transmission and storage	lenght of transmission pipelines	km	22696.00	2889.13	65.57	lenght of transmission pipelines	km	34035.00	426.07	14.50
	7. Distribution	lenght of distribution pipelines	km	282612.00	751.78	212.46	lenght of distribution pipelines	km	544399.00	15.49	8.43
	8. Other	gas consumed	TJ	893519.00	67.62	60.42	gas consumed	TJ	1427287.03	29.10	41.53
Denmark	**Natural Gas**					**2.38**					**64.69**
	3. Exploration	Gas explored	m^3	2892052.00	0.01	0.03	Gas explored	m^3	NO	NO	NO
	4. Production	Gas produced	10^6 m^3	5137.00	380.00	1.95	Gas produced	10^6 m^3	1322.00	380.00	0.50
	5. Processing	Gas produced	10^6 m^3	5137.00	NA	NA	Gas produced	10^6 m^3	1322.00	NA	NA

1.B.2.b Fugitive CH_4 Emissions from Natural gas		1990					2021				
	GHG source category	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)
		Description	Unit	Value			Description	Unit	Value		
	6. Transmission and storage	Gas transmission	10^6 m^3	2739.00	52.22	0.14	Gas transmission	10^6 m^3	3093.00	89.66	0.28
	7. Distribution	Gas distributed	10^6 m^3	1749.06	145.27	0.25	Gas distributed	10^6 m^3	2177.35	96.52	0.21
	8. Other	Incl. In transmission	m^3	NO	NO	NO	Incl. In transmission	m^3	NO	NO	NO
Spain	**Natural Gas**					**5.42**					**5.03**
	3. Exploration	Mm3 gas produced	Mm^3	NO	NO	NO	Mm3 gas produced	Mm^3	NO	NO	NO
	4. Production	Mm3 gas produced	Mm^3	1254.88	464.56	0.58	Mm3 gas produced	Mm^3	41.92	2087.72	0.09
	5. Processing	Mm3 gas produced	Mm^3	1254.88	150.00	0.19	Mm3 gas produced	Mm^3	41.92	150.00	0.01
	6. Transmission and storage	PJ gas (NCV)	PJ	198.09	5897.06	1.17	PJ gas (NCV)	PJ	1237.02	569.46	0.70
	7. Distribution	PJ of gaseous fuels (natural gas, LPG, gas work gas or propanized air) distributed by networks	PJ	205.50	16957.55	3.48	PJ of gaseous fuels (natural gas, LPG, gas work gas or propanized air) distributed by networks	PJ	1247.80	3393.02	4.23
	8. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Estonia	**Natural Gas**					**2.24**					**0.72**
	4. Exploration	Exploration	NA	NO	NO	NO	Exploration	NA	NO	NO	NO
	5. Production	Production	NA	NO	NO	NO	Production	NA	NO	NO	NO
	6. Processing	Processing	NA	NO	NO	NO	Processing	NA	NO	NO	NO
	7. Transmission and storage	Amount of the transmission of Natural Gas	PJ	51.17	5734.64	0.29	Amount of the transmission of Natural Gas	PJ	16.51	5734.64	0.09
	8. Distribution	Amount of natural gas distributed	PJ	51.17	38000.60	1.94	Amount of natural gas distributed	PJ	16.51	38000.60	0.63
	9. Other	Other	NA	NO	NO	NO	Other	NA	NO	NO	NO
Finland	**Natural Gas**					**0.17**					**0.61**
	4. Exploration		NO	NO	NO	NO		NO	NO	NO	NO
	5. Production		NO	NO	NO	NO		NO	NO	NO	NO
	6. Processing		NA	NO	NO	NO		NA	NA	NO	NO

1.B.2.b Fugitive CH_4 Emissions from Natural gas		1990					2021				
	GHG source category	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)
		Description	Unit	Value			Description	Unit	Value		
	7. Transmission and storage	PJ gas consumed	PJ	90.76	1873.15	0.17	PJ gas consumed	PJ	73.53	3432.85	0.25
	8. Distribution	PJ gas distributed	NO	NO	NO	NO	PJ gas distributed	NO	20.74	17361.11	0.36
	9. Other		NO	NO	NO	NO		NO	NO	NO	NO
France	**Natural Gas**					**60.81**					**30.30**
France	4. Exploration	NO	PJ	NO	NO	NO	NO	PJ	NO	NO	NO
France	5. Production	NO	PJ	IE	IE	IE	NO	PJ	IE	IE	IE
France	6. Processing	Gas processed	PJ	309.00	2376.20	0.73	Gas processed	PJ	6.06	303.96	0.00
France	7. Transmission and storage	Gas consumed	PJ	1091.00	24425.57	26.65	Gas consumed	PJ	1565.11	6890.22	10.78
France	8. Distribution	Gas consumed	PJ	1091.00	30640.07	33.43	Gas consumed	PJ	1565.11	12465.61	19.51
France	9. Other	NO	PJ	NO	NO	NO	NO	PJ	NO	NO	NO
Greece	**Natural Gas**					**0.37**					**3.85**
Greece	5. Exploration			NE	NE	NE			NE	NE	NE
Greece	6. Production		mil_m^3	123.00	1930.00	0.24		mil_m^3	4.02	1930.00	0.01
Greece	7. Processing		mil_m^3	123.00	IE	IE		mil_m^3	4.02	IE	IE
Greece	8. Transmission and storage		mil_m^3	123.00	298.00	0.04		mil_m^3	6435.82	298.00	1.92
Greece	9. Distribution		mil_m^3	86.24	1100.00	0.09		mil_m^3	1753.07	1100.00	1.93
Greece	10. Other			IE	IE	IE			IE	IE	IE
Croatia	**Natural Gas**					**5.54**					**3.87**
Croatia	5. Exploration	Natural gas production	1000000 m^3	1982.30	IE	IE	Natural gas production	1000000 m^3	745.90	IE	IE
Croatia	6. Production	gas produced	1000000 m^3	1982.30	1340.76	2.66	gas produced	1000000 m^3	745.90	1340.76	1.00
Croatia	7. Processing	gas produced	1000000 m^3	1982.30	592.00	1.17	gas produced	1000000 m^3	745.90	592.00	0.44
Croatia	8. Transmission and storage	marketable gas	1000000 m^3	2686.60	480.00	1.29	marketable gas	1000000 m^3	2905.90	480.00	1.39
Croatia	9. Distribution	utility sales	1000000 m^3	379.30	1100.00	0.42	utility sales	1000000 m^3	942.00	1100.00	1.04

1.B.2.b Fugitive CH_4 Emissions from Natural gas		1990					2021				
	GHG source category	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)
		Description	Unit	Value			Description	Unit	Value		
	10. Other		NO	NO	NO	NO		NO	NO	NO	NO
Hungary	Natural Gas					50.10					51.56
	6. Exploration		NA	IE	IE	IE		NA	IE	IE	IE
	7. Production	Gas production (million m3)	million m^3	4874.00	1340.00	6.53	Gas production (million m3)	million m^3	1526.00	1340.00	2.04
	8. Processing	Sweet gas plants-raw gas feed (million m3)	million m^3	1593.00	940.86	1.50	Sweet gas plants-raw gas feed (million m3)	million m^3	534.10	935.14	0.50
	9. Transmission and storage	Pipeline length	km	4046.00	3873.43	15.67	Pipeline length	km	5889.00	2055.87	12.11
	10. Distribution	length of pipelines	km	22559.00	1170.00	26.39	length of pipelines	km	85059.00	433.86	36.90
	11. Other		NO	NO	NO	NO		NO	NO	NO	NO
Ireland	Natural Gas					0.88					2.52
	6. Exploration	Natural gas exploration	PJ	NO	NE	NE	Natural gas exploration	PJ	NO	NE	NE
	7. Production	Production (PJ)	PJ	78.58	0.32	0.00	Production (PJ)	PJ	52.68	22.97	0.00
	8. Processing		PJ	IE	IE	IE		PJ	IE	IE	IE
	9. Transmission and storage		PJ	78.93	1608.49	0.13		PJ	202.54	1773.22	0.36
	10. Distribution		PJ	37.35	20067.08	0.75		PJ	95.85	22526.86	2.16
	11. Other		PJ	NO	NO	NO		PJ	NO	NO	NO
Italy	Natural Gas					329.45					110.85
	6. Exploration	Wells explored	Number	36.00	158.15	0.01	Wells explored	Number	NO	NO	NO
	7. Production	Gas produced	Mm^3	17296.39	1726.36	29.86	Gas produced	Mm^3	3498.68	114.25	0.40
	8. Processing	Gas produced	Mm^3	17296.39	773.26	13.37	Gas produced	Mm^3	3498.68	51.16	0.18
	9. Transmission and storage	Gas transported	Mm^3	45683.58	822.12	37.56	Gas transported	Mm^3	75770.00	280.32	21.24
	10. Distribution	Gas distributed	Mm^3	20632.00	12051.86	248.65	Gas distributed	Mm^3	34213.40	2602.14	89.03
	11. Other	other	NA	NO	NO	NO	other	NA	NO	NO	NO
Lithua	Natural Gas					10.42					9.55
	7. Exploration		NO	NO	NO	NO		NO	NO	NO	NO

1.B.2.b Fugitive CH_4 Emissions from Natural gas		1990					2021				
	GHG source category	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)
		Description	Unit	Value			Description	Unit	Value		
	8. Production		NO	NO	NO	NO		NO	NO	NO	NO
	9. Processing		NO	NO	NO	NO		NO	NO	NO	NO
	10. Transmission and storage	Natural gas leakages	kt	2.01	977699.00	1.97	Natural gas leakages	kt	1.98	965743.00	1.91
	11. Distribution	Natural gas leakages	kt	8.65	977699.00	8.46	Natural gas leakages	kt	7.85	965743.00	7.58
	12. Other	Natural gas leakages	NO	NO	NO	NO	Natural gas leakages	NO	0.06	965743.00	0.06
Luxembourg	**Natural Gas**					**1.20**					**1.20**
	7. Exploration	gas exploration	NA	NO	NO	NO	gas exploration	NA	NO	NO	NO
	8. Production	gas produced	NA	NO	NO	NO	gas produced	NA	NO	NO	NO
	9. Processing	NO	NA	NO	NO	NO	NO	NA	NO	NO	NO
	10. Transmission and storage	gas consumed	TJ	28035.09	12.96	0.36	gas consumed	TJ	28035.09	12.96	0.36
	11. Distribution	gas consumed	TJ	28035.09	29.69	0.83	gas consumed	TJ	28035.09	29.69	0.83
	12. Other	NO	NA	NO	NO	NO	NO	NA	NO	NO	NO
Latvia	**Natural Gas**					**7.09**					**3.26**
	7. Exploration	Exploration	m^3	NO	NO	NO	Exploration	m^3	NO	NO	NO
	8. Production	Production	m^3	NO	NO	NO	Production	m^3	NO	NO	NO
	9. Processing	Processing	m^3	NO	NO	NO	Processing	m^3	NO	NO	NO
	10. Transmission and storage	Transmission and storage	m^3	125172.00	0.69	0.09	Transmission and storage	m^3	12252.00	0.68	0.01
	11. Distribution	Distribution	m^3	694188.00	0.69	0.48	Distribution	m^3	731110.00	0.65	0.48
	12. Other	Other	m^3	12435406.00	0.52	6.53	Other	m^3	4257635.00	0.65	2.78
Malta	**Natural Gas**					**NO**					**NO**
	8. Exploration	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	9. Production	gas produced	NO	NO	NO	NO	gas produced	NO	NO	NO	NO
	10. Processing	gas processed	no	NO	NO	NO	gas processed	no	NO	NO	NO
	11. Transmission and storage	gas consumed	NO	NO	NO	NO	gas consumed	NO	NO	NO	NO

1.B.2.b Fugitive CH_4 Emissions from Natural gas		**1990**					**2021**				
		Activity data					**Activity data**				
	GHG source category	**Description**	**Unit**	**Value**	**CH_4 IEF (kg/unit)**	**CH_4 EM (kt)**	**Description**	**Unit**	**Value**	**CH_4 IEF (kg/unit)**	**CH_4 EM (kt)**
	12. Distribution	gas consumed	NO	NO	NO	NO	gas consumed	NO	NO	NO	NO
	13. Other	gas consumed	NO	NO	NO	NO	gas consumed	NO	NO	NO	NO
Netherlands	**Natural Gas**					**16.84**					**9.42**
	8. Exploration		NA	NA	IE	IE		NA	NA	IE	IE
	9. Production	Gas produced	mln m^3	72131.00	IE	IE	Gas produced	mln m^3	20524.00	IE	IE
	10. Processing		NA	IE	IE	IE		NA	IE	IE	IE
	11. Transmission and storage	Gas transmitted	PJ	2648.08	4121.34	10.91	Gas transmitted	PJ	3029.00	1344.01	4.07
	12. Distribution	Length distribution network	10^3 km	99.98	59294.88	5.93	Length distribution network	10^3 km	125.12	42747.12	5.35
	13. Other		NO	NO	NO	NO		NO	NO	NO	NO
Poland	**Natural Gas**					**30.13**					**52.10**
	8. Exploration	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	9. Production	Production	10^6m^3	3218.20	2300.00	7.40	Production	10^6m^3	4312.90	2288.59	9.87
	10. Processing		10^6m^3	3218.20	1030.00	3.31		10^6m^3	4312.90	1030.00	4.44
	11. Transmission and storage	gas consumed	10^6m^3	12096.03	505.00	6.11	gas consumed	10^6m^3	23541.94	505.00	11.89
	12. Distribution	gas consumed	10^6m^3	12096.03	1100.00	13.31	gas consumed	10^6m^3	23541.94	1100.00	25.90
	13. Other	NA	NA	NO	NO	NO	NA	NA	NO	NO	NO
Portugal	**Natural Gas**					**NO**					**2.09**
	9. Exploration		NO	NO	NO	NO		NO	NO	NO	NO
	10. Production		NO	NO	NO	NO		NO	NO	NO	NO
	11. Processing		NO	NO	NO	NO		NO	NO	NO	NO
	12. Transmission and storage		toe NG Transmitted	NO	NO	NO		toe NG Transmitted	4902.18	10.92	0.05
	13. Distribution		toe NG Distributed	NO	NO	NO		toe NG Distributed	1771.36	1150.30	2.04
	14. Other		NO	NO	NO	NO		NO	NO	NO	NO
Roma	**Natural Gas**					**647.35**					**52.38**
	9. Exploration	gas produced	PJ	IE	IE	IE	gas produced	PJ	IE	IE	IE

1.B.2.b Fugitive CH_4 Emissions from Natural gas		1990					2021				
	GHG source category	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)	Activity data			CH_4 IEF (kg/unit)	CH_4 EM (kt)
		Description	Unit	Value			Description	Unit	Value		
	10. Production	gas produced	10^6m^3	28336.00	12190.00	345.42	gas produced	10^6m^3	8937.89	1340.00	11.98
	11. Processing	gas produced and processed	10^6m^3	28336.00	250.00	7.08	gas produced and processed	10^6m^3	8937.89	590.00	5.27
	12. Transmission and storage	gas produced	10^6m^3	35667.00	633.00	22.58	gas produced	10^6m^3	14130.39	244.43	3.45
	13. Distribution	gas supplied	10^6m^3	35667.00	1800.00	64.20	gas supplied	10^6m^3	12502.54	1100.00	13.75
	14. Other	gas consumed	PJ	809.19	257135.36	208.07	gas consumed	PJ	290.38	61724.70	17.92
Slovakia	**Natural Gas**					**44.14**					**7.57**
	9. Exploration		NA	NO	NO	NO		NA	NO	NO	NO
	10. Production	Production/Processing	mil m^3	444.00	2300.00	1.02	Production/Processing	mil m^3	65.33	2300.00	0.15
	11. Processing		mil m^3	444.00	1030.00	0.46		mil m^3	65.33	1030.00	0.07
	12. Transmission and storage	Transfer	mil m^3	73600.00	480.00	35.33	Transfer	mil m^3	40361.57	30.46	1.23
	13. Distribution	Distribution	mil m^3	6666.00	1100.00	7.33	Distribution	mil m^3	5471.00	1100.00	6.02
	14. Other	Storage	mil m3	1.00	25.00	0.00	Storage	mil m^3	4368.00	25.00	0.11
Slovenia	**Natural Gas**					**1.70**					**1.41**
	10. Exploration	NA	1000 m^3	NO	NO	NO	NA	1000 m^3	NO	NO	NO
	11. Production	Gas production	1000 m^3	23631.00	12.19	0.29	Gas production	1000 m^3	5066.00	1.34	0.01
	12. Processing	NA	1000 m^3	NO	NO	NO	NA	1000 m^3	NO	NO	NO
	13. Transmission and storage	Marketable gas	1000 m^3	892000.60	0.48	0.43	Marketable gas	1000 m^3	952166.00	0.37	0.35
	14. Distribution	Utility sale	1000 m^3	892000.60	1.10	0.98	Utility sale	1000 m^3	952166.00	1.10	1.05
	15. Other	NA	1000 m^3	NO	NO	NO	NA	1000 m^3	NO	NO	NO
Sweden	**Natural Gas**					**2.69**					**1.44**
	10. Exploration	Gas produced		NO	NO	NO	Gas produced		NO	NO	NO
	11. Production	Gas produced		NO	NO	NO	Gas produced		NO	NO	NO
	12. Processing	Gas produced		NO	NO	NO	Gas produced		NO	NO	NO
	13. Transmission and storage	Length of transmission pipelines	km	NA	NA	0.05	Length of transmission pipelines	km	NA	NA	0.08

1.B.2.b Fugitive CH_4 Emissions from Natural gas		**1990**					**2021**				
	GHG source category	**Activity data**			**CH_4 IEF (kg/unit)**	**CH_4 EM (kt)**	**Activity data**			**CH_4 IEF (kg/unit)**	**CH_4 EM (kt)**
		Description	**Unit**	**Value**			**Description**	**Unit**	**Value**		
	14. Distribution	Length of distribution pipelines	km	NA	NA	2.65	Length of distribution pipelines	km	NA	NA	1.36
	15. Other			NO	NO	NO			NO	NO	NO

3.2.6.3 CO_2 Emissions from Venting and Flaring (1.B.2.c)

Fugitive emissions from this source correspond to Emissions from venting and flaring of associated gas and waste gas/vapour streams at oil and gas facilities.

CO_2 emissions from 1.B.2.c – Venting and Flaring – account for 0.1% of total EU GHG emissions in 2021 and for 4 % of all fugitive emissions in the EU-27. Between 1990 and 2021 CO_2 emissions from this source decreased by 49 %.

All but three countries (Austria, Cyprus, Malta) - are reporting CO_2 emissions in this category.

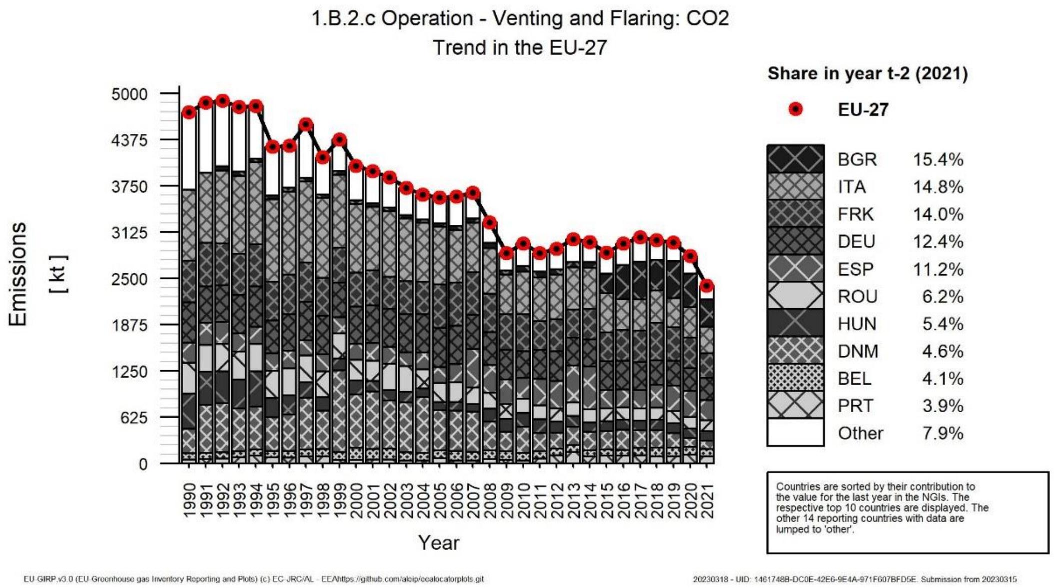
The emission decreases between 1990 and 2021 observed in the Netherlands (-96 %), Italy (-63 %), Germany (-45 %), Hungary (-72 %) and Romania (-65 %) contributed most significantly to the overall reduction in the EU-27 between 1990 and 2021.

Table 3.109: 1.B.2.c Fugitive CO_2 emissions from Other emissions: Countries' contributions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	IE	IE	IE	-	-	-	-	-	NA	NA
Belgium	84	101	98	4.1%	14	17%	-3	-3%	T3	PS
Bulgaria	NO,IE	454	369	15.4%	369	∞	-85	-19%	T1	D
Croatia	0	0	0	0.0%	0	-97%	0	-47%	T1	D
Cyprus	NO,NE	NO	NO	-	-	-	-	-	NA	NA
Czechia	2	4	3	0.1%	1	71%	0	-9%	T1	D
Denmark	328	126	111	4.6%	-217	-66%	-15	-12%	T3	PS
Estonia	0	0	0	0.0%	0	-68%	0	13%	T1	D
Finland	111	76	68	2.8%	-43	-39%	-8	-11%	CS	CS
France	560	406	335	14.0%	-225	-40%	-71	-17%	T1,T2,T3	CS,D,PS
Germany	544	311	298	12.4%	-245	-45%	-13	-4%	T2	CS
Greece	43	5	3	0.1%	-40	-93%	-2	-36%	T1	D
Hungary	471	132	130	5.4%	-341	-72%	-2	-1%	T1,T3	CS,D
Ireland	NO	0	0	0.0%	0	∞	0	35%	CS,T3	CS,PS
Italy	956	418	356	14.8%	-599	-63%	-61	-15%	T1	D
Latvia	0	0	0	0.0%	0	-2%	0	-4%	T3	CS
Lithuania	1	1	1	0.1%	1	129%	0	-11%	T1	D
Luxembourg	0	0	0	0.0%	0	51%	0	18%	CS	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	774	33	29	1.2%	-746	-96%	-4	-12%	T2	PS
Poland	44	81	85	3.5%	41	95%	4	4%	T1	D
Portugal	52	116	94	3.9%	41	79%	-22	-19%	NO	NO
Romania	424	155	150	6.2%	-274	-65%	-6	-4%	T1	D
Slovakia	5	1	1	0.0%	-4	-89%	0	-11%	T1	CS
Slovenia	0	0	0	0.0%	0	-90%	0	-26%	T1	D
Spain	275	345	269	11.2%	-6	-2%	-76	-22%	CS,T1,T2	CS,D,PS
Sweden	73	37	0	0.0%	-73	-100%	-37	-100%	T2	CS
EU-27	**4 745**	**2 802**	**2 401**	**100%**	**-2 344**	**-49%**	**-401**	**-14%**	**-**	**-**

Note: Austria includes CO_2 emissions from venting and flaring in 1.A.1b Petroleum refining

Figure 3.184: 1.B.2.c Venting and Flaring: Emission trend and share for the emitting countries of CO_2



3.2.6.4 Emissions from Other (1.B.2.d)

Fugitive emissions from other correspond to emissions from geothermal energy production and all other energy production that are not included in categories 1.B.1 and 1.B.2.

Six countries report CO_2 emissions in this sector, three are reporting CH_4 emissions and two countries report N_2O emissions. The description of the subcategories is presented inTable 3.110.

Table 3.110 Description of subcategories in sector 1.B.2.d for CO_2-, N_2O- and CH_4-emissions for reporting countries

Member state	Emission	Subcategory
Finland	CO_2, CH_4	Distribution of town gas
Greece	CO_2, N_2O	LPG transport
Hungary	CH_4, CO_2	Groundwater extraction and CO_2 mining
Italy	CH_4, CO_2, N_2O	Flaring in refineries
Poland	CO_2	Underground storage of gas
Portugal	CO_2	Geothermal

3.2.7 CO_2 capture and storage (1.C)

CO_2 capture and storage is not an EU key category (see Annex 1.1). Finland is the only Member State reporting captured CO_2 emissions in this category for the years 1993 to 2021.

The amount of CO_2 captured reflects the CO_2 captured in pulp and paper mills in Finland, where precipitated calcium carbonate (PCC) is formed and then used in the paper and paperboard industry. The final use of the CO_2 captured is considered as long-term storage except if the products are combusted. The resulting fossil CO_2 emissions from combustion of products containing PCC are taken into account in the corresponding categories in the greenhouse gas inventory of Finland. A detailed description of the methodology is provided in Finland's NIR.

Captured CO_2 emissions reported in 1C 'CO_2 capture and storage' correspond to 0.003 % of total EU-27 GHG emissions in 2021. The emissions captured increased between 1993 and 2021 by 11 167 %.

3.2.8 Energy – non-key categories

Table 3.111 provides an overview on the role of non-key categories in the Energy sector.

Table 3.111 Aggregated GHG emission from non-key categories in the energy sector

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.1.a Public Electricity and Heat Production: Biomass (CH_4)	39.3	1 973.9	2 018.1	0.08%	1 978.8	5041%	44.2	2%
1.A.1.a Public Electricity and Heat Production: Biomass (N_2O)	202.1	1 288.2	1 404.6	0.05%	1 202.5	595%	116.4	9%
1.A.1.a Public Electricity and Heat Production: Gaseous Fuels (CH_4)	180.3	1 281.4	1 294.5	0.05%	1 114.2	618%	13.2	1%
1.A.1.a Public Electricity and Heat Production: Gaseous Fuels (N_2O)	134.2	710.2	685.9	0.03%	551.6	411%	-24.3	-3%
1.A.1.a Public Electricity and Heat Production: Liquid Fuels (CH_4)	157.2	23.1	25.6	0.00%	-131.6	-84%	2.5	11%
1.A.1.a Public Electricity and Heat Production: Liquid Fuels (N_2O)	332.5	57.7	64.9	0.00%	-267.6	-80%	7.2	12%
1.A.1.a Public Electricity and Heat Production: Other Fuels (CH_4)	17.7	44.9	45.5	0.00%	27.9	158%	0.6	1%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.1.a Public Electricity and Heat Production: Other Fuels (N_2O)	116.6	298.6	299.1	0.01%	182.6	157%	0.5	0%
1.A.1.a Public Electricity and Heat Production: Peat (CH_4)	9.2	6.8	5.8	0.00%	-3.5	-37%	-1.0	-15%
1.A.1.a Public Electricity and Heat Production: Peat (N_2O)	110.3	61.8	47.5	0.00%	-62.9	-57%	-14.3	-23%
1.A.1.a Public Electricity and Heat Production: Solid Fuels (CH_4)	193.3	67.6	77.7	0.00%	-115.6	-60%	10.1	15%
1.A.1.a Public Electricity and Heat Production: Solid Fuels (N_2O)	4 387.0	1 838.1	2 153.0	0.08%	-2 233.9	-51%	315.0	17%
1.A.1.b Petroleum Refining: Biomass (CH_4)	2.1	0.1	0.1	0.00%	-2.0	-95%	0.0	-5%
1.A.1.b Petroleum Refining: Biomass (N_2O)	3.1	1.2	1.1	0.00%	-2.0	-65%	-0.1	-9%
1.A.1.b Petroleum Refining: Gaseous Fuels (CH_4)	6.3	24.4	20.8	0.00%	14.5	229%	-3.5	-15%
1.A.1.b Petroleum Refining: Gaseous Fuels (N_2O)	120.3	46.6	38.5	0.00%	-81.8	-68%	-8.1	-17%
1.A.1.b Petroleum Refining: Liquid Fuels (CH_4)	68.6	44.3	55.7	0.00%	-12.9	-19%	11.4	26%
1.A.1.b Petroleum Refining: Liquid Fuels (N_2O)	248.2	214.3	206.3	0.01%	-41.9	-17%	-8.0	-4%
1.A.1.b Petroleum Refining: Other Fuels (CH_4)	6.5	0.1	0.2	0.00%	-6.3	-97%	0.0	14%
1.A.1.b Petroleum Refining: Other Fuels (CO_2)	920.7	276.1	34.1	0.00%	-886.6	-96%	-242.0	-88%
1.A.1.b Petroleum Refining: Other Fuels (N_2O)	8.6	0.4	0.5	0.00%	-8.1	-95%	0.1	20%
1.A.1.b Petroleum Refining: Peat (CH_4)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.1.b Petroleum Refining: Peat (CO_2)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.1.b Petroleum Refining: Peat (N_2O)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.1.b Petroleum Refining: Solid Fuels (CH_4)	0.6	0.0	0.0	0.00%	-0.6	-98%	0.0	-6%
1.A.1.b Petroleum Refining: Solid Fuels (CO_2)	3 633.0	94.2	97.6	0.00%	-3 535.4	-97%	3.4	4%
1.A.1.b Petroleum Refining: Solid Fuels (N_2O)	26.6	0.4	0.4	0.00%	-26.2	-99%	0.0	3%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Biomass (CH_4)	92.0	145.9	139.9	0.01%	47.9	52%	-6.0	-4%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Biomass (N_2O)	3.4	43.5	41.3	0.00%	37.9	1114%	-2.2	-5%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Gaseous Fuels (CH_4)	76.3	50.0	56.4	0.00%	-19.9	-26%	6.4	13%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Gaseous Fuels (N_2O)	15.9	25.2	25.1	0.00%	9.1	57%	-0.2	-1%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Liquid Fuels (CH_4)	3.8	1.2	1.3	0.00%	-2.5	-65%	0.1	11%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Liquid Fuels (CO_2)	3 136.5	1 125.7	1 230.6	0.05%	-1 905.9	-61%	104.9	9%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Liquid Fuels (N_2O)	12.7	2.2	2.5	0.00%	-10.2	-81%	0.3	12%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Other Fuels (CH_4)	5.5	0.0	0.0	0.00%	-5.5	-100%	0.0	-23%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Other Fuels (CO_2)	456.1	0.1	0.1	0.00%	-456.0	-100%	0.0	-23%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Other Fuels (N_2O)	8.1	0.0	0.0	0.00%	-8.1	-100%	0.0	-23%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Peat (CH_4)	0.1	0.0	0.0	0.00%	0.0	-43%	0.0	9%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Peat (CO_2)	175.5	71.0	77.5	0.00%	-97.9	-56%	6.6	9%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Peat (N_2O)	0.6	0.2	0.3	0.00%	-0.3	-56%	0.0	9%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Solid Fuels (CH_4)	174.2	17.3	17.6	0.00%	-156.6	-90%	0.4	2%
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries: Solid Fuels (N_2O)	612.8	108.2	88.6	0.00%	-524.2	-86%	-19.6	-18%
1.A.2.a Iron and Steel: Biomass (CH_4)	0.3	0.6	0.5	0.00%	0.2	60%	-0.1	-24%
1.A.2.a Iron and Steel: Biomass (N_2O)	0.4	0.9	0.8	0.00%	0.4	106%	-0.1	-16%
1.A.2.a Iron and Steel: Gaseous Fuels (CH_4)	20.6	19.2	17.6	0.00%	-3.0	-14%	-1.5	-8%
1.A.2.a Iron and Steel: Gaseous Fuels (N_2O)	111.0	37.8	39.5	0.00%	-71.6	-64%	1.6	4%
1.A.2.a Iron and Steel: Liquid Fuels (CH_4)	13.9	0.4	0.5	0.00%	-13.4	-96%	0.1	19%
1.A.2.a Iron and Steel: Liquid Fuels (N_2O)	25.6	1.8	2.0	0.00%	-23.6	-92%	0.2	11%
1.A.2.a Iron and Steel: Other Fuels (CH_4)	4.1	0.0	0.0	0.00%	-4.1	-99%	0.0	-46%
1.A.2.a Iron and Steel: Other Fuels (CO_2)	652.9	34.3	11.7	0.00%	-641.2	-98%	-22.7	-66%
1.A.2.a Iron and Steel: Other Fuels (N_2O)	5.2	0.1	0.0	0.00%	-5.2	-99%	0.0	-52%
1.A.2.a Iron and Steel: Peat (CH_4)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.2.a Iron and Steel: Peat (CO_2)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.2.a Iron and Steel: Peat (N_2O)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.2.a Iron and Steel: Solid Fuels (CH_4)	240.1	113.2	134.3	0.01%	-105.7	-44%	21.2	19%
1.A.2.a Iron and Steel: Solid Fuels (N_2O)	297.3	123.6	149.1	0.01%	-148.2	-50%	25.5	21%
1.A.2.b Non-Ferrous Metals: Biomass (CH_4)	0.0	1.2	1.2	0.00%	1.2	34636%	0.0	2%
1.A.2.b Non-Ferrous Metals: Biomass (N_2O)	0.0	1.5	1.6	0.00%	1.6	35978%	0.0	2%
1.A.2.b Non-Ferrous Metals: Gaseous Fuels (CH_4)	2.2	18.5	43.6	0.00%	41.4	1854%	25.1	136%
1.A.2.b Non-Ferrous Metals: Gaseous Fuels (N_2O)	4.1	7.8	9.1	0.00%	4.9	119%	1.3	17%
1.A.2.b Non-Ferrous Metals: Liquid Fuels (CH_4)	4.4	0.8	0.7	0.00%	-3.7	-84%	-0.1	-13%
1.A.2.b Non-Ferrous Metals: Liquid Fuels (CO_2)	4 400.5	928.4	837.2	0.03%	-3 563.3	-81%	-91.1	-10%
1.A.2.b Non-Ferrous Metals: Liquid Fuels (N_2O)	11.0	3.2	2.7	0.00%	-8.3	-76%	-0.6	-17%
1.A.2.b Non-Ferrous Metals: Other Fuels (CH_4)	0.4	0.0	0.0	0.00%	-0.4	-100%	0.0	-58%
1.A.2.b Non-Ferrous Metals: Other Fuels (CO_2)	64.9	0.9	0.4	0.00%	-64.5	-99%	-0.5	-56%
1.A.2.b Non-Ferrous Metals: Other Fuels (N_2O)	0.5	0.0	0.0	0.00%	-0.5	-98%	0.0	-49%
1.A.2.b Non-Ferrous Metals: Peat (CH_4)	0.0	0.0	0.0	0.00%	0.0	-100%	0.0	0%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.2.b Non-Ferrous Metals: Peat (CO_2)	6.5	0.0	0.0	0.00%	-6.5	-100%	0.0	0%
1.A.2.b Non-Ferrous Metals: Peat (N_2O)	0.0	0.0	0.0	0.00%	0.0	-100%	0.0	0%
1.A.2.b Non-Ferrous Metals: Solid Fuels (CH_4)	9.8	2.5	2.6	0.00%	-7.2	-74%	0.1	3%
1.A.2.b Non-Ferrous Metals: Solid Fuels (CO_2)	4 702.3	1 088.1	1 097.2	0.04%	-3 605.1	-77%	9.1	1%
1.A.2.b Non-Ferrous Metals: Solid Fuels (N_2O)	25.6	4.2	4.4	0.00%	-21.2	-83%	0.2	4%
1.A.2.c Chemicals: Biomass (CH_4)	1.8	14.0	12.5	0.00%	10.7	597%	-1.4	-10%
1.A.2.c Chemicals: Biomass (N_2O)	7.6	21.8	20.0	0.00%	12.4	163%	-1.8	-8%
1.A.2.c Chemicals: Gaseous Fuels (CH_4)	55.8	399.3	418.3	0.02%	362.6	650%	19.0	5%
1.A.2.c Chemicals: Gaseous Fuels (N_2O)	40.5	46.7	48.1	0.00%	7.5	19%	1.3	3%
1.A.2.c Chemicals: Liquid Fuels (CH_4)	45.8	21.4	23.5	0.00%	-22.3	-49%	2.1	10%
1.A.2.c Chemicals: Liquid Fuels (N_2O)	133.4	43.0	58.3	0.00%	-75.1	-56%	15.3	36%
1.A.2.c Chemicals: Other Fuels (CH_4)	17.1	7.9	8.4	0.00%	-8.7	-51%	0.5	6%
1.A.2.c Chemicals: Other Fuels (CO_2)	3 041.2	1 294.8	1 514.9	0.06%	-1 526.3	-50%	220.1	17%
1.A.2.c Chemicals: Other Fuels (N_2O)	24.1	15.5	17.2	0.00%	-6.9	-29%	1.8	11%
1.A.2.c Chemicals: Peat (CH_4)	0.2	0.0	0.0	0.00%	-0.2	-100%	0.0	0%
1.A.2.c Chemicals: Peat (CO_2)	191.1	0.0	0.0	0.00%	-191.1	-100%	0.0	0%
1.A.2.c Chemicals: Peat (N_2O)	3.4	0.0	0.0	0.00%	-3.4	-100%	0.0	0%
1.A.2.c Chemicals: Solid Fuels (CH_4)	28.2	22.0	26.4	0.00%	-1.7	-6%	4.4	20%
1.A.2.c Chemicals: Solid Fuels (N_2O)	63.3	31.2	37.5	0.00%	-25.7	-41%	6.3	20%
1.A.2.d Pulp, Paper and Print: Biomass (CH_4)	52.0	133.3	123.7	0.00%	71.7	138%	-9.7	-7%
1.A.2.d Pulp, Paper and Print: Biomass (N_2O)	171.8	321.6	319.6	0.01%	147.8	86%	-2.1	-1%
1.A.2.d Pulp, Paper and Print: Gaseous Fuels (CH_4)	35.8	122.8	136.2	0.01%	100.4	281%	13.3	11%
1.A.2.d Pulp, Paper and Print: Gaseous Fuels (N_2O)	25.6	41.2	43.4	0.00%	17.8	69%	2.1	5%
1.A.2.d Pulp, Paper and Print: Liquid Fuels (CH_4)	13.2	7.4	7.5	0.00%	-5.7	-43%	0.1	1%
1.A.2.d Pulp, Paper and Print: Liquid Fuels (N_2O)	32.5	5.0	4.7	0.00%	-27.8	-85%	-0.3	-5%
1.A.2.d Pulp, Paper and Print: Other Fuels (CH_4)	0.4	3.5	3.5	0.00%	3.2	895%	0.1	2%
1.A.2.d Pulp, Paper and Print: Other Fuels (CO_2)	57.8	451.6	461.9	0.02%	404.1	699%	10.2	2%
1.A.2.d Pulp, Paper and Print: Other Fuels (N_2O)	0.6	5.3	5.5	0.00%	4.9	842%	0.2	3%
1.A.2.d Pulp, Paper and Print: Peat (CH_4)	0.7	0.5	0.4	0.00%	-0.2	-36%	-0.1	-16%
1.A.2.d Pulp, Paper and Print: Peat (CO_2)	1 117.6	692.2	590.2	0.02%	-527.4	-47%	-102.0	-15%
1.A.2.d Pulp, Paper and Print: Peat (N_2O)	8.7	4.7	4.0	0.00%	-4.8	-55%	-0.8	-16%
1.A.2.d Pulp, Paper and Print: Solid Fuels (CH_4)	15.7	4.6	4.6	0.00%	-11.1	-71%	0.0	0%
1.A.2.d Pulp, Paper and Print: Solid Fuels (N_2O)	35.3	20.5	25.3	0.00%	-10.1	-28%	4.7	23%
1.A.2.e Food Processing, Beverages and Tobacco: Biomass (CH_4)	7.7	284.9	282.6	0.01%	274.9	3569%	-2.3	-1%
1.A.2.e Food Processing, Beverages and Tobacco: Biomass (N_2O)	15.7	100.8	97.6	0.00%	81.9	521%	-3.3	-3%
1.A.2.e Food Processing, Beverages and Tobacco: Gaseous Fuels (CH_4)	21.0	216.4	249.1	0.01%	228.1	1088%	32.7	15%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.2.e Food Processing, Beverages and Tobacco: Gaseous Fuels (N_2O)	15.0	29.9	32.5	0.00%	17.5	116%	2.6	9%
1.A.2.e Food Processing, Beverages and Tobacco: Liquid Fuels (CH_4)	18.3	3.0	2.1	0.00%	-16.1	-88%	-0.8	-28%
1.A.2.e Food Processing, Beverages and Tobacco: Liquid Fuels (N_2O)	65.9	9.9	9.0	0.00%	-56.8	-86%	-0.9	-9%
1.A.2.e Food Processing, Beverages and Tobacco: Other Fuels (CH_4)	0.0	0.2	0.3	0.00%	0.2	711%	0.0	7%
1.A.2.e Food Processing, Beverages and Tobacco: Other Fuels (CO_2)	4.8	24.8	85.5	0.00%	80.7	1692%	60.8	245%
1.A.2.e Food Processing, Beverages and Tobacco: Other Fuels (N_2O)	0.0	0.3	0.3	0.00%	0.3	634%	0.0	7%
1.A.2.e Food Processing, Beverages and Tobacco: Peat (CH_4)	0.3	0.0	0.0	0.00%	-0.3	-100%	0.0	0%
1.A.2.e Food Processing, Beverages and Tobacco: Peat (CO_2)	139.1	0.0	0.0	0.00%	-139.1	-100%	0.0	0%
1.A.2.e Food Processing, Beverages and Tobacco: Peat (N_2O)	1.3	0.0	0.0	0.00%	-1.3	-100%	0.0	0%
1.A.2.e Food Processing, Beverages and Tobacco: Solid Fuels (CH_4)	32.3	10.2	10.4	0.00%	-21.9	-68%	0.2	2%
1.A.2.e Food Processing, Beverages and Tobacco: Solid Fuels (N_2O)	55.7	16.4	16.5	0.00%	-39.2	-70%	0.1	1%
1.A.2.f Non-metallic minerals: Biomass (CH_4)	24.5	57.4	60.6	0.00%	36.1	147%	3.1	5%
1.A.2.f Non-metallic minerals: Biomass (N_2O)	52.9	105.8	119.2	0.00%	66.3	125%	13.4	13%
1.A.2.f Non-metallic minerals: Gaseous Fuels (CH_4)	30.0	85.1	98.0	0.00%	68.0	227%	12.9	15%
1.A.2.f Non-metallic minerals: Gaseous Fuels (N_2O)	122.2	122.8	141.1	0.01%	18.9	15%	18.2	15%
1.A.2.f Non-metallic minerals: Liquid Fuels (CH_4)	59.5	25.8	29.9	0.00%	-29.6	-50%	4.1	16%
1.A.2.f Non-metallic minerals: Liquid Fuels (N_2O)	635.0	261.7	321.0	0.01%	-314.0	-49%	59.2	23%
1.A.2.f Non-metallic minerals: Other Fuels (CH_4)	4.9	88.2	90.8	0.00%	85.9	1771%	2.5	3%
1.A.2.f Non-metallic minerals: Other Fuels (N_2O)	12.5	180.9	189.8	0.01%	177.3	1419%	8.9	5%
1.A.2.f Non-metallic minerals: Peat (CH_4)	0.0	0.0	0.0	0.00%	0.0	-100%	0.0	-100%
1.A.2.f Non-metallic minerals: Peat (CO_2)	26.9	0.1	0.0	0.00%	-26.9	-100%	-0.1	-100%
1.A.2.f Non-metallic minerals: Peat (N_2O)	0.1	0.0	0.0	0.00%	-0.1	-100%	0.0	-100%
1.A.2.f Non-metallic minerals: Solid Fuels (CH_4)	138.7	29.6	29.7	0.00%	-108.9	-79%	0.1	0%
1.A.2.f Non-metallic minerals: Solid Fuels (N_2O)	393.0	117.3	91.8	0.00%	-301.2	-77%	-25.4	-22%
1.A.2.g Other Manufacturing Industries and Constructions: Biomass (CH_4)	100.9	201.4	210.6	0.01%	109.7	109%	9.2	5%
1.A.2.g Other Manufacturing Industries and Constructions: Biomass (N_2O)	173.1	326.7	349.1	0.01%	176.0	102%	22.4	7%
1.A.2.g Other Manufacturing Industries and Constructions: Gaseous Fuels (CH_4)	80.2	393.0	412.0	0.02%	331.8	414%	19.0	5%
1.A.2.g Other Manufacturing Industries and Constructions: Gaseous Fuels (N_2O)	140.8	240.1	250.1	0.01%	109.3	78%	10.0	4%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.2.g Other Manufacturing Industries and Constructions: Liquid Fuels (CH_4)	111.8	33.5	32.9	0.00%	-78.9	-71%	-0.6	-2%
1.A.2.g Other Manufacturing Industries and Constructions: Liquid Fuels (N_2O)	966.7	635.0	714.3	0.03%	-252.4	-26%	79.3	12%
1.A.2.g Other Manufacturing Industries and Constructions: Other Fuels (CH_4)	13.3	6.2	6.2	0.00%	-7.2	-54%	0.0	0%
1.A.2.g Other Manufacturing Industries and Constructions: Other Fuels (N_2O)	25.7	48.9	47.1	0.00%	21.4	83%	-1.8	-4%
1.A.2.g Other Manufacturing Industries and Constructions: Peat (CH_4)	0.1	0.0	0.0	0.00%	0.0	-38%	0.0	49%
1.A.2.g Other Manufacturing Industries and Constructions: Peat (CO_2)	21.5	12.8	28.5	0.00%	7.0	33%	15.7	123%
1.A.2.g Other Manufacturing Industries and Constructions: Peat (N_2O)	0.2	0.1	0.2	0.00%	0.0	-21%	0.1	127%
1.A.2.g Other Manufacturing Industries and Constructions: Solid Fuels (CH_4)	122.7	8.8	9.0	0.00%	-113.6	-93%	0.2	3%
1.A.2.g Other Manufacturing Industries and Constructions: Solid Fuels (N_2O)	645.5	136.4	130.8	0.00%	-514.7	-80%	-5.6	-4%
1.A.3.a Domestic Aviation: Aviation Gasoline (CH_4)	1.8	0.4	0.5	0.00%	-1.3	-72%	0.1	23%
1.A.3.a Domestic Aviation: Aviation Gasoline (CO_2)	428.5	133.4	148.2	0.01%	-280.3	-65%	14.8	11%
1.A.3.a Domestic Aviation: Aviation Gasoline (N_2O)	6.4	2.3	2.9	0.00%	-3.5	-55%	0.7	29%
1.A.3.a Domestic Aviation: Biomass (CH_4)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	492%
1.A.3.a Domestic Aviation: Biomass (N_2O)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	510%
1.A.3.a Domestic Aviation: Jet Kerosene (CH_4)	6.9	3.7	4.5	0.00%	-2.4	-34%	0.8	21%
1.A.3.a Domestic Aviation: Jet Kerosene (N_2O)	94.5	59.6	73.0	0.00%	-21.5	-23%	13.4	23%
1.A.3.b Road Transportation: Biomass (CH_4)	0.0	56.9	63.1	0.00%	63.1	678536%	6.2	11%
1.A.3.b Road Transportation: Biomass (N_2O)	0.1	406.0	429.4	0.02%	429.3	341006%	23.4	6%
1.A.3.b Road Transportation: Diesel Oil (CH_4)	540.1	189.6	191.8	0.01%	-348.3	-64%	2.1	1%
1.A.3.b Road Transportation: Gaseous Fuels (CH_4)	12.6	68.0	87.6	0.00%	75.1	598%	19.7	29%
1.A.3.b Road Transportation: Gaseous Fuels (N_2O)	1.3	18.8	22.9	0.00%	21.6	1654%	4.0	21%
1.A.3.b Road Transportation: Gasoline (N_2O)	3 394.6	483.9	509.0	0.02%	-2 885.6	-85%	25.1	5%
1.A.3.b Road Transportation: Liquefied Petroleum Gases (LPG) (CH_4)	47.2	54.6	57.6	0.00%	10.3	22%	3.0	5%
1.A.3.b Road Transportation: Liquefied Petroleum Gases (LPG) (N_2O)	15.6	77.6	81.1	0.00%	65.4	418%	3.5	5%
1.A.3.b Road Transportation: Other Fuels (CH_4)	0.0	5.6	6.7	0.00%	6.7	100%	1.1	19%
1.A.3.b Road Transportation: Other Fuels (N_2O)	0.0	13.3	15.0	0.00%	15.0	100%	1.7	12%
1.A.3.b Road Transportation: Other Liquid Fuels (CH_4)	1.1	0.1	0.1	0.00%	-1.0	-93%	0.0	0%
1.A.3.b Road Transportation: Other Liquid Fuels (CO_2)	439.9	56.7	61.1	0.00%	-378.7	-86%	4.5	8%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.3.b Road Transportation: Other Liquid Fuels (N_2O)	0.3	0.1	0.1	0.00%	-0.2	-70%	0.0	9%
1.A.3.c Railways: Biomass (CH_4)	0.0	0.2	0.2	0.00%	0.2	1694283%	0.0	17%
1.A.3.c Railways: Biomass (N_2O)	0.0	1.7	1.8	0.00%	1.8	#########	0.1	6%
1.A.3.c Railways: Gaseous Fuels (CH_4)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	0%
1.A.3.c Railways: Gaseous Fuels (CO_2)	0.0	6.4	7.1	0.00%	7.1	100%	0.7	12%
1.A.3.c Railways: Gaseous Fuels (N_2O)	0.0	0.1	0.1	0.00%	0.1	100%	0.0	12%
1.A.3.c Railways: Liquid Fuels (CH_4)	19.1	4.9	5.1	0.00%	-14.0	-73%	0.2	4%
1.A.3.c Railways: Liquid Fuels (N_2O)	596.4	161.5	166.8	0.01%	-429.6	-72%	5.3	3%
1.A.3.c Railways: Other Fuels (CH_4)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	17%
1.A.3.c Railways: Other Fuels (CO_2)	0.0	5.3	5.0	0.00%	5.0	100%	-0.3	-6%
1.A.3.c Railways: Other Fuels (N_2O)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	17%
1.A.3.c Railways: Solid Fuels (CH_4)	17.1	0.5	0.6	0.00%	-16.4	-96%	0.1	32%
1.A.3.c Railways: Solid Fuels (CO_2)	661.6	30.0	32.1	0.00%	-629.5	-95%	2.1	7%
1.A.3.c Railways: Solid Fuels (N_2O)	2.8	0.1	0.1	0.00%	-2.7	-95%	0.0	6%
1.A.3.d Domestic Navigation: Biomass (CH_4)	0.0	2.9	4.4	0.00%	4.4	100%	1.5	51%
1.A.3.d Domestic Navigation: Biomass (N_2O)	0.0	1.4	1.6	0.00%	1.6	100%	0.2	16%
1.A.3.d Domestic Navigation: Gas/Diesel Oil (CH_4)	25.6	17.0	18.5	0.00%	-7.1	-28%	1.5	9%
1.A.3.d Domestic Navigation: Gas/Diesel Oil (N_2O)	192.7	131.2	151.7	0.01%	-41.0	-21%	20.5	16%
1.A.3.d Domestic Navigation: Gaseous Fuels (CH_4)	0.0	30.2	37.6	0.00%	37.6	100%	7.4	24%
1.A.3.d Domestic Navigation: Gaseous Fuels (CO_2)	0.0	110.7	144.4	0.01%	144.4	100%	33.7	30%
1.A.3.d Domestic Navigation: Gaseous Fuels (N_2O)	0.0	0.4	0.5	0.00%	0.5	100%	0.1	34%
1.A.3.d Domestic Navigation: Gasoline (CH_4)	48.7	34.3	34.3	0.00%	-14.4	-30%	0.0	0%
1.A.3.d Domestic Navigation: Gasoline (CO_2)	1 543.2	1 374.0	1 379.6	0.05%	-163.6	-11%	5.6	0%
1.A.3.d Domestic Navigation: Gasoline (N_2O)	5.9	7.0	7.1	0.00%	1.1	19%	0.1	1%
1.A.3.d Domestic Navigation: Other Fuels (CH_4)	0.0	0.7	0.7	0.00%	0.7	100%	0.0	5%
1.A.3.d Domestic Navigation: Other Fuels (CO_2)	0.0	30.7	32.4	0.00%	32.4	100%	1.7	5%
1.A.3.d Domestic Navigation: Other Fuels (N_2O)	0.0	0.2	0.2	0.00%	0.2	100%	0.0	5%
1.A.3.d Domestic Navigation: Other Liquid Fuels (CH_4)	0.1	0.3	0.3	0.00%	0.1	109%	0.0	-1%
1.A.3.d Domestic Navigation: Other Liquid Fuels (CO_2)	5.7	37.8	35.5	0.00%	29.8	522%	-2.3	-6%
1.A.3.d Domestic Navigation: Other Liquid Fuels (N_2O)	0.0	0.2	0.2	0.00%	0.2	465%	0.0	-5%
1.A.3.d Domestic Navigation: Residual Fuel Oil (CH_4)	16.2	14.3	11.1	0.00%	-5.0	-31%	-3.1	-22%
1.A.3.d Domestic Navigation: Residual Fuel Oil (N_2O)	49.7	40.7	32.6	0.00%	-17.1	-34%	-8.1	-20%
1.A.3.e Other Transportation: Biomass (CH_4)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	-17%
1.A.3.e Other Transportation: Biomass (N_2O)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	19%
1.A.3.e Other Transportation: Gaseous Fuels (CH_4)	11.1	7.3	8.1	0.00%	-3.0	-27%	0.8	12%
1.A.3.e Other Transportation: Gaseous Fuels (CO_2)	4 591.5	3 934.1	3 943.3	0.15%	-648.2	-14%	9.2	0%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.3.e Other Transportation: Gaseous Fuels (N_2O)	21.0	17.4	20.0	0.00%	-1.0	-5%	2.6	15%
1.A.3.e Other Transportation: Liquid Fuels (CH_4)	2.1	0.3	0.3	0.00%	-1.8	-84%	0.0	11%
1.A.3.e Other Transportation: Liquid Fuels (CO_2)	1 339.3	664.7	707.7	0.03%	-631.6	-47%	43.0	6%
1.A.3.e Other Transportation: Liquid Fuels (N_2O)	30.6	10.1	11.0	0.00%	-19.6	-64%	1.0	10%
1.A.3.e Other Transportation: Other Fuels (CH_4)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.3.e Other Transportation: Other Fuels (CO_2)	0.0	1.6	1.1	0.00%	1.1	100%	-0.4	-28%
1.A.3.e Other Transportation: Other Fuels (N_2O)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.3.e Other Transportation: Solid Fuels (CH_4)	0.5	0.0	0.0	0.00%	-0.5	-100%	0.0	0%
1.A.3.e Other Transportation: Solid Fuels (CO_2)	54.7	0.0	0.0	0.00%	-54.7	-100%	0.0	0%
1.A.3.e Other Transportation: Solid Fuels (N_2O)	0.6	0.0	0.0	0.00%	-0.6	-100%	0.0	0%
1.A.4.a Commercial/Institutional: Biomass (CH_4)	160.4	442.1	474.9	0.02%	314.5	196%	32.8	7%
1.A.4.a Commercial/Institutional: Biomass (N_2O)	37.2	156.2	168.9	0.01%	131.7	354%	12.7	8%
1.A.4.a Commercial/Institutional: Gaseous Fuels (CH_4)	101.7	203.6	223.5	0.01%	121.9	120%	20.0	10%
1.A.4.a Commercial/Institutional: Gaseous Fuels (N_2O)	87.1	140.6	154.0	0.01%	66.9	77%	13.4	9%
1.A.4.a Commercial/Institutional: Liquid Fuels (CH_4)	147.9	78.0	82.9	0.00%	-64.9	-44%	5.0	6%
1.A.4.a Commercial/Institutional: Liquid Fuels (N_2O)	259.0	99.6	99.0	0.00%	-160.1	-62%	-0.6	-1%
1.A.4.a Commercial/Institutional: Other Fuels (CH_4)	9.5	31.3	32.7	0.00%	23.2	245%	1.4	4%
1.A.4.a Commercial/Institutional: Other Fuels (N_2O)	16.0	144.7	141.6	0.01%	125.6	787%	-3.1	-2%
1.A.4.a Commercial/Institutional: Peat (CH_4)	0.7	0.2	0.2	0.00%	-0.5	-71%	0.0	19%
1.A.4.a Commercial/Institutional: Peat (CO_2)	232.8	28.6	33.7	0.00%	-199.1	-86%	5.1	18%
1.A.4.a Commercial/Institutional: Peat (N_2O)	0.9	0.1	0.2	0.00%	-0.8	-80%	0.0	24%
1.A.4.a Commercial/Institutional: Solid Fuels (CH_4)	1 640.7	8.8	10.3	0.00%	-1 630.5	-99%	1.5	17%
1.A.4.a Commercial/Institutional: Solid Fuels (N_2O)	128.9	12.2	14.5	0.00%	-114.5	-89%	2.2	18%
1.A.4.b Residential: Biomass (N_2O)	1 516.0	2 357.6	2 551.1	0.10%	1 035.2	68%	193.6	8%
1.A.4.b Residential: Gaseous Fuels (CH_4)	590.2	631.1	703.6	0.03%	113.3	19%	72.5	11%
1.A.4.b Residential: Gaseous Fuels (N_2O)	224.2	310.1	336.0	0.01%	111.8	50%	25.9	8%
1.A.4.b Residential: Liquid Fuels (CH_4)	349.3	166.1	159.9	0.01%	-189.4	-54%	-6.2	-4%
1.A.4.b Residential: Liquid Fuels (N_2O)	527.4	209.1	180.4	0.01%	-347.0	-66%	-28.7	-14%
1.A.4.b Residential: Other Fuels (CH_4)	0.0	0.4	0.4	0.00%	0.4	100%	0.0	5%
1.A.4.b Residential: Other Fuels (CO_2)	0.0	11.8	12.6	0.00%	12.6	100%	0.8	7%
1.A.4.b Residential: Other Fuels (N_2O)	0.0	0.1	0.1	0.00%	0.1	100%	0.0	6%
1.A.4.b Residential: Peat (CH_4)	288.1	70.4	67.8	0.00%	-220.3	-76%	-2.6	-4%
1.A.4.b Residential: Peat (CO_2)	3 585.1	870.2	842.5	0.03%	-2 742.5	-76%	-27.7	-3%
1.A.4.b Residential: Peat (N_2O)	13.7	3.2	3.2	0.00%	-10.6	-77%	-0.1	-3%
1.A.4.b Residential: Solid Fuels (N_2O)	786.0	129.3	125.7	0.00%	-660.2	-84%	-3.6	-3%

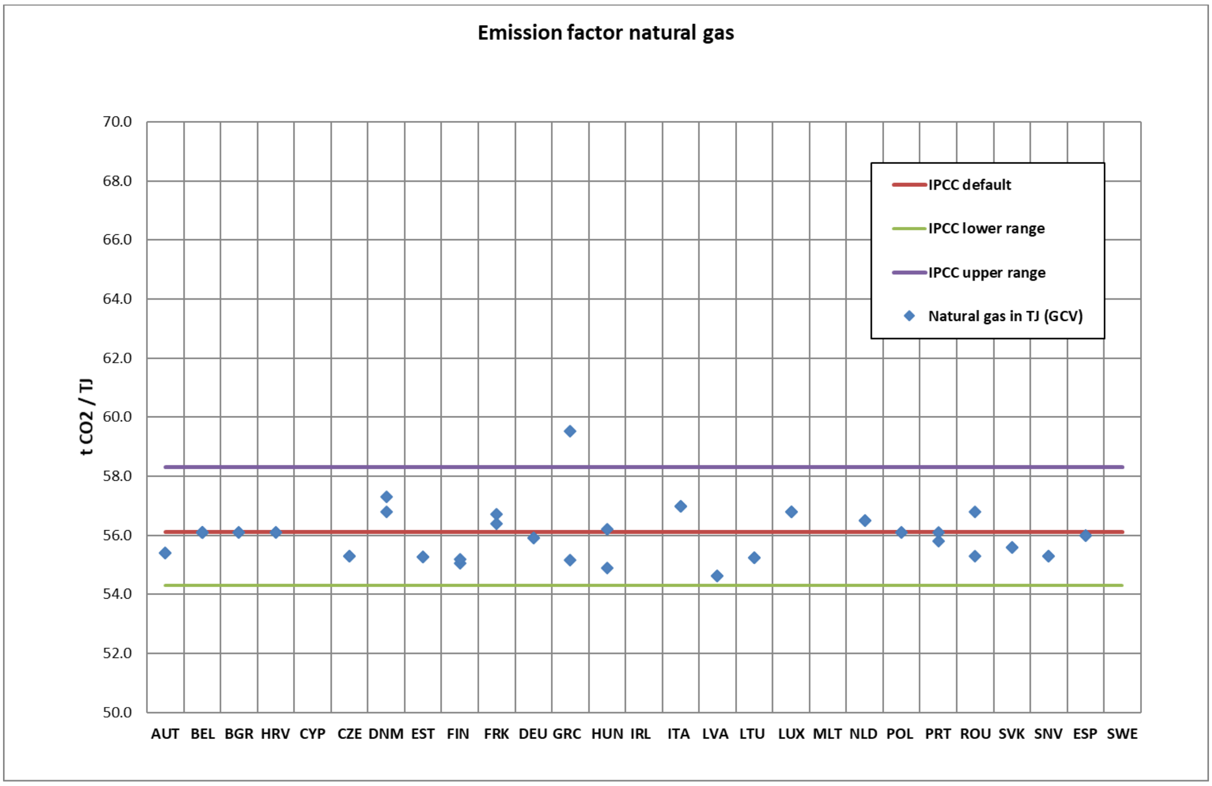
EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.4.c Agriculture/Forestry/Fishing: Biomass (CH_4)	110.9	613.9	650.1	0.02%	539.1	486%	36.2	6%
1.A.4.c Agriculture/Forestry/Fishing: Biomass (N_2O)	20.6	158.2	161.7	0.01%	141.2	685%	3.6	2%
1.A.4.c Agriculture/Forestry/Fishing: Gaseous Fuels (CH_4)	86.4	1 352.5	1 464.2	0.05%	1 377.8	1595%	111.7	8%
1.A.4.c Agriculture/Forestry/Fishing: Gaseous Fuels (N_2O)	7.5	7.4	8.6	0.00%	1.1	15%	1.2	16%
1.A.4.c Agriculture/Forestry/Fishing: Liquid Fuels (CH_4)	222.3	100.3	99.3	0.00%	-123.0	-55%	-0.9	-1%
1.A.4.c Agriculture/Forestry/Fishing: Liquid Fuels (N_2O)	2 937.5	2 963.1	2 901.6	0.11%	-35.9	-1%	-61.5	-2%
1.A.4.c Agriculture/Forestry/Fishing: Other Fuels (CH_4)	0.0	0.4	0.4	0.00%	0.4	100%	0.0	4%
1.A.4.c Agriculture/Forestry/Fishing: Other Fuels (CO_2)	0.0	67.9	63.6	0.00%	63.6	100%	-4.3	-6%
1.A.4.c Agriculture/Forestry/Fishing: Other Fuels (N_2O)	0.0	3.4	3.2	0.00%	3.2	100%	-0.1	-4%
1.A.4.c Agriculture/Forestry/Fishing: Peat (CH_4)	1.0	7.3	8.0	0.00%	7.0	736%	0.6	9%
1.A.4.c Agriculture/Forestry/Fishing: Peat (CO_2)	45.0	185.8	202.2	0.01%	157.2	350%	16.4	9%
1.A.4.c Agriculture/Forestry/Fishing: Peat (N_2O)	0.4	1.9	1.5	0.00%	1.1	249%	-0.4	-21%
1.A.4.c Agriculture/Forestry/Fishing: Solid Fuels (CH_4)	738.7	277.6	230.9	0.01%	-507.8	-69%	-46.7	-17%
1.A.4.c Agriculture/Forestry/Fishing: Solid Fuels (N_2O)	33.6	13.3	11.1	0.00%	-22.5	-67%	-2.2	-17%
1.A.5.a Other Other Sectors: Biomass (CH_4)	0.4	2.5	2.6	0.00%	2.2	572%	0.2	6%
1.A.5.a Other Other Sectors: Biomass (N_2O)	0.2	0.4	0.5	0.00%	0.3	142%	0.1	28%
1.A.5.a Other Other Sectors: Gaseous Fuels (CH_4)	0.5	0.9	1.0	0.00%	0.5	103%	0.1	14%
1.A.5.a Other Other Sectors: Gaseous Fuels (CO_2)	728.8	664.5	796.5	0.03%	67.7	9%	132.0	20%
1.A.5.a Other Other Sectors: Gaseous Fuels (N_2O)	1.1	1.0	1.1	0.00%	0.0	-2%	0.1	10%
1.A.5.a Other Other Sectors: Liquid Fuels (CH_4)	6.7	3.7	5.4	0.00%	-1.4	-20%	1.7	47%
1.A.5.a Other Other Sectors: Liquid Fuels (CO_2)	6 751.8	2 625.5	3 800.5	0.14%	-2 951.3	-44%	1 175.0	45%
1.A.5.a Other Other Sectors: Liquid Fuels (N_2O)	40.7	12.3	17.7	0.00%	-23.0	-56%	5.4	44%
1.A.5.a Other Other Sectors: Other Fuels (CH_4)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	238%
1.A.5.a Other Other Sectors: Other Fuels (CO_2)	0.0	0.3	1.0	0.00%	1.0	100%	0.7	235%
1.A.5.a Other Other Sectors: Other Fuels (N_2O)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	208%
1.A.5.a Other Other Sectors: Peat (CH_4)	0.3	0.0	0.0	0.00%	-0.3	-100%	0.0	0%
1.A.5.a Other Other Sectors: Peat (CO_2)	24.0	0.0	0.0	0.00%	-24.0	-100%	0.0	0%
1.A.5.a Other Other Sectors: Peat (N_2O)	0.1	0.0	0.0	0.00%	-0.1	-100%	0.0	0%
1.A.5.a Other Other Sectors: Solid Fuels (CH_4)	283.8	0.2	0.3	0.00%	-283.5	-100%	0.1	37%
1.A.5.a Other Other Sectors: Solid Fuels (N_2O)	18.6	0.0	0.0	0.00%	-18.6	-100%	0.0	1%
1.A.5.b Other Other Sectors: Biomass (CH_4)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	6%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 1. Energy in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
1.A.5.b Other Other Sectors: Biomass (N_2O)	0.0	0.1	0.1	0.00%	0.1	100%	0.0	3%
1.A.5.b Other Other Sectors: Gaseous Fuels (CH_4)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.5.b Other Other Sectors: Gaseous Fuels (CO_2)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.5.b Other Other Sectors: Gaseous Fuels (N_2O)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.5.b Other Other Sectors: Liquid Fuels (CH_4)	42.0	4.4	3.3	0.00%	-38.7	-92%	-1.1	-25%
1.A.5.b Other Other Sectors: Liquid Fuels (N_2O)	113.4	30.9	23.3	0.00%	-90.1	-79%	-7.6	-25%
1.A.5.b Other Other Sectors: Other Fuels (CH_4)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	-32%
1.A.5.b Other Other Sectors: Other Fuels (CO_2)	0.0	0.6	0.6	0.00%	0.6	100%	0.0	4%
1.A.5.b Other Other Sectors: Other Fuels (N_2O)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	-32%
1.A.5.b Other Other Sectors: Solid Fuels (CH_4)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.5.b Other Other Sectors: Solid Fuels (CO_2)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.A.5.b Other Other Sectors: Solid Fuels (N_2O)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.B.1.a Coal Mining and Handling: Operation (CO_2)	664.2	142.0	138.5	0.01%	-525.7	-79%	-3.5	-2%
1.B.1.a Coal Mining and Handling: Operation (N_2O)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
1.B.1.b Solid Fuel Transformation: Operation (CH_4)	307.0	106.0	99.3	0.00%	-207.7	-68%	-6.7	-6%
1.B.1.b Solid Fuel Transformation: Operation (CO_2)	6 133.8	3 094.2	3 257.5	0.12%	-2 876.3	-47%	163.3	5%
1.B.1.b Solid Fuel Transformation: Operation (N_2O)	0.0	0.0	0.0	0.00%	0.0	100%	0.0	-75%
1.B.1.c Other Solid fuel operation: Operation (CH_4)	126.5	92.3	108.7	0.00%	-17.8	-14%	16.4	18%
1.B.1.c Other Solid fuel operation: Operation (CO_2)	6.9	71.2	72.8	0.00%	65.9	952%	1.7	2%
1.B.1.c Other Solid fuel operation: Operation (N_2O)	0.0	0.0	0.0	0.00%	0.0	53%	0.0	26%
1.B.2.a Oil: Operation (N_2O)	22.1	6.4	5.5	0.00%	-16.7	-75%	-0.9	-15%
1.B.2.b Natural Gas: Operation (CO_2)	2 364.9	877.8	871.4	0.03%	-1 493.5	-63%	-6.4	-1%
1.B.2.c Venting and Flaring: Operation (CH_4)	6 507.9	3 202.0	3 017.4	0.11%	-3 490.6	-54%	-184.6	-6%
1.B.2.c Venting and Flaring: Operation (CO_2)	4 745.1	2 802.0	2 401.3	0.09%	-2 343.8	-49%	-400.7	-14%
1.B.2.c Venting and Flaring: Operation (N_2O)	14.3	10.3	8.4	0.00%	-6.0	-42%	-1.9	-19%
1.B.2.d Other emissions from energy production: Operation (CH_4)	361.6	662.2	644.4	0.02%	282.7	78%	-17.9	-3%
1.B.2.d Other emissions from energy production: Operation (CO_2)	682.3	2 032.6	1 908.2	0.07%	1 225.9	180%	-124.3	-6%
1.B.2.d Other emissions from energy production: Operation (N_2O)	9.5	6.2	6.7	0.00%	-2.8	-29%	0.5	8%
1.C CO_2 Transport and Storage: Fuels (CO_2)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%

3.3 Methodological issues and uncertainties (EU-KP)

The previous section presented for each EU key category in CRF Sector 1 an overview of the Member States' contributions to the key categories in terms of level and trend, and - for each key category - summary information on methodologies and emission factors using the notations T1, T2, D, etc. No detailed explanations of Member States methods used is included for 1A because for most categories the method used is simply multiplying activity data by (country-specific) emissions factors. The most relevant parameter for estimating the GHG emissions from 1A is the emission factor. Therefore, the following figures include overviews of emission factors used by the Member States for the most relevant fuels and also provide the uncertainty range of default emission factors. Where relevant, information from Member States is added that are using emission factors which are significantly outside the range of the default emission factors. The figures show that the large majority of country-specific emission factors used by the EU Member States are within the uncertainty range of the IPCC default emission factors. Note that Annex III of the EU NIR includes an extraction of the emission factors used by MS for each fuel; the following figures summarize this Annex. In addition the Member States' national inventory reports include more detailed information on national methods and circumstances.

Figure 3.185 Emission factors used by Member States for natural gas



GRC: The higher value is used in 1A1c and is due to the following factors: 1. The consumption of natural gas in 1A1c sector corresponds almost 100% to natural gas produced within the country. 2. The EF is based on ETS reporting, therefore it is a plant specific EF which has been verified according to EU ETS rules. 3. As it was reported in the 2016 NIR, domestic natural gas is produced from two reservoirs, which have high carbon contents (e.g. the "Prinos" reservoir in 2014 had a carbon content of 16.22tC/TJ). 4. The inter-annual changes of the IEFs are caused by the inter-annual changes of the share of each reservoir in the total natural gas production.

Figure 3.186   Emission factors used by Member States for gas/diesel oil

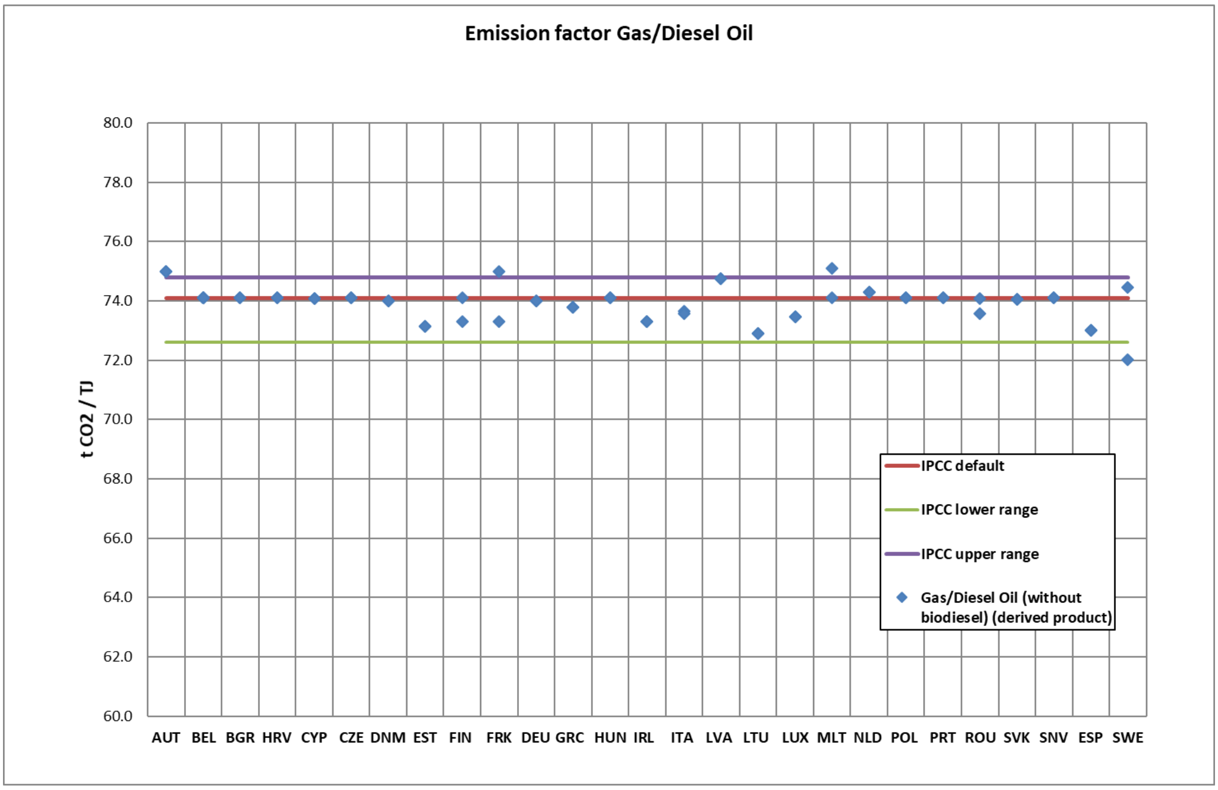


Figure 3.187   Emission factors used by Member States for LPG

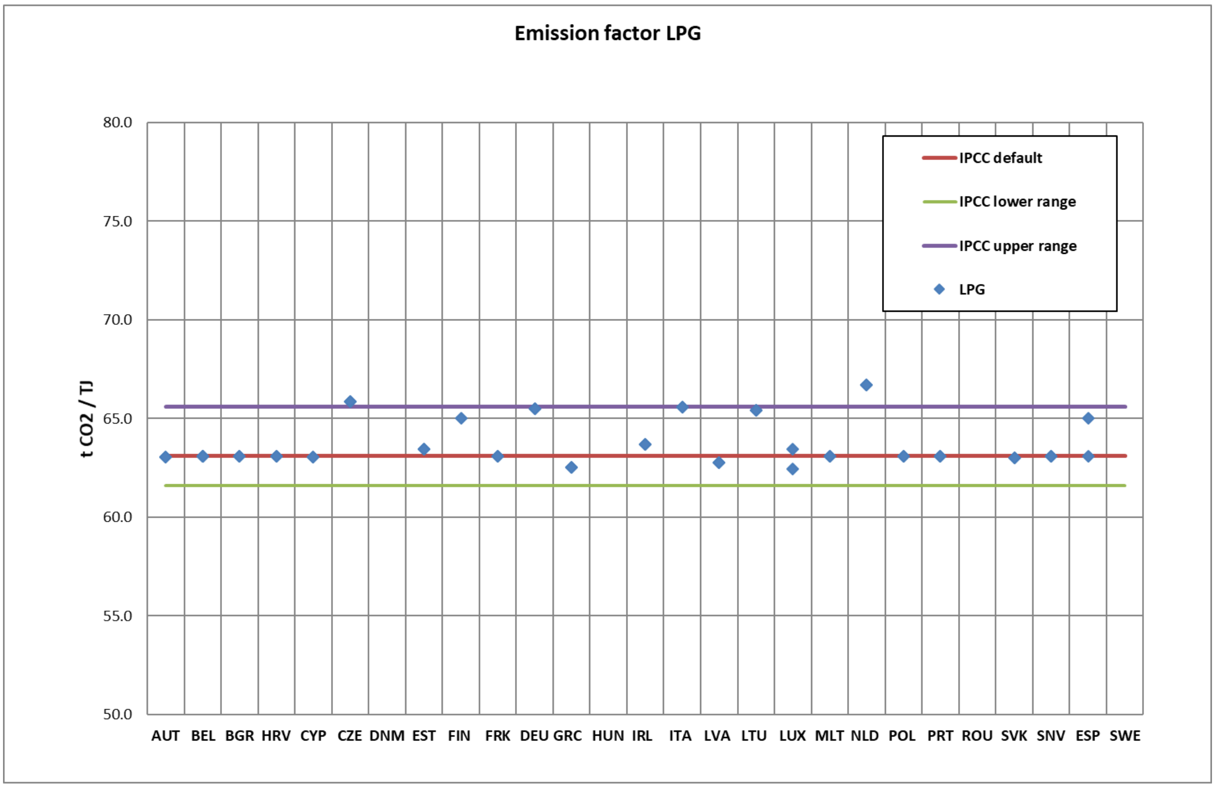
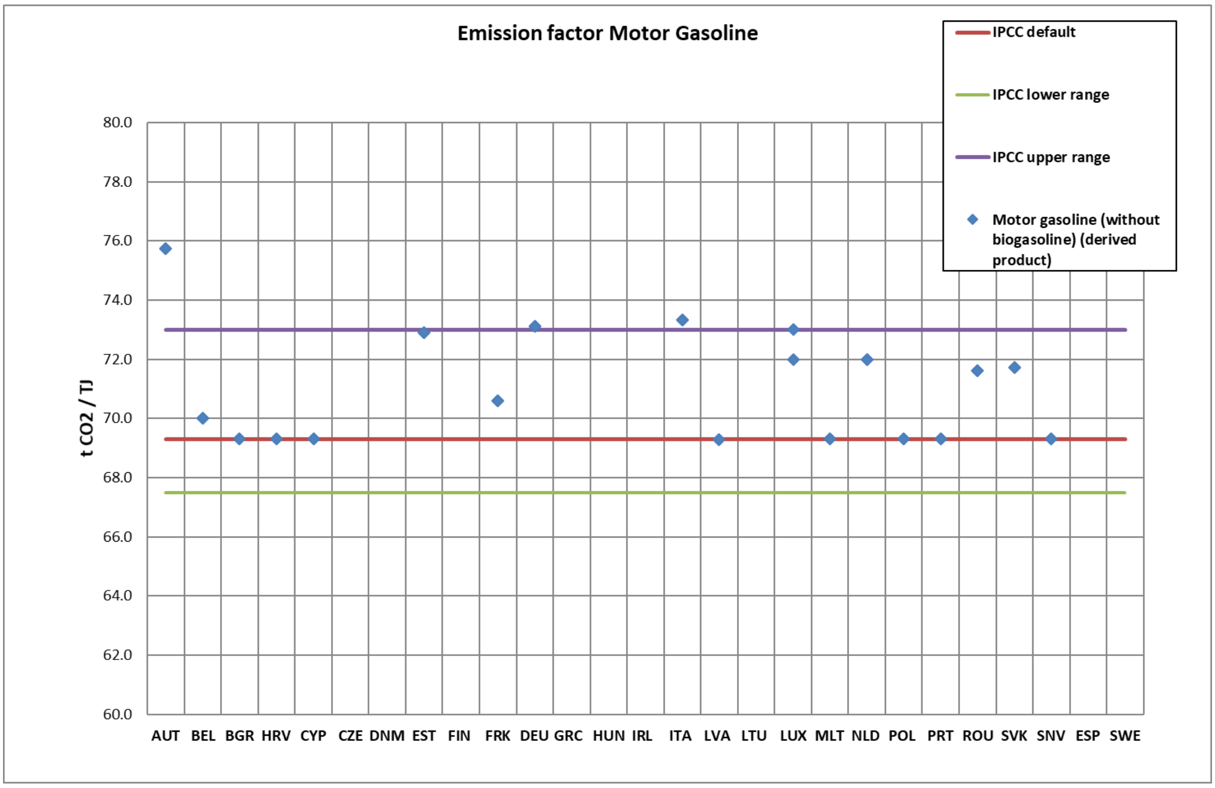


Figure 3.188 Emission factors used by Member States for motor gasoline



AUT: The Austrian IEF is above the upper IPCC default values due to the application of the comparatively low NCV from the national energy balance, which is 41.8 TJ/kt Gasoline for the year 2021. The application of the IPCC default NCV (44.3 TJ/kt) would increase activity data and thus reduce the CO_2-IEF to about 70 t/TJ. Austria therefore does not assume that emissions from Gasoline are overestimated.

Figure 3.189 Emission factors used by Member States for jet kerosene

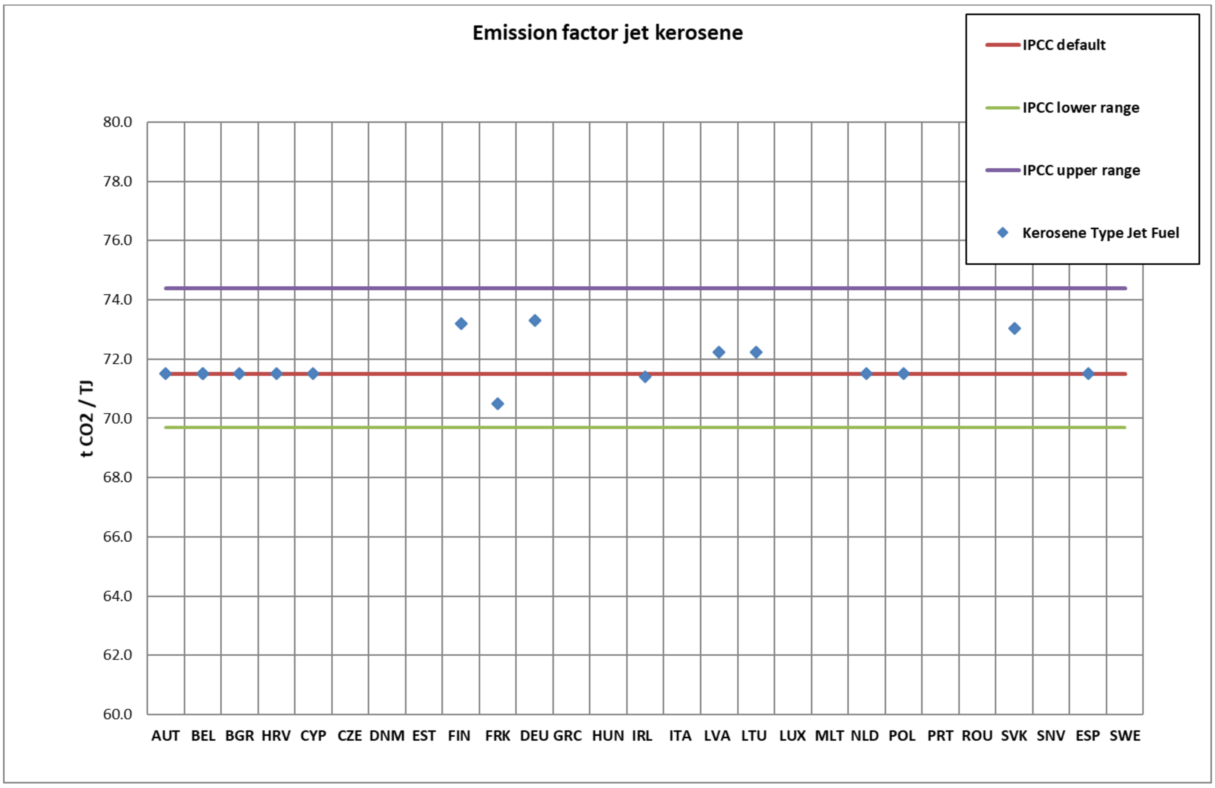
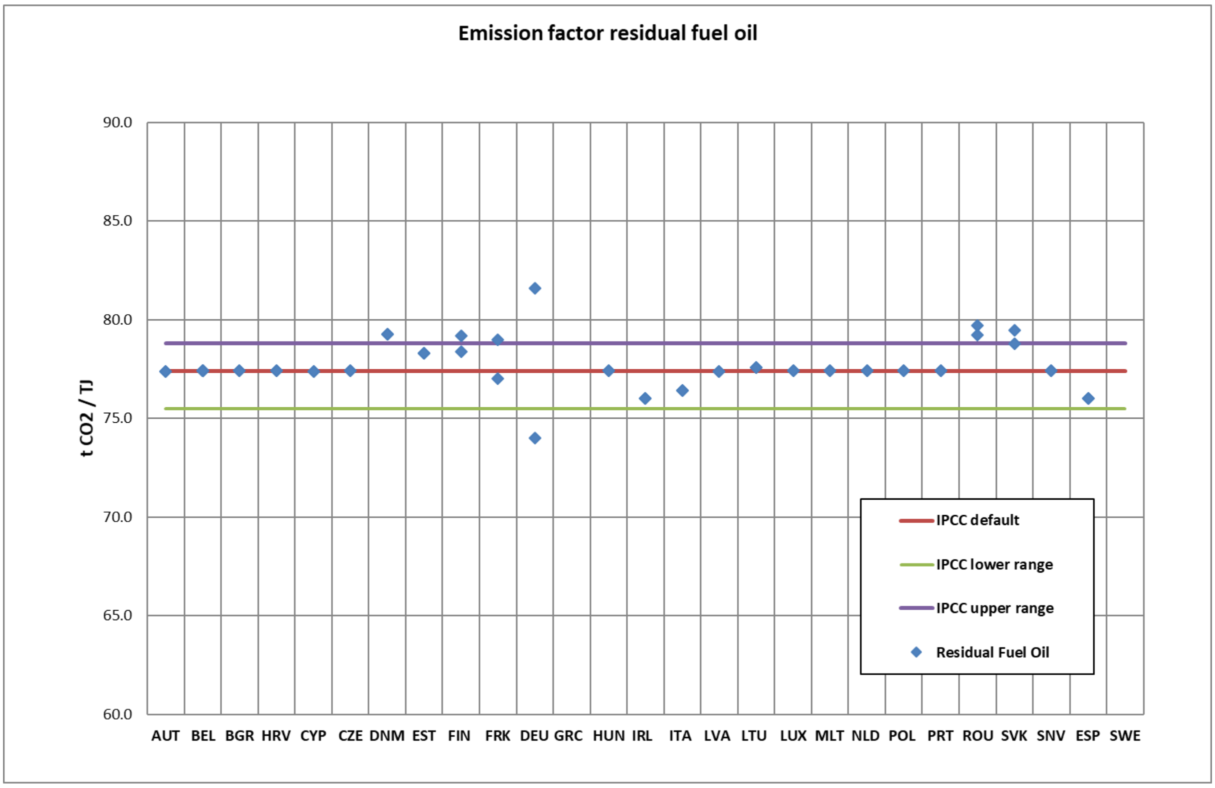


Figure 3.190 Emission factors used by Member States for residual fuel oil



DEU: The higher value is for heavy residual fuel oil, the value is for light fuel oil.

ROU: Romania has developed a specific methodology for the elaboration of national values of specific CO_2 emission factors and the energy sector. Primary data are collected from EU-ETS operators, the data are further processed and national values are developed, based on the previous mentioned methodology. Primarily, a number of 36 EU-ETS operators were considered.

Figure 3.191 Emission factors used by Member States for petroleum coke

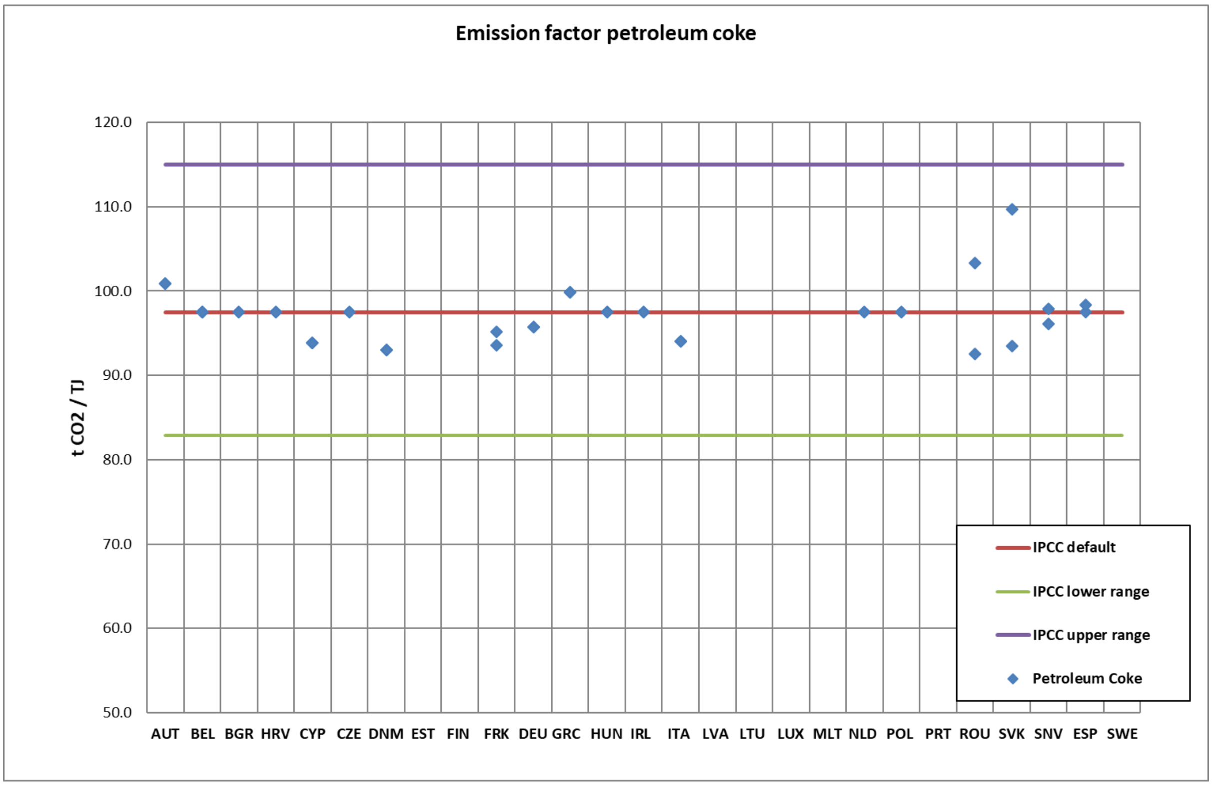


Figure 3.192 Emission factors used by Member States for refinery gas

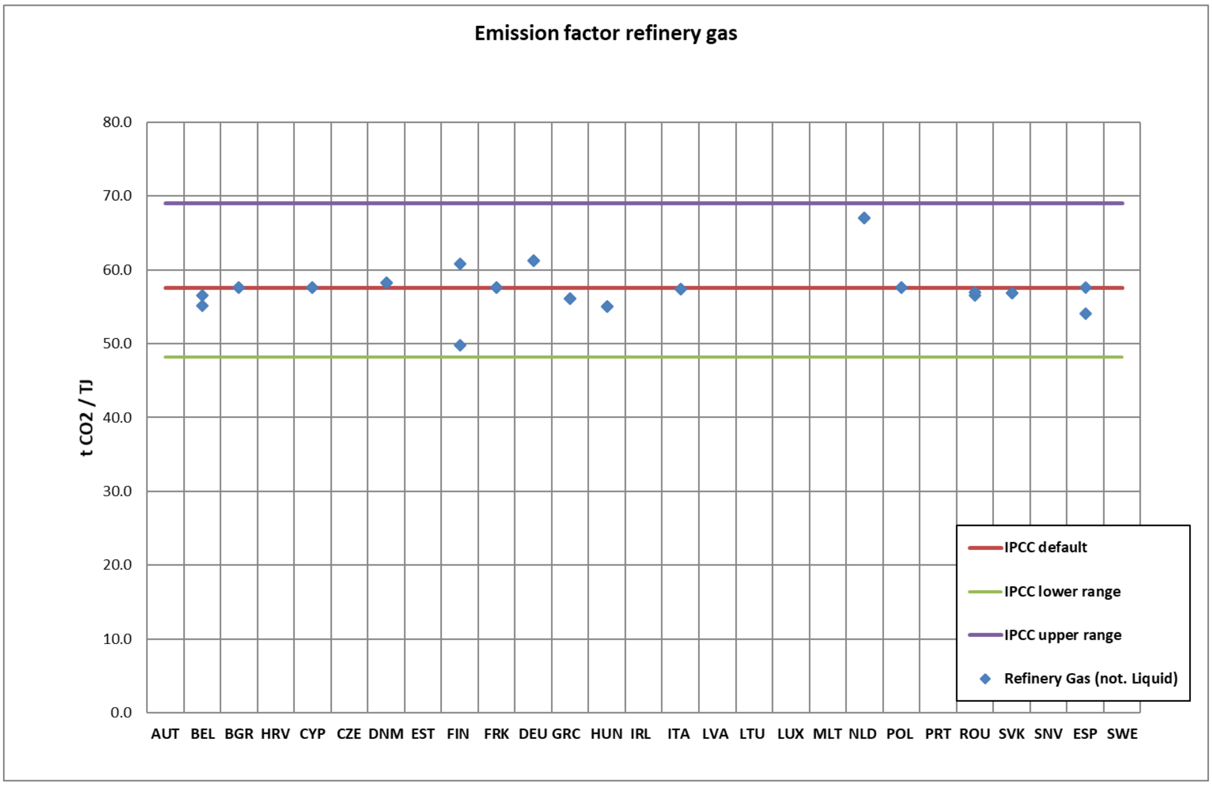


Figure 3.193 Emission factors used by Member States for bituminous coal

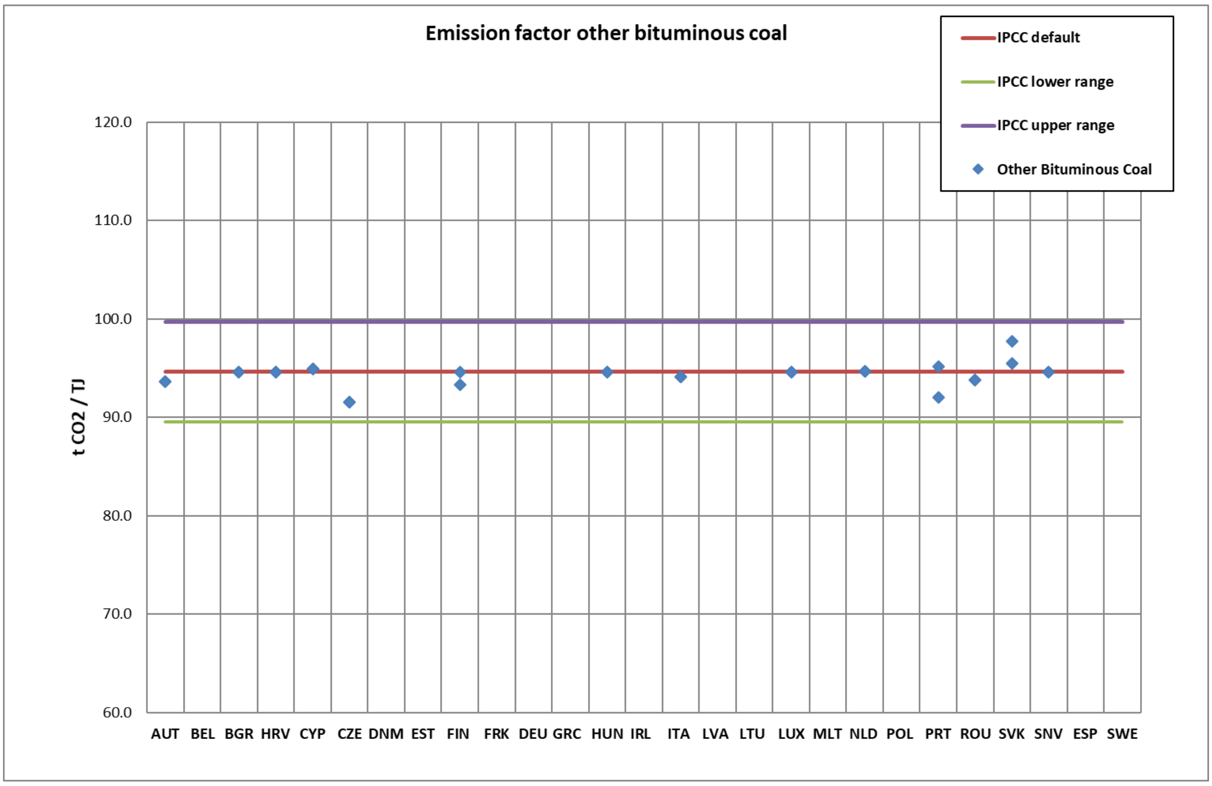
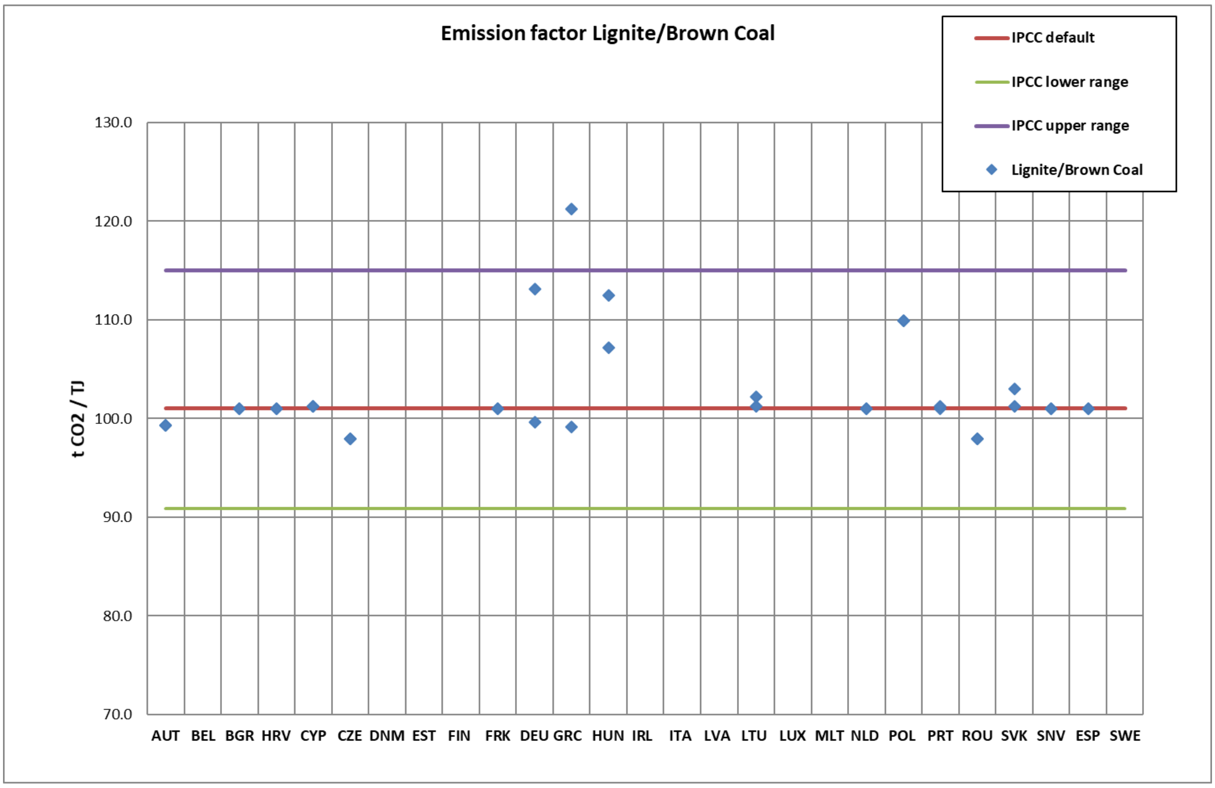


Figure 3.194 Emission factors used by Member States for lignite



GRC: A country specific carbon content of lignite used for electricity production was used in emission calculations for the period 1990-2005 (33.95 tC/TJ), which is based on studies of the Public Power Corporation (PPC 1993). For the period thereafter plant specific values for CC were used, based on verified EU-ETS reports, ranging from 33.74 to 35.37 tC/TJ. These values lies out of the range suggested by the 2006 IPCC Guidelines. However, given that the net calorific value of the Greek lignite is one of lowest (see Papanicolaou et al., 2004 for an overview of the properties of the Greek lignites) a high value for the carbon content is expected. Moreover, according to international literature (Fott, 1999) the suggested value by IPCC corresponds to a net calorific value of 13 TJ / kt, which is not representative of national circumstances (see Table 3.14 and Figure 3.5). -The oxidation factor 98% is used for the combustion of lignite for electricity production. This is based on a study of the Public Power Corporation (PPC 1993) and verified EU-ETS reports.

Figure 3.195 Emission factors used by Member States for coking coal

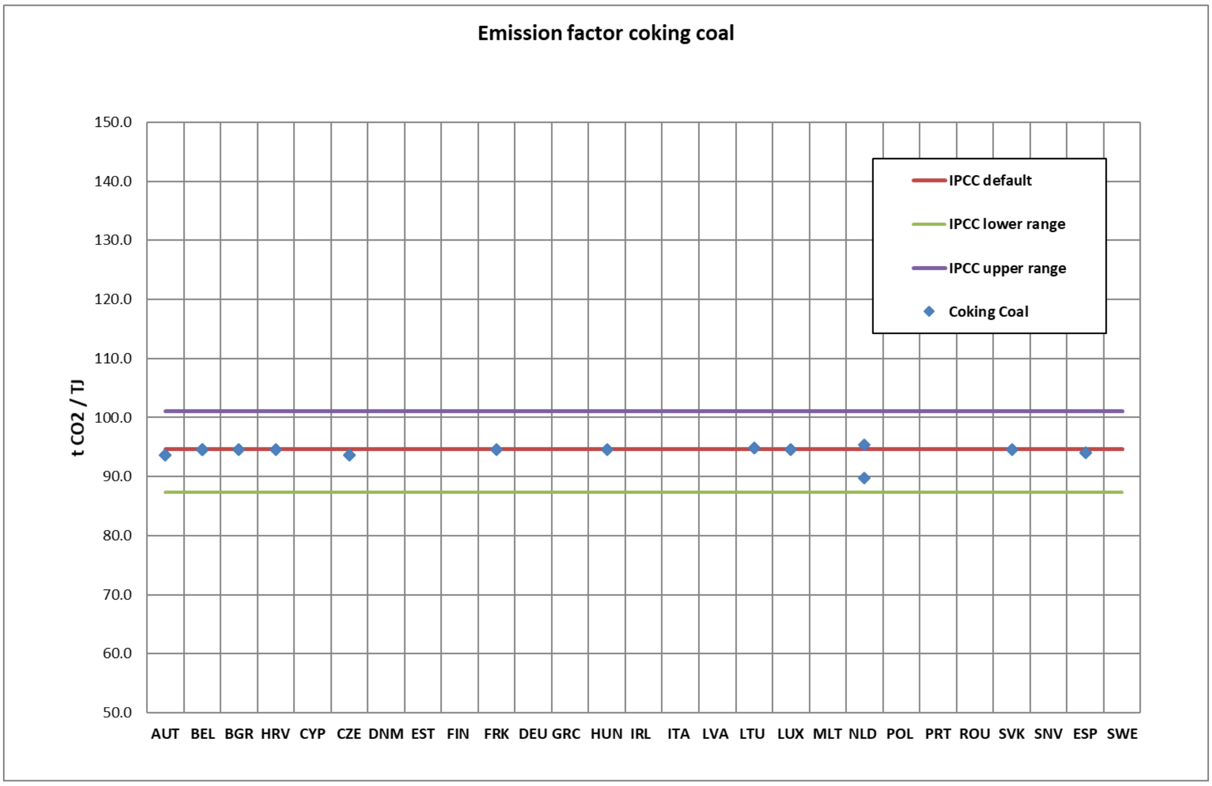


Figure 3.196 Emission factors used by Member States for coke oven coke

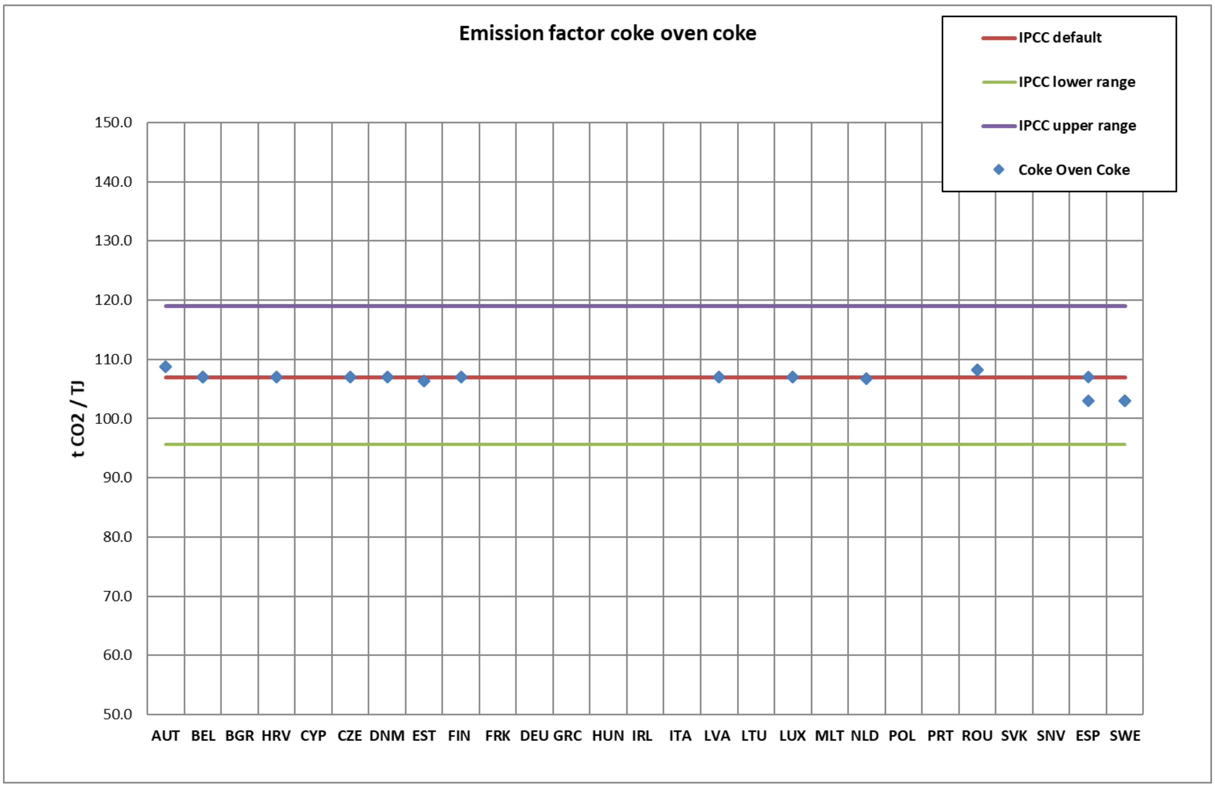
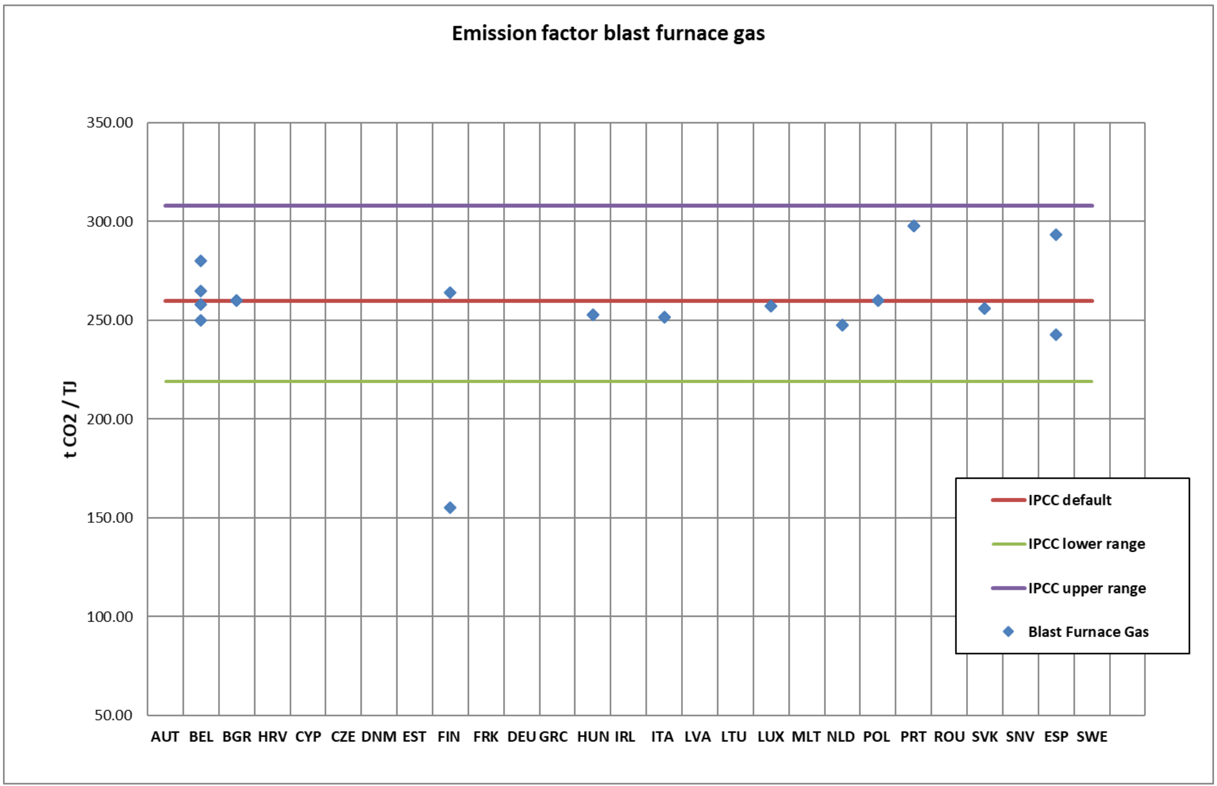


Figure 3.197 Emission factors used by Member States for blast furnace gas



<u>BEL:</u> Highest value max. Wallonia, lowest value min. Flanders

<u>FIN:</u> Because the number of plants is very small, we have to aggregate certain fuel types to more general categories. In this case, blast furnace gas includes actually two types of gas. One is more like carbon moNO_xide (EF 155), and the other actual blast furnace gas (EF around 265). Both EF values (or range for actual blast furnace gas) are based on plant-level data. In the calculations we use different fuel codes for each fuel type (each plant), but in reporting we aggregate them in the same group, which is named as blast furnace gas (it should probably be 'Blast furnace gas and other derived gases from metal industries').

Figure 3.198 Emission factors used by Member States for anthracite

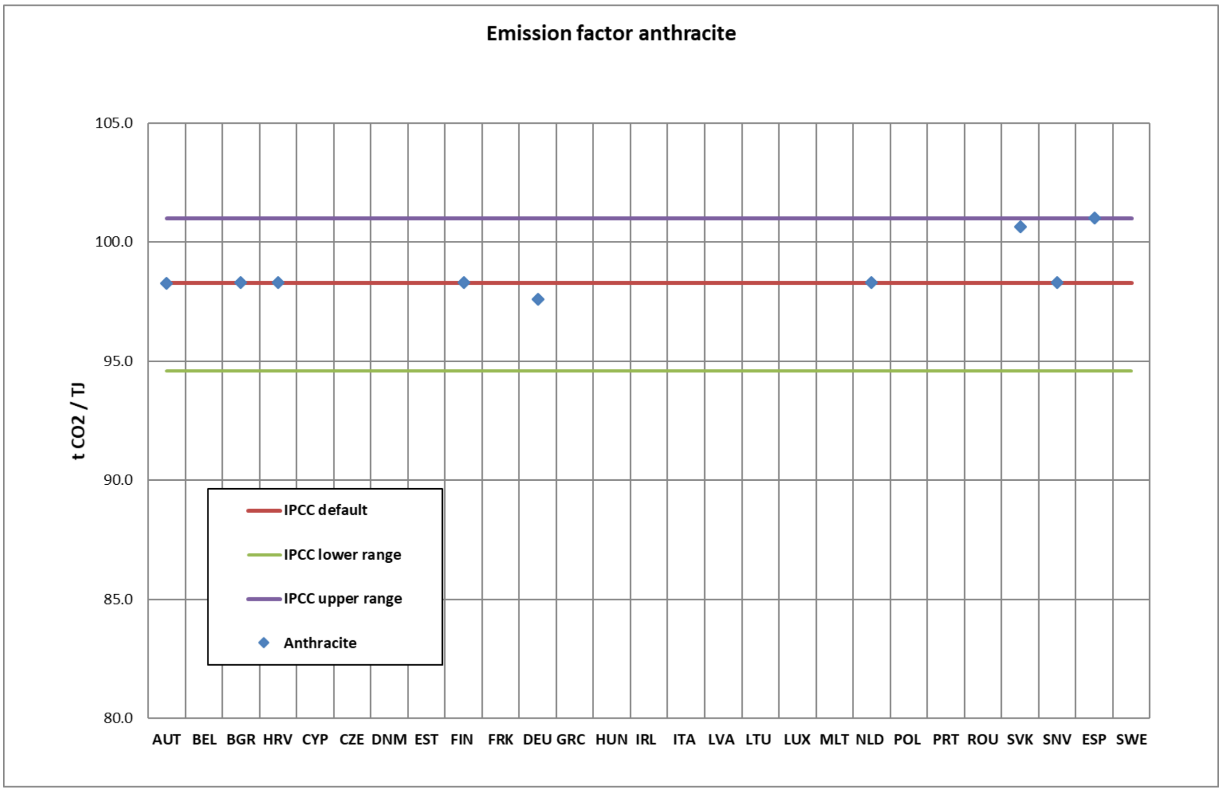
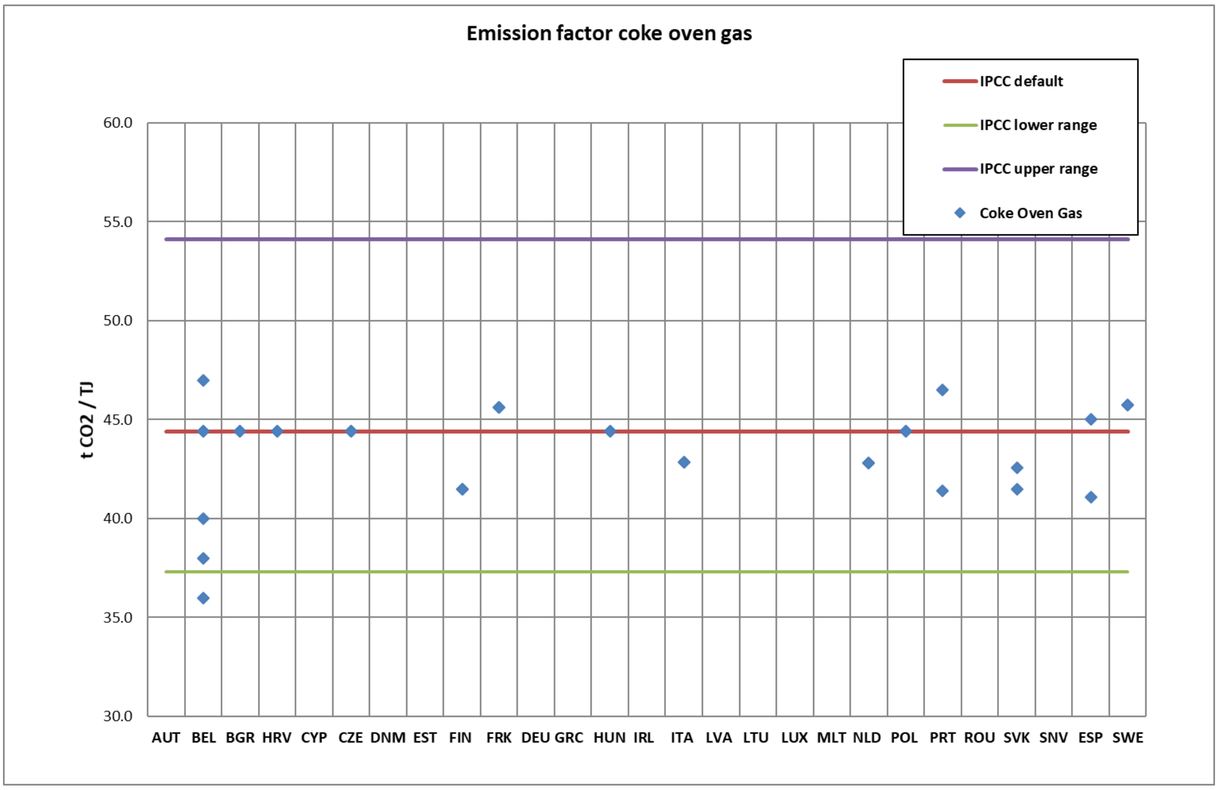


Figure 3.199 Emission factors used by Member States for coke oven gas



* BEL: Highest value max. Wallonia, lowest value min. Wallonia

Table 3.112 shows the total EU uncertainty estimates for the sector ‘Energy’ (excluding 1A3 ‘Transport’ and 1B ‘Fugitive’) for the relevant gases for each source category. For those emissions for which no split by source category was available, uncertainty estimates were made for stationary combustion as a whole. The highest level uncertainty was estimated for CH_4 from 1A1c and the lowest for CO_2 from 1A2c. With regard to trend CH_4 from 1A1a shows the highest uncertainty estimates, CO_2 from 1A2a the lowest. The results of this year's uncertainty analysis are very similar to the results in 2022. For a description of the Tier 1 uncertainty analysis carried out for the EU see Chapter 1.6.

Table 3.112 Sector 1 Energy (excl. 1A3b and 1B): Uncertainty estimates for EU-KP

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
1.A.1.a Public electricity and heat production	CO_2	579 693	317 909	-45.2%	2.5%	1.0%
1.A.1.a Public electricity and heat production	CH_4	268	2 718	912.6%	51.6%	483.6%
1.A.1.a Public electricity and heat production	N_2O	2 475	1 951	-21.2%	17.0%	4.7%
1.A.1.b Petroleum refining	CO_2	57 375	49 208	-14.2%	4.7%	1.5%
1.A.1.b Petroleum refining	CH_4	21	27	23.8%	42.0%	47.2%
1.A.1.b Petroleum refining	N_2O	204	91	-55.3%	23.3%	21.1%
1.A.1.c Manufacture of solid fuels and other energy industries	CO_2	72 773	16 194	-77.7%	7.5%	4.5%
1.A.1.c Manufacture of solid fuels and other energy industries	CH_4	113	149	31.6%	109.6%	38.0%
1.A.1.c Manufacture of solid fuels and other energy industries	N_2O	590	119	-79.9%	22.6%	18.7%
1.A.2.a Iron and Steel	CO_2	52 180	41 299	-20.9%	5.2%	0.6%
1.A.2.a Iron and Steel	CH_4	85	80	-5.4%	24.6%	5.5%
1.A.2.a Iron and Steel	N_2O	205	104	-49.4%	35.1%	47.1%
1.A.2.b Non-ferrous Metals	CO_2	2 220	1 070	-51.8%	2.7%	6.3%
1.A.2.b Non-ferrous Metals	CH_4	2	1	-62.4%	36.5%	33.5%
1.A.2.b Non-ferrous Metals	N_2O	15	2	-86.1%	58.5%	53.0%
1.A.2.c Chemicals	CO_2	24 330	7 660	-68.5%	1.8%	1.9%
1.A.2.c Chemicals	CH_4	18	24	33.0%	49.8%	54.5%
1.A.2.c Chemicals	N_2O	26	26	-0.5%	107.3%	59.0%
1.A.2.d Pulp, Paper and Print	CO_2	3 122	1 646	-47.3%	3.4%	2.8%
1.A.2.d Pulp, Paper and Print	CH_4	16	21	30.4%	28.1%	7.9%
1.A.2.d Pulp, Paper and Print	N_2O	64	74	15.5%	35.6%	9.6%
1.A.2.e Food Processing, Beverages and Tobacco	CO_2	7 725	4 053	-47.5%	2.0%	1.9%
1.A.2.e Food Processing, Beverages and Tobacco	CH_4	12	17	42.9%	56.7%	63.7%
1.A.2.e Food Processing, Beverages and Tobacco	N_2O	34	11	-68.8%	64.2%	34.2%
1.A.2.f Non-metallic minerals	CO_2	28 181	21 123	-25.0%	3.4%	1.4%
1.A.2.f Non-metallic minerals	CH_4	75	52	-30.1%	24.9%	16.1%
1.A.2.f Non-metallic minerals	N_2O	210	182	-13.7%	38.5%	18.3%
1.A.2.g Other	CO_2	164 236	85 097	-48.2%	3.5%	1.2%
1.A.2.g Other	CH_4	210	278	32.6%	26.6%	14.0%
1.A.2.g Other	N_2O	1 026	649	-36.7%	26.9%	12.6%
1.A.4.a Commercial/Institutional	CO_2	84 206	50 176	-40.4%	7.1%	3.1%
1.A.4.a Commercial/Institutional	CH_4	1 771	265	-85.0%	46.5%	93.3%
1.A.4.a Commercial/Institutional	N_2O	231	145	-37.0%	82.1%	18.9%
1.A.4.b Residential	CO_2	192 708	126 795	-34.2%	7.0%	2.3%

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
1.A.4.b Residential	CH_4	4 560	3 199	-29.8%	54.5%	54.8%
1.A.4.b Residential	N_2O	875	568	-35.1%	70.0%	45.1%
1.A.4.c Agriculture/forestry/fishing	CO_2	31 305	22 812	-27.1%	7.0%	1.8%
1.A.4.c Agriculture/forestry/fishing	CH_4	458	1 776	287.7%	43.3%	137.9%
1.A.4.c Agriculture/forestry/fishing	N_2O	167	290	73.6%	70.7%	34.9%
1.A.5 Other	CO_2	21 244	6 431	-69.7%	3.9%	2.8%
1.A.5 Other	CH_4	333	12	-96.3%	38.4%	43.8%
1.A.5 Other	N_2O	172	39	-77.0%	83.3%	35.0%
1.A (where no subsector data were submitted)	*all*	61 246	*50 790*	*-17.1%*	*1.6%*	*1.0%*
1.A.1 (where no subsector data were submitted)	*all*	*714 184*	*442 543*	*-38.0%*	*12.8%*	*11.3%*
1.A.2 (where no subsector data were submitted)	*all*	*429 277*	*263 955*	*-38.5%*	*7.9%*	*2.8%*
1.A.3 (where no subsector data were submitted)	*all*	*245 206*	*295 719*	*20.6%*	*3.3%*	*1.1%*
1.A.4 (where no subsector data were submitted)	*all*	*380 746*	*314 767*	*-17.3%*	*5.3%*	*2.5%*
1.A.5 (where no subsector data were submitted)	*all*	*0*	*0*	*0.0%*	*0.0%*	*0.0%*
Total - 1.A (where no subsector data were submitted)	**all**	**61 246**	**50 790**	**-17.1%**	**1.6%**	**1.0%**
Total - 1.A.1	**all**	**1 427 697**	**830 909**	**-41.8%**	**6.9%**	**5.7%**
Total - 1.A.2	**all**	**713 271**	**427 423**	**-40.1%**	**5.0%**	**1.7%**
Total - 1.A.3	**all**	**657 388**	**765 169**	**16.4%**	**2.3%**	**0.6%**
Total - 1.A.4	**all**	**697 025**	**520 793**	**-25.3%**	**3.7%**	**1.6%**
Total - 1.A.5	**all**	**21 749**	**6 483**	**-70.2%**	**3.9%**	**2.8%**
Total - 1.A	**all**	**3 578 377**	**2 601 568**	**-27.3%**	**2.6%**	**2.3%**

Note: Emissions are in kt CO_2 equivalents; trend uncertainty is presented as percentage points; the sum of the source category emissions may not be the total sector emissions because uncertainty estimates are not available for all source categories.

Table 3.113 shows the total EU uncertainty estimates for the sector 1.B 'Fugitive emissions' and the uncertainty estimates for the relevant gases for each source category. The highest level uncertainties were estimated for N_2O from 1B2 and the lowest for CO_2 from 1B1; the highest trend uncertainties were estimated for N_2O from 1B2, the lowest for CO_2 from 1B1. Uncertainties analysis show very similar results as in 2022.

Table 3.113 1B Fugitive Emissions: Uncertainty estimates for EU-KP

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
1.B.1 Solid Fuels	CO_2	6 787	3 371	-50.3%	14.6%	7.8%
1.B.1 Solid Fuels	CH_4	82 150	25 265	-69.2%	72.9%	11.5%
1.B.1 Solid Fuels	N_2O	0.0	0.0	0.0%	0.0%	0.0%
1.B.2. Oil and Natural Gas and other emissions from energy production	CO_2	12 338	12 491	1.2%	22.3%	14.9%
1.B.2. Oil and Natural Gas and other emissions from energy production	CH_4	49 915	13 714	-72.5%	41.4%	18.8%
1.B.2. Oil and Natural Gas and other emissions from energy production	N_2O	35	13	-63.2%	155.8%	48.6%

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
1.B (werhe no subsector data were submitted)	*all*	*17 484*	*6 324*	*-63.8%*	*35.4%*	*30.7%*
Total - 1.B	**all**	**168 709**	**61 178**	**-63.7%**	**35.7%**	**8.6%**

Note: Emissions are in Gg CO_2 equivalents; trend uncertainty is presented as percentage points; the sum of the source category emissions may not be the total sector emissions because uncertainty estimates are not available for all source categories.

Table 3.114 shows the total EU-KP uncertainty estimates for the sector 1A3 'Transport' and the uncertainty estimates for the relevant gases for each source category. The highest uncertainty was estimated for N_2O from 1A3d and the lowest for CO_2 from 1A3e. With regard to trend CH_4 from 1A3d show the highest uncertainty estimates, CO_2 from 1A3b the lowest. The results of this year's uncertainty analysis are very similar to the results in 2022.

Table 3.114 1A3 Transport: Uncertainty estimates for EU

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
1.A.3.a Domestic aviation	CO_2	5 696	3 890	-31.7%	12.9%	2.9%
1.A.3.a Domestic aviation	CH_4	5	2	-52.3%	70.7%	23.1%
1.A.3.a Domestic aviation	N_2O	47	20	-57.7%	168.9%	47.8%
1.A.3.b Road transport	CO_2	372 692	446 869	19.9%	3.3%	0.5%
1.A.3.b Road transport	CH_4	3 497	624	-82.2%	30.3%	8.4%
1.A.3.b Road transport	N_2O	3 049	4 362	43.1%	34.2%	10.0%
1.A.3.c Railways	CO_2	8 260	2 688	-67.5%	4.9%	2.8%
1.A.3.c Railways	CH_4	28	3	-87.6%	67.3%	22.4%
1.A.3.c Railways	N_2O	386	124	-68.0%	74.0%	39.6%
1.A.3.d Domestic navigation	CO_2	12 934	7 982	-38.3%	33.2%	15.6%
1.A.3.d Domestic navigation	CH_4	22	55	153.4%	55.6%	69.7%
1.A.3.d Domestic navigation	N_2O	165	130	-21.2%	245.3%	39.0%
1.A.3.e Other transportation	CO_2	5 345	2 677	-49.9%	2.8%	1.9%
1.A.3.e Other transportation	CH_4	10	5	-44.4%	63.4%	20.1%
1.A.3.e Other transportation	N_2O	45	18	-60.3%	76.5%	53.6%
Total - 1.A.3	**all**	**657 388**	**765 169**	**16.4%**	**2.3%**	**0.6%**

Note: Emissions are in Gg CO_2 equivalents; trend uncertainty is presented as percentage points; the sum of the source category emissions may not be the total sector emissions because uncertainty estimates are not available for all source categories.

3.4 Sector-specific quality assurance and quality control

There are several activities for improving the quality of GHG emissions from energy: Before and during the compilation of the EU GHG inventory, several checks are made of the Member States data in particular for time series consistency of emissions and implied emission factors, comparisons of implied emission factors across Member States and checks of internal consistency. Table 3.115 summarizes the main checks carried out on Member States' submissions.

Table 3.115 Quality checks carried out on Member States' submissions

Issue	Check
Completeness	Check categories where Member States report the notation key NE for potential underestimations Check categories where Member States report a notation key and 20 or more Member States report emissions and assess if there are potential over- or underestimates All years, but focus on last reporting year and also 1990 Focus on EU key categories
Time series of emissions	Check time series consistency of Member States' emission estimates for potential over- and underestimates: All years, but focus on last reporting year and also 1990 Focus on EU key categories
Time series of IEFs	Check time series consistency of Member States' IEFs for potential over- and underestimates: All years, but focus on last reporting year and also 1990 Focus on EU key categories
Outlier checks of IEFs	Compare IEFs across Member States and assess if there are potential over- and underestimations of emissions Compare Member States' IEFs with (range of) default EF from 2006 IPCC GL All years, but focus on last reporting year and also 1990 Focus on EU key categories
Recalculations	Check categories where Member States provide recalculations and focus on those of more than 0.05% of national total emissions for each main gas and assess if there are potential over- or underestimates. Also explanations for recalculations were checked either from MS Annexes - MMR IR Art. 8 or NIR. All years, but focus on last reporting year and also 1990 Focus on EU key categories
Follow-up from 2021	Check if issues that were classified as "Unresolved" or "Partly resolved" in 2022 have been resolved by Member States in 2022.
Implementation of UNFCCC and ESD review recommendations	Check if recommendations from the latest UNFCCC review reports have been implemented by Member States. Check if recommendations from ESD review 2022 have been implemented by Member States.
Reporting of non-energy use of fossil fuels	Check plausibility of reporting in CRF table 1A(d) as compares reporting in CRF table 1A(b), 1A(c) and the IPPU sector.

In the second half of the year, the EU internal review is carried out for selected source categories. In 2005, the EU internal review was carried out for the first time. Since 2012 the EU internal reviews are carried out in the context of the ESD reviews.

- In 2012 a comprehensive review was carried out for all sectors and all EU Member States in order to fix the base year for the 2020 targets under the EU Effort Sharing Decision (ESD review 2012). This review also covered the energy sector of the MS GHG inventories (peer review).
- In 2015, a few Member States volunteered to be reviewed under step 2 of the ESD trial review for the sector energy.
- In 2016, again a comprehensive review was carried out for all sectors and all EU Member States with a focus on the years 2005, 2008-2010, 2013 and 2014 in order to track progress of the EU Member States under the EU Effort Sharing Decision (ESD review 2016).
- In 2017-2019, annual reviews were carried out for all significant issues identified during the initial checks phase with a focus on the years 2015-2017 in order to track progress of the EU Member States under the EU Effort Sharing Decision.
- In 2020, again a comprehensive review was carried out for all sectors and all EU Member States with a focus on the years 2005, 2016-2018 in order to track progress of the EU Member States under the EU Effort Sharing Decision and in order to fix the base year for the 2030 targets under the EU Effort Sharing Regulation (ESD review 2020).

- In 2021 an annual review was carried out for all significant issues identified during the initial checks phase with a focus on the year 2019 in order to track progress of the EU Member States under the EU Effort Sharing Decision.
- In 2022 an annual review is carried out for all significant issues identified during the initial checks phase with a focus on the year 2020 in order to track progress of the EU Member States under the EU Effort Sharing Decision.

In addition, every year after the ESD review capacity building activities are organized. In 2022 the energy-related webinar had 82 participants from 26 countries. Main issues discussed at the webinar were:

- Difference between CRF and Eurostat AD for subcategory 1.A.4.b
- Use of NCVs and CO_2 EFs from EU ETS reports to non-industrial sectors (1.A.4)
- High CO_2 IEF of other fuels (MSW)
- Adjustment of energy balance data to reflect EU- ETS data

EU ETS data

Since the inventory 2005 plant-specific data is available from the EU Emission Trading Scheme (EU ETS). This information has been used by EU Member States for quality checks and as input for calculating total CO_2 emissions for the sectors Energy and Industrial Processes in this report (see Section 1.4.2). During the ESD reviews and during the initial checks consistency checks have been carried out between EU ETS data and the inventory estimates.

Eurostat energy data

During the initial checks carried out before the compilation of the EU GHG inventory Eurostat energy data is used for cross checking the sectoral and reference approach of the MS submissions. This cross check between the European energy reporting system and the EU GHG inventory system is an important QA/QC element of the EU GHG inventory compilation.

The quality of the EU GHG inventory is directly affected by the quality of Member States and EU energy statistics systems. EU energy statistics are collected by Eurostat on the basis of the EU energy statistics regulation[24]. The energy statistics regulation was adopted as part of the energy package and establishes a common framework for the production, transmission, evaluation and dissemination of comparable energy statistics in the EU.

This regulation aims at collecting detailed statistical data on energy flows by energy commodity at annual and monthly level. It ensures harmonised and coherent reporting of national energy data, which is indispensable for the assessment of EU energy policies and targets. The content and structure of this regulation reflects the essence of the existing European statistical system, a system that is part of the international energy statistical system, and is in direct link with the national statistical structures (classifications) and methodologies. It also has concrete links to other statistical domains, such as economic, environment, trade and business statistics. These links provide an additional dimension in safeguarding data quality assurance.

The European energy statistics system and the quality of the EU inventory are directly affected by this regulation that:

- ensures a stable and institutional basis for energy statistics in the EU
- guarantees long-term availability of energy data for EU policies
- reinforces available resources for the production of the basic energy statistics at national level

[24] REGULATION (EC) No 1099/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 October 2008 on energy statistics as amended by Commission Regulation (EU) No 147/2013 of 13 February 2013.

The energy statistics regulation helps improving the QA/QC of the EU inventory as it:

- makes available more detailed energy statistics by fuel
- allows the estimation of CO_2 emissions from energy with the reference and sectoral approach
- assures the quality of the underlying energy statistics
- improves timeliness of energy statistics
- provides a formal legal framework assuring consistency between national and Eurostat data

Moreover, Article 6, paragraph 2 stipulates that:

'Every reasonable effort shall be undertaken to ensure coherence between energy data declared in the energy statistics regulation, and data declared in accordance with Commission Decision No 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol'.

In addition, Annex V of the Governance Regulation in conjunction with Article 17 of the Commission Implementing Regulation 2020/1208 requires Member States to report to the European Commission textual information on the comparison between the reference approach calculated on the basis of the data included in the greenhouse gas inventory and the reference approach calculated on the basis of the data reported pursuant to the Energy Statistics Regulation. Member States with differences of more than +/- 2% in the total national apparent fossil fuel consumption have to provide quantitative information and explanations for the year X-2 in accordance with the tabular format set out in Annex XIV of the Commission Implementing Regulation.

Eurocontrol data

Since 2010 there have been framework contracts in place between the European Commission and Eurocontrol, the European Organization for the Safety of Air Navigation, related to the improvement of GHG and air pollutant emission inventories submitted by the EU Member States to the UNFCCC and UNECE. The aim has been to assist the MS in improving their annual emission inventories, i.e. by providing better estimates of fuel split in domestic/international aviation using real flight data from Eurocontrol. In the framework of this cooperation, the European Environment Agency, with its ETC CM (European Topic Centre on Climate Change Mitigation) work programs, compares the MS inventory submissions with Eurocontrol data and produces a report where the outcome of these comparisons is presented and discussed.

The most recent data provided by Eurocontrol was in Aug.-Sep. 2022, following the information that has been given in previous years related to fuel consumption and emissions for CO_2, CH_4, N_2O and other pollutants for domestic and international aviation, covering the period from 2005 to 2021. The main update of the Aug.-Sep. 2022 version of data was the recalculations for years 2017-2021. Eurocontrol uses a bottom-up modelling approach with the Advanced Emissions Model (AEM). This is a Tier 3b methodology based on information of flight plan and trajectories. Flight plan data is only available for flights under Instrumental Flight Rules (IFR). Flights under Visual Flight Rules (VFR) are not included in the dataset of Eurocontrol.

The latest version of the report with the comparison of MS inventories (15 Jan. 2023 submission) with Eurocontrol data for years 2005-2021 has been prepared and delivered early March 2023. Main checks included domestic and international fuel consumption for jet kerosene and aviation gasoline; in addition, domestic share and implied emission factor (IEF) CO_2, CH_4, and N_2O for both jet kerosene and aviation gasoline. A general observation that can be made from the comparisons is that in most cases the Eurocontrol values present small differences compared to the MS inventories. Higher differences are observed in a few cases, i.e. for individual countries and for a specific fuel/data category. Specifically, at EU-27 level:

- Domestic kerosene values are close for years 2005-2016 (differences from -4% to -1%), while the differences become higher for years 2017-2021 (from -42% to -32%).
- Domestic aviation gasoline Eurocontrol values are very low, i.e. slightly higher than 0 for all years; hence, there are big differences with MS inventories (from -94% to -85%).
- International kerosene values are close for all years (differences from -6% to 3%).
- Values of domestic share in total (i.e. domestic + international) kerosene consumption are very close for years 2005-2016 (differences from -4% to 1%), while higher differences are observed for years 2017-2021 (from -37% to -26%).
- Total kerosene values are close for all years (differences from -8% to 2%).

Methodological differences: There are possibly methodological differences between Eurocontrol and MS inventories. For example, in domestic aviation gasoline, the Eurocontrol methodology is based exclusively on flights under IFR; small aircrafts, which mostly use aviation gasoline, usually fly under VFR and, therefore, are not sufficiently covered. Another difference is that the Eurocontrol values strictly refer to aviation activities, i.e. flights, and the fuel consumed in these activities is modelled for individual trajectories. While in the MS inventories, the fuel consumption has to be adapted to the national energy balances.

Military aviation: This source is strictly excluded from Eurocontrol and, as clarified in the CRF tables, domestic aviation should not include emissions from military aviation. The emissions from military mobile sources should be reported under category 1.A.5.b (Other mobile military use).

Domestic share: Domestic share in total (i.e. domestic + international) fuel consumption is an important indicator for the aviation sector. Some MS mention in their NIRs that their national energy balances provide separately the fuel sold for domestic and international flights or that the fuel consumption at individual airports is defined as being used for domestic or international flights. In any case, Eurostat and Eurocontrol (which has detailed information for the origin/destination pairs of most flights) can be used to derive this indicator.

Tier method: A possible inconsistency may exist in the definition of Tier method reported by countries in their NIRs. For example, Tier 1 from the IPCC guidelines considers only the use of fuel from national energy statistics, whereas in the EMEP/EEA Guidebook the Tier 1 method already separates between LTO and cruise phase. It is proposed to report information based on the IPCC guidelines in order to allow for a consistent overview of applied methodologies. Specifically:

- Tier 1: Fuel consumption data split by domestic and international aviation.
- Tier 2: LTO data from number of flights (2a) or from flights by aircraft type (2b).
- Tier 3: LTO data for individual aircrafts and data on the origin/destination pairs of flights (3a) and on air traffic movements (3b).

Table 3.116 provides an overview of how the Eurocontrol data has been used by MS.

Table 3.116 Use of Eurocontrol data by Member States

	Use of Eurocontrol data for kerosene consumption				
	For comparison / verification	For planned improvements	Indirect use	Direct use	How has the time series consistency been ensured?
Austria	-	-	-	-	-

	Use of Eurocontrol data for kerosene consumption				
	For comparison / verification	For planned improvements	Indirect use	Direct use	How has the time series consistency been ensured?
Belgium			Data per airport, to make distribution of emissions in the regions possible	In Flemish region for international flights. In Wallonia, for N_2O and CH_4	
Bulgaria			LTO per aircraft type for years 1996-2021		
Croatia	-	-	-	-	-
Cyprus				For domestic and international flights	Trend of domestic share from Eurocontrol data has been applied to years 2005-2021
Czechia				Emissions calculated with Eurocontrol IEFs	
Denmark			List of aircraft types provided by Eurocontrol		
Estonia	-	-	-	-	-
Finland				For domestic flights from 2005 onwards	Own model (ILMI) has been used for years before 2005 and partly until 2008; since 2010 the model was not updated; no specific adaptation
France	Not mentioned, numbers match very closely				
Germany	Yes				
Greece				For domestic and international flights	Emissions for 1990-2005 have been recalculated taking into account only international aviation fuel consumption and by applying Tier 1 methodology
Hungary				For domestic flights	Fuel use (and, consequently, emissions) for years before 2005 has been adapted with built-in extrapolation procedures; same share of kerosene use from Eurocontrol 2005-2015 for domestic flights has been applied for years 1985-2004
Ireland				Fuel consumption based on origin and destination data for domestic air travel provided by Eurocontrol (2005-2021)	
Italy	Yes			Domestic	Emissions recalculated based on Eurocontrol; linear interpolation between 1999 (the year of Tier 3) and 2005 for fuel consumption and emission factors
Latvia	Yes				
Lithuania					
Luxembourg	-	-	-	-	-
Malta				Domestic aviation (2005-2021)	
Netherlands	-	-	-	-	-

	Use of Eurocontrol data for kerosene consumption				
	For comparison / verification	For planned improvements	Indirect use	Direct use	How has the time series consistency been ensured?
Poland				For share of domestic flights	Due to lack of Eurocontrol data for years prior to 2005, the share of domestic use for years 1988-2004 was assumed as a 5-years average from Eurocontrol data for years 2005-2009
Portugal					
Romania	-	-	-	-	-
Slovakia				Eurocontrol data on the number of flights, fuel consumption and domestic share was used	For years 1990-2004, summary information from Eurocontrol database was used (emission factors and domestic share)
Slovenia				For domestic flights, since 2017 data on fuel consumption from Eurocontrol	Only a small amount of domestic flights has been recorded by Eurocontrol; no adaptation for years 1990-2004
Spain				For domestic and international flights	An adaptation model has been applied to link results based on national statistics with Eurocontrol
Sweden	-	-	-	-	-

3.5 Sector-specific improvements

The improvements implemented in 2023 were mainly due to draft recommendations made by the UNFCCC review team 2022. The major improvements are included in included in Table 10.7 in chapter 10.

3.6 Comparison between the sectoral approach and the reference approach (EU-KP)

The IPCC reference approach for CO_2 from fossil fuels for the EU is based on Eurostat energy data (Eurostat database, February 2023) for apparent consumption included in CRF table 1A(b) and data from MS CRF submissions for CRF table 1A(d). The reason for using Eurostat data in CRF table 1A(b) is that Eurostat provides a coherent data set for all Member States for apparent consumption in TJ whereas in the CRF submissions some MS use TJ and other MS use kt. Up to 2017 also for CRF table 1A(d) we used apparent consumption from Eurostat. The reason for having used Eurostat data in CRF table 1A(d) for many years was that also for non-energy use of fuels Eurostat provided a coherent data set for all 28 EU Member States. The drawback of Eurostat data was that the definition of non-energy use of fuels in energy statistics is narrower than the definition in the IPCC guidelines because fuels used as reductants are not classified as non-energy use of fuels in energy statistics. In addition, Member States may use other data than the energy balance for compiling the non-energy use data (e.g. EU ETS data, environmental reporting of companies, etc.). Therefore, the EU decided to change the reporting in CRF table 1A(d) and calculate all data as the sum of respective MS data. The drawback of this approach is that Member States may use different allocation of energy use and non-energy use of fuels (e.g. in iron and steel) depending on the allocation in the sectoral approach.

Energy statistics are submitted to Eurostat by Member States on an annual basis with the five joint Eurostat/IEA/UNECE questionnaires on solid fuels, oil, natural gas, electricity and heat, and renewables and wastes. On the basis of this information Eurostat provides the annual energy balances which can be used for the estimation of CO_2 emissions from fossil fuels by Member State and for the EU as a whole.

The Eurostat data for the EU IPCC reference approach includes activity data and net calorific values as available in the Eurostat database. For the calculation of CO_2 emissions, the IPCC default carbon emission factors are used.

The IPCC reference approach method at EU level is a three-step process.

- The Energy Statistics Regulation (Regulation EC/1099/2008) is the basis for MS reporting of energy data to Eurostat as well as the basis for the EU's IPCC Reference Approach. For each of the EU Member States, annual data on energy production, imports, exports, international bunkers and stock changes by fuel are available from Eurostat's database http://ec.europa.eu/eurostat/data/database The energy data used for the Reference Approach in the EU 2023 inventory submission, and reported in table 1.A(b), corresponds to the sum of the EU Member States.
- The energy data in Eurostat's database can be exported in mass or volume units or in Terajoules. The latter is based on the calorific values reported by MS in the energy questionnaires, on a net basis. Table 1.A(b) was reported in Terajoules. The data was downloaded in February 2023.
- The carbon emission factors are those from the IPCC 2006 Guidelines http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
- The carbon excluded from table 1.A(b) is fully consistent with the data included in table 1.A(d).
- Eurostat data is not used for table 1.A(d). Instead we use the sum of the Member States CRF data because the definition of Eurostat non-energy use of fuels is narrower than in the IPCC guidelines and because the reporting in column I is closely linked to the inventories in IPPU sectors.
- The fractions of carbon oxidised reported in table 1.A(b) are the default 2006 IPCC factors of 1, thus assuming complete oxidation of emissions.

CRF table 1A(c) compares EU CO_2 emissions calculated with the IPCC reference approach and the sectoral approach (Table 3.117). The percentage differences for both energy consumption and CO_2 emissions are very similar to previous submissions.

Table 3.117 Comparison of reference approach and sectoral approach for EU

[1. Energy][1.AC Comparison of CO2 Emissions from Fuel Combustion]	Unit	1990	2000	2010	2015	2020	2020
Fuel consumption							
Sectoral approach	PJ	44 510	43 368	42 606	37 957	33 381	35 445
Apparent energy consumption (excluding non-energy use, reductants and feedstocks)	PJ	44 174	42 479	41 896	36 829	33 065	35 052
Energy consumption difference	%	-0,8	-2,1	-1,7	-3,0	-0,9	-1,1
CO2 emissions							
Reference approach	kt	3 457 177	3 191 595	3 085 579	2 749 115	2 356 340	2 516 860
Sectoral approach	kt	3 522 371	3 285 064	3 163 326	2 835 185	2 390 283	2 552 389
Difference	%	-1,9	-2,8	-2,5	-3,0	-1,4	-1,4

Table 3.118 provides an overview for EU Member States on differences between the Eurostat and national reference approach for apparent consumption in TJ for 2021. For the EU the differences are very small. However, for some Member States the two data sets show larger differences. The main reasons for diverging energy data are:

- the use of different calorific values (CV)
- differences in the basic energy balance data reported by Member States to Eurostat (in the joint questionnaires) and to the Commission and the UNFCCC (in the CRF tables)

Table 3.118 Comparison between Eurostat and national reference approach for apparent consumption for EU for 2021 (CRF 1.A) [25]

	Total gaseous			Total liquid			Total solid		
	Eurostat TJ	Crf TJ	Difference %	Eurostat TJ	Crf TJ	Difference %	Eurostat TJ	Crf TJ	Difference %
AT	304 907	304 907	0,0%	452 039	450 294	-0,4%	103 477	104 296	0,8%
BE	635 507	635 507	0,0%	771 808	771 808	0,0%	97 454	98 456	1,0%
BG	105 304	105 304	0,0%	174 004	175 582	0,9%	172 628	172 517	-0,1%
CY	- -	- -	0,0%	77 766	77 898	0,2%	586	586	0,0%
CZ	304 636	305 334	0,2%	355 175	353 396	-0,5%	508 797	507 698	-0,2%
DE	3 123 351	3 147 467	0,8%	3 962 241	3 857 772	-2,6%	1 867 132	1 855 154	-0,6%
DK	88 435	88 439	0,0%	229 029	233 264	1,8%	29 820	29 723	-0,3%
EE	14 570	14 649	0,5%	43 970	43 970	2,0%	103 662	98 203	-5,3%
ES	1 168 762	1 171 465	0,2%	1 846 955	1 799 735	-2,6%	129 784	118 306	-8,8%
FI	88 412	88 909	0,6%	314 143	303 598	-3,4%	77 055	76 650	-0,5%
FR	1 460 981	1 461 898	0,1%	2 606 211	2 596 809	-0,4%	221 854	222 126	0,1%
GR	206 346	206 346	0,0%	404 144	412 290	2,0%	76 657	77 408	1,0%
HR	105 725	105 725	0,0%	114 428	113 031	-1,2%	15 122	15 124	0,0%
HU	366 947	366 947	0,0%	308 611	308 578	0,0%	70 464	70 477	0,0%
IE	190 695	190 997	0,2%	243 732	247 579	1,6%	18 663	18 737	0,4%
IT	2 440 311	2 440 601	0,0%	1 817 766	1 894 953	4,2%	240 571	240 571	0,0%
LT	82 553	82 555	0,0%	118 138	114 713	-2,9%	5 635	5 633	0,0%
LU	26 011	26 011	0,0%	77 315	78 125	1,0%	1 610	1 528	-5,0%
LV	38 111	38 207	0,3%	56 208	57 237	1,8%	962	966	0,5%
MT	13 324	13 324	0,0%	12 178	11 932	-2,0%	- -	- -	0,0%
NL	1 316 248	1 320 900	0,4%	1 053 308	1 028 571	-2,3%	172 081	172 300	0,1%
PL	730 192	715 468	-2,0%	1 210 725	1 222 595	1,0%	1 704 845	1 700 886	-0,2%
PT	217 318	218 038	0,3%	352 754	355 670	0,8%	23 686	23 687	0,0%
RO	405 363	401 310	-1,0%	401 308	399 949	-0,3%	145 781	145 829	0,0%
SE	52 459	51 826	-1,2%	335 639	360 952	7,5%	60 855	63 492	4,3%
SI	30 798	30 796	0,0%	83 707	84 401	0,8%	42 625	42 612	0,0%
SK	171 167	171 103	0,0%	149 447	149 772	0,2%	96 505	96 868	0,4%
EU-27	13 688 433	13 704 032	0,1%	17 572 748	17 504 475	-0,4%	5 988 313	5 959 834	-0,5%

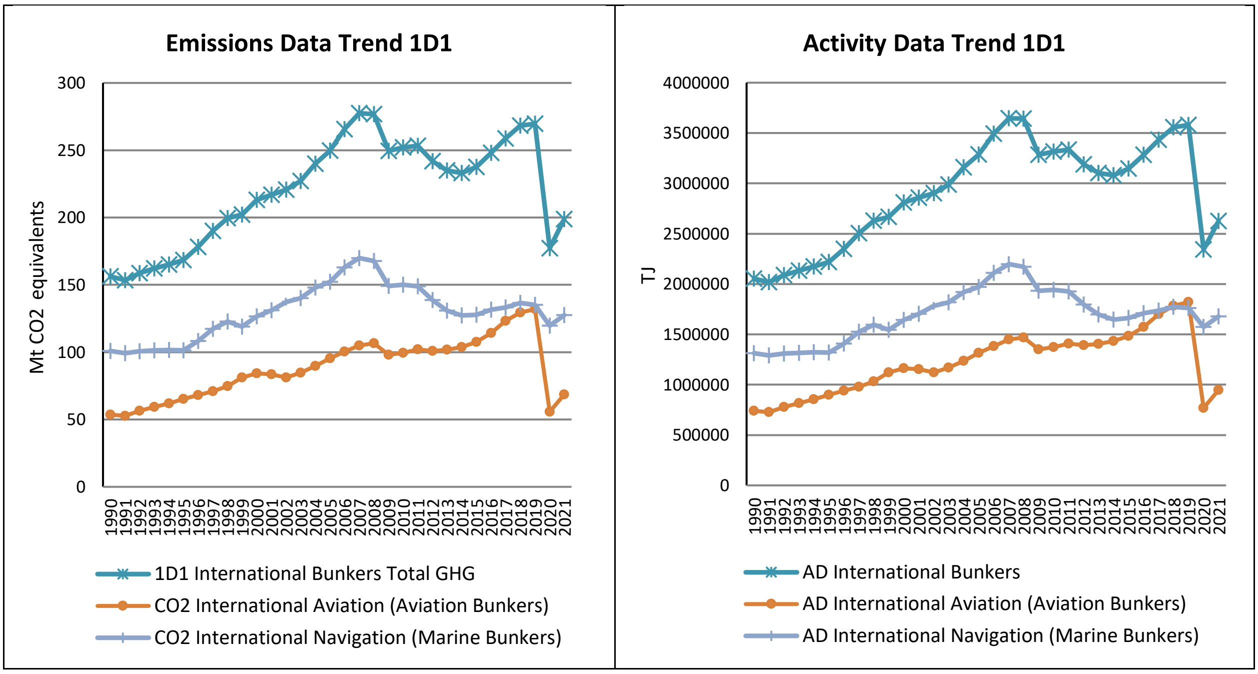
3.7 International aviation (aviation bunkers) and international navigation (marine bunkers) (EU)

International bunker emissions include emissions from aviation and marine bunkers reported under CRF category 1.D.1. The EU emissions are derived as the sum of the international bunker emissions of the countries[26]. Between 1990 and 2021, total greenhouse gas emissions from international bunkers increased by 27 % in the EU. CO_2 emissions from marine bunkers accounted for 64 % of total greenhouse gas emissions from international bunkers in 2021, while from aviation bunkers 34 % (Figure 3.200).

[25] Minus means that Member State-based estimates are lower than the Eurostat-based estimates. The table does not include the UK because the Eurostat database does not include data for the UK.

[26] The definitions in Tables 2.8 and 2.9 of the 2000 IPCC good practice guidance for the distinction between domestic and international transport are based on activities within 'one (i.e. the same) country' and are independent of the nationality or flag of the carrier. The decision trees in Figures 2.6 and 2.8 request for separate allocation between domestic and international transport activities. As the EU is neither a country nor a nation, the interpretation of the good practice guidance is that the EU emissions must be the sum of the countries estimates.

Figure 3.200 1D1 International bunkers: Greenhouse gas emissions (in Mt of CO_2 equ.) and activity data (in TJ)



3.7.1 International Aviation (1D1a) (EU)

This mobile source category includes emissions from civil international aviation, i.e. passenger and freight activity of flights having their origin and destination (O-D) in different countries. The main fuel used is jet kerosene, while the use of aviation gasoline is almost negligible.

CO_2 emissions from 1D1a International Aviation

CO_2 emissions from international aviation accounted for 2 % of total GHG emissions in EU, 2021 (including indirect CO_2, with LULUCF and international aviation). Considering only international aviation, CO_2 accounted for 98.3 % of total GHG emissions from international aviation in EU, 2021.

The time series of CO_2 emissions and activity data from 1D1a International aviation, years 1990-2021, are shown in Figure 3.201

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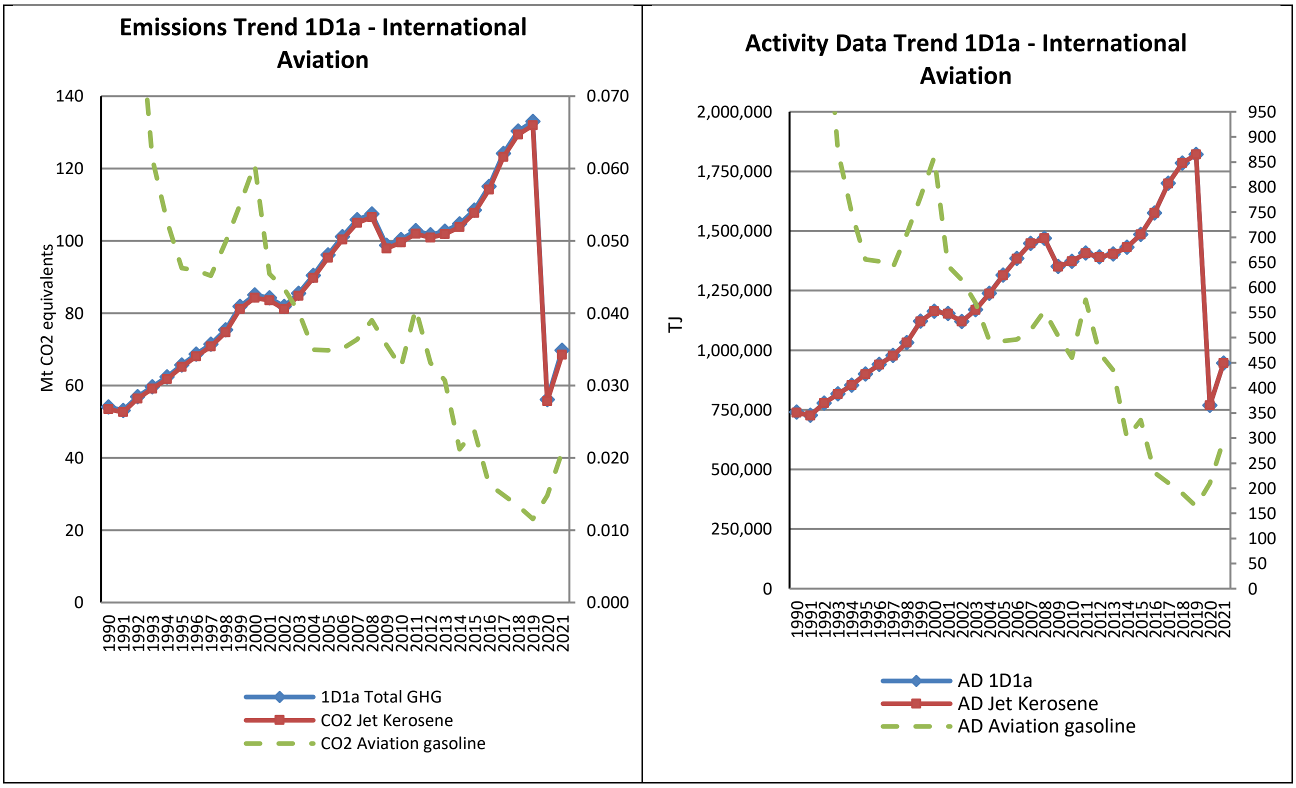
Figure 3.201   1D1a International Aviation: CO_2 emissions (in Mt) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.119 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), and change between years for international aviation. Between 1990 and 2021, CO_2 emissions from international aviation increased by 28 % in the EU, while between 2020 and 2021 the corresponding change was 23 % increase. Top five countries in 2021 were Germany, France, Spain, Netherlands, and Italy, which accounted for the 69 % of the EU value.

Table 3.119 1D1a International Aviation bunkers: CO_2 emissions per country (in kt), share in EU (%), and change between years

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	880	1 044	1 228	1.8%	348	39%	184	18%
Belgium	3 125	3 606	4 543	6.6%	1 417	45%	936	26%
Bulgaria	713	412	491	0.7%	-223	-31%	79	19%
Croatia	497	164	298	0.4%	-198	-40%	134	82%
Cyprus	718	327	555	0.8%	-163	-23%	228	70%
Czechia	670	347	375	0.5%	-295	-44%	28	8%
Denmark	1 753	976	1 258	1.8%	-495	-28%	282	29%
Estonia	107	72	129	0.2%	22	21%	57	79%
Finland	1 008	869	824	1.2%	-184	-18%	-45	-5%
France	8 809	8 250	8 356	12.2%	-453	-5%	107	1%
Germany	12 073	13 691	18 144	26.5%	6 071	50%	4 453	33%
Greece	2 475	1 324	2 512	3.7%	37	1%	1 188	90%
Hungary	505	309	375	0.5%	-130	-26%	66	21%
Ireland	1 073	1 178	1 316	1.9%	243	23%	137	12%
Italy	4 285	3 788	4 961	7.2%	676	16%	1 173	31%
Latvia	221	178	239	0.3%	18	8%	61	34%
Lithuania	399	163	185	0.3%	-213	-54%	23	14%
Luxembourg	394	1 636	1 867	2.7%	1 473	373%	230	14%
Malta	197	194	248	0.4%	51	26%	53	27%
Netherlands	4 604	6 631	7 292	10.6%	2 688	58%	661	10%
Poland	640	1 372	1 760	2.6%	1 120	175%	388	28%
Portugal	1 533	1 569	1 996	2.9%	463	30%	427	27%
Romania	790	142	246	0.4%	-544	-69%	105	74%
Slovakia	67	55	65	0.1%	-2	-3%	11	19%
Slovenia	49	26	27	0.0%	-22	-46%	1	2%
Spain	4 741	6 424	8 259	12.1%	3 518	74%	1 835	29%
Sweden	1 335	927	986	1.4%	-349	-26%	59	6%
EU-27	**53 660**	**55 672**	**68 534**	**1**	**14 874**	**28%**	**12 861**	**23%**

1D1a International Aviation – Jet Kerosene (CO_2)

CO_2 emissions from jet kerosene accounted for 98.2 % of total GHG emissions from international aviation in 2021.

Figure 3. shows the time series of CO_2 emissions in EU from international aviation – jet kerosene and the highest shares of countries. Figure 3. shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 72.5 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.3 1D1a International Aviation – Jet Kerosene: Time series of CO_2 emissions in EU and highest shares of countries

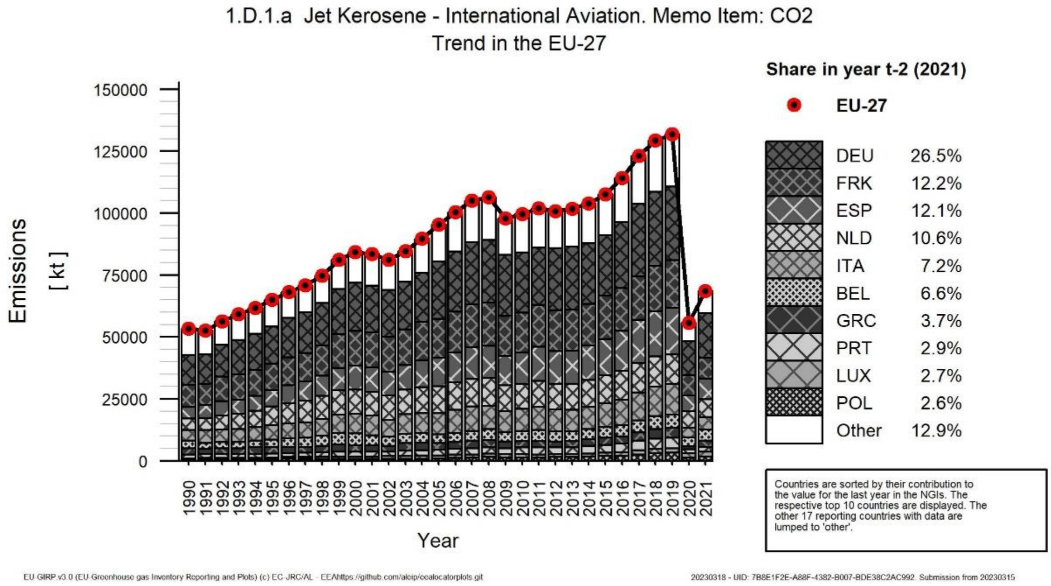
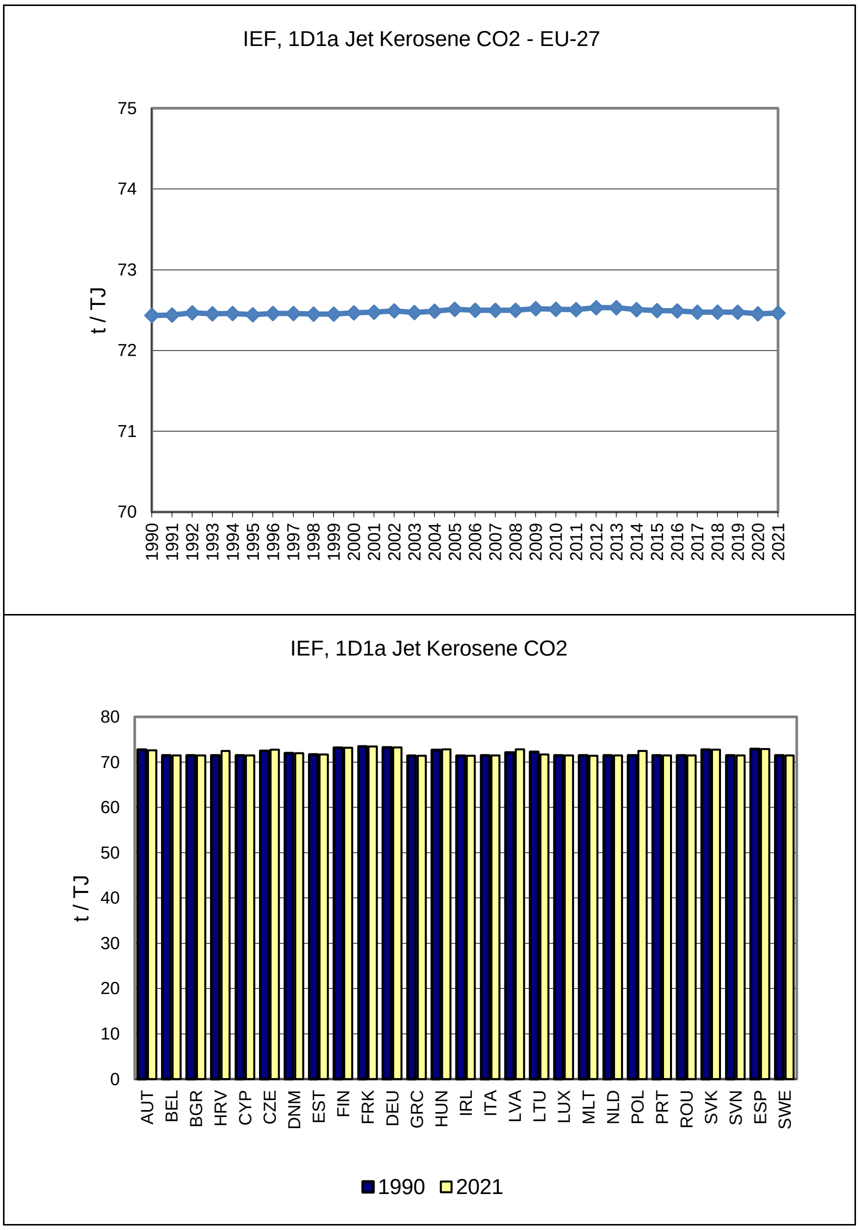


Figure 3.4: 1D1a International Aviation - Jet Kerosene: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



3.7.2 International Navigation (1D1b) (EU)

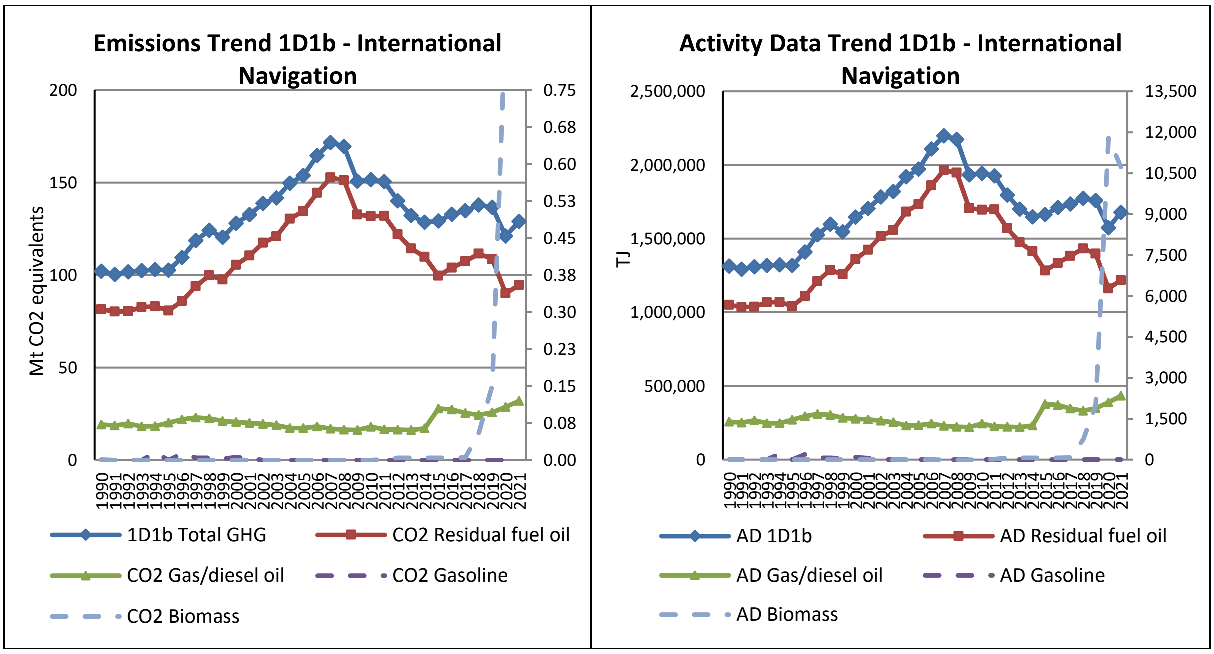
This mobile source category includes emissions from international waterborne transport, i.e. passenger and freight activity of trips having their origin and destination (O-D) in different countries. The main fuel used is residual fuel oil, followed by gas/diesel oil. Fishing vessels are excluded and they are reported separately under category 1A4ciii (Other sectors – Fishing).

CO_2 emissions from 1D1b International Navigation

CO_2 emissions from international navigation accounted for 4 % of total GHG emissions in EU, 2021 (including indirect CO_2, with LULUCF and international aviation). Considering only international navigation, CO_2 accounted for 98.8 % of total GHG emissions from international navigation in EU, 2021.

The time series of CO_2 emissions and activity data from 1D1b International navigation, years 1990-2021, are shown in Figure 3.202.

Figure 3.202 1D1b International Navigation: CO_2 emissions (in Mt) and activity data (in TJ)



Data displayed as dashed line refers to the secondary axis.

Table 3.120 shows the CO_2 emissions per country and at EU level (in kt), share of each country in EU (%), and change between years for international navigation. Between 1990 and 2021, CO_2 emissions from international navigation increased by 26 % in the EU, while between 2020 and 2021 the corresponding change was 7 % increase. Top five countries in 2021 were Netherlands, Belgium, Spain, Sweden, and Malta, which accounted for the 78 % of the EU value.

Table 3.120 1D1b International Navigation: CO_2 emissions per country (in kt), share in EU (%), and change between years

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	46	43	61	0.0%	15	33%	19	44%
Belgium	13 313	20 470	25 559	20.0%	12 246	92%	5 088	25%
Bulgaria	183	261	265	0.2%	82	45%	3	1%
Croatia	147	64	74	0.1%	-73	-49%	11	17%
Cyprus	183	874	800	0.6%	618	338%	-74	-8%
Czechia	NO	NO	NO	-	-	-	-	-
Denmark	3 013	1 629	1 370	1.1%	-1 643	-55%	-259	-16%
Estonia	573	906	941	0.7%	368	64%	35	4%
Finland	1 832	980	877	0.7%	-955	-52%	-102	-10%
France	7 961	3 122	3 544	2.8%	-4 417	-55%	422	14%
Germany	6 917	3 518	3 752	2.9%	-3 166	-46%	234	7%
Greece	8 106	5 338	5 925	4.6%	-2 181	-27%	587	11%
Hungary	NE,NO	NO,NE	NO,NE	-	-	-	-	-
Ireland	57	477	528	0.4%	471	830%	51	11%
Italy	4 280	4 194	5 633	4.4%	1 354	32%	1 440	34%
Latvia	1 515	648	672	0.5%	-843	-56%	24	4%
Lithuania	302	581	593	0.5%	291	96%	12	2%
Luxembourg	0	0	0	0.0%	0	-83%	0	5%
Malta	956	7 027	6 231	4.9%	5 275	552%	-796	-11%
Netherlands	34 944	37 117	35 693	28.0%	749	2%	-1 424	-4%
Poland	1 265	947	1 092	0.9%	-173	-14%	145	15%
Portugal	1 400	2 192	2 147	1.7%	747	53%	-45	-2%
Romania	NO	132	104	0.1%	104	∞	-28	-21%
Slovakia	65	15	17	0.0%	-47	-74%	2	15%
Slovenia	NO,NA	378	280	0.2%	280	∞	-98	-26%
Spain	11 587	20 535	23 500	18.4%	11 914	103%	2 965	14%
Sweden	2 333	8 179	7 941	6.2%	5 607	240%	-238	-3%
EU-27	**100 978**	**119 628**	**127 601**	**1**	**26 623**	**26%**	**7 973**	**7%**

1D1b International Navigation – Residual Fuel Oil (CO_2)

CO_2 emissions from residual fuel oil accounted for 73 % of total GHG emissions from international navigation in 2021.

Figure 3.203 shows the time series of CO_2 emissions in EU from international navigation – residual fuel oil and the highest shares of countries. Figure 3.204 shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 77.6 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.203 1D1b International Navigation – Residual Fuel Oil: Time series of CO_2 emissions in EU and highest shares of countries

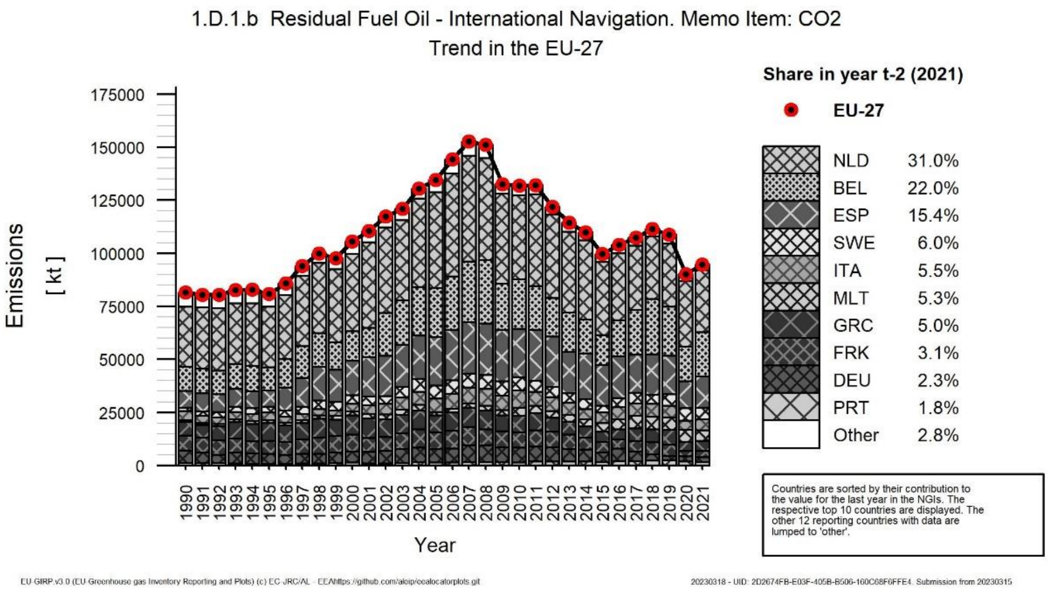
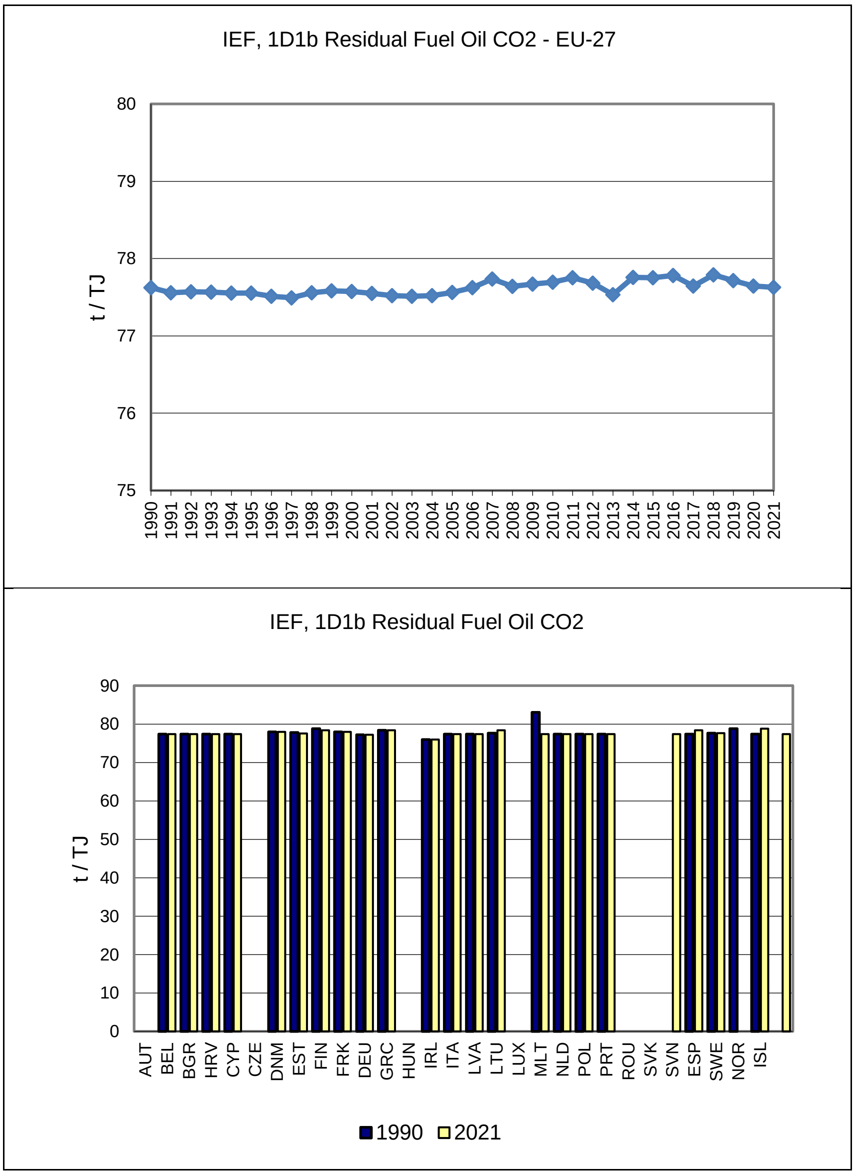


Figure 3.204 1D1b International Navigation – Residual Fuel Oil: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



1D1b International Navigation – Gas/Diesel Oil (CO_2)

CO_2 emissions from gas/diesel oil accounted for 25 % of total GHG emissions from international navigation in 2021.

Figure 3.205 shows the time series of CO_2 emissions in EU from international navigation – gas/diesel oil and the highest shares of countries. Figure 3. shows the CO_2 implied emission factor (IEF) in EU and per country (in t/TJ). From the latter it is observed that the CO_2 IEF at EU level is almost constant over the years at 74 t/TJ, while the corresponding values per country are also concentrated around this EU average value without significant deviations in both 1990 and 2021.

Figure 3.205 1D1b International Navigation – Gas/Diesel Oil: Time series of CO_2 emissions in EU and highest shares of countries

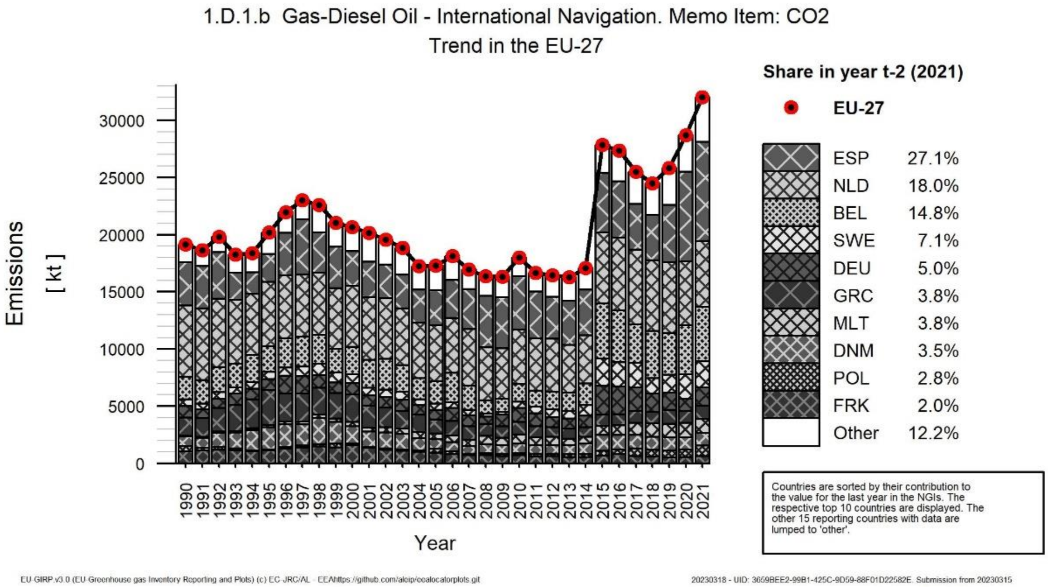
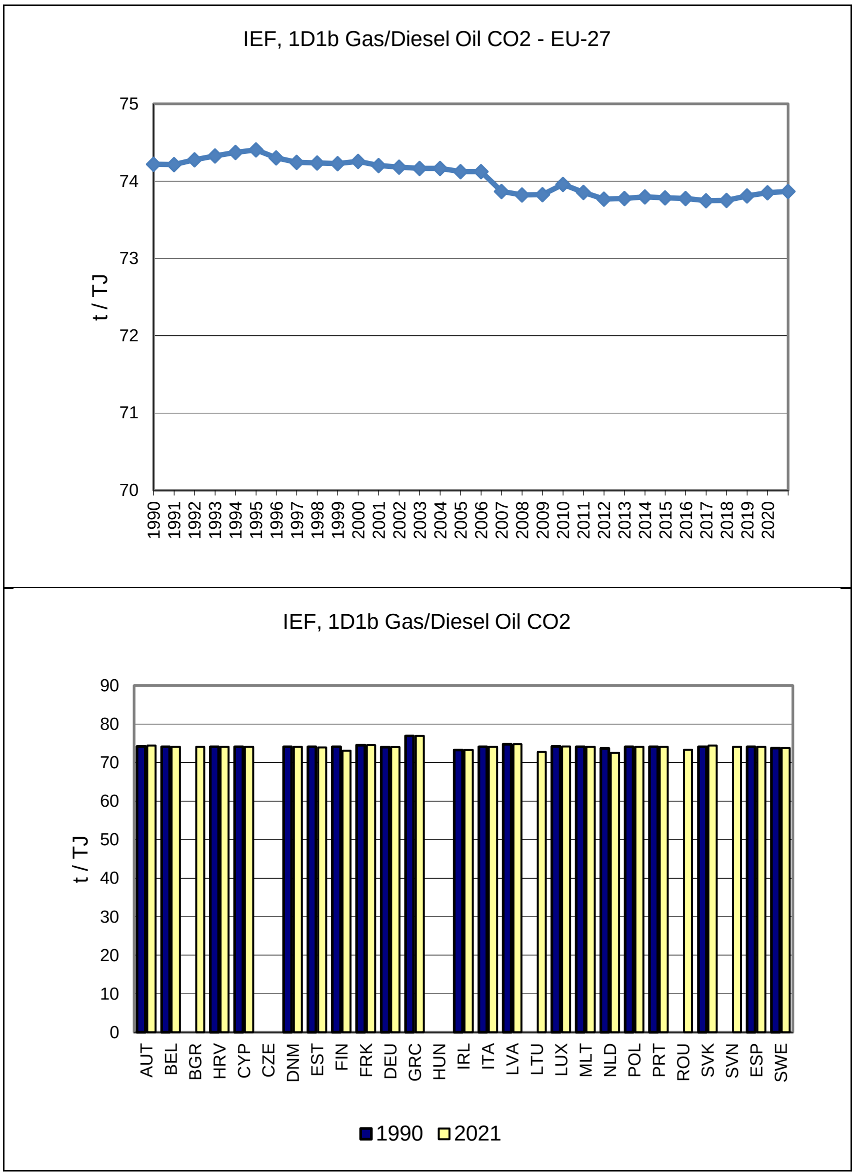


Figure 3.9: 1D1b International Navigation – Gas/Diesel Oil: CO_2 Implied Emission Factor (IEF) in EU and per country (in t/TJ)



3.8 Feedstocks and non-energy use of fuels

According to the 2006 IPCC guidelines non non-energy fuels is divided into three categories:

(1) Raw materials for the chemical industry (Feedstocks). These fossil fuels are used in particular in the production of organic compounds and to a lesser extent in the production of inorganic chemicals (e.g. ammonia) and their derivatives. For organic substances, normally part of the carbon contained in the feedstock remains largely stored in these products. Typical examples of raw materials are feedstocks for the petrochemical industry (naphtha), natural gas, or different types of oils (e.g. the production of hydrogen for the subsequent production of ammonia by partial oxidation).

(2) Reductants. Carbon is used as a reductant in metallurgy and inorganic technologies. Unlike the previous case, here when using fossil fuel as reductant only a very small amount of carbon

remains fixed in the products for a longer time and the larger part of the carbon is oxidized during the reduction process. Metallurgical coke is a typical reductant.

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

The non-energy use of fuels is reported in CRF table 1.A(d). The purpose of CRF table 1A(d) is twofold:

(1) The table should make transparent the amount of carbon from non-energy use of fuels that is subtracted from the carbon included in all fuels (both energy and non-energy use) in order to make a meaningful comparison between sectoral and reference approach.

(2) The table should make transparent in which categories other than Energy CO_2 emissions from non-energy use of fuels are included in the inventory (mostly IPPU). Therefore, the table serves as a basis for consistency checks with the IPPU sector reporting.

Table **3.121** shows the fuels that were used for the purpose of non-energy use in the EU in 2021. All data in CRF table 1A(d) is calculated as the sum of respective MS data. It shows that 7 % of non-energy use of fuels are liquid fuels with naphta, bitumen and LPG showing the largest contribution to NEU of liquid fuels. Naphta and LPG are mainly used as feedstock in the petrochemical industry. Bitumen is mainly used in the construction industry. Natural gas accounts for 14 % of non-energy use of fuels and is mainly used for feedstock in ammonia production. Coke oven / gas coke accounts for 9 % of NEU of fuels and is mainly used as reductant in the metal industry.

Table 3.121   Fuel quantity for non-energy use in TJ and % for the EU

Fuel			TJ	%
Liquid fossil	Primary fuels	Crude oil	382	0.01%
		Natural gas liquids	60 000	1.2%
		Gasoline	1 900	0.039%
		Jet kerosene	NO	0.0%
		Other kerosene	1 335	0.03%
		Gas/diesel oil	123 657	2.5%
		Residual fuel oil	51 964	1.1%
		Liquefied petroleum gases (LPG)	448 490	9.1%
		Ethane	36 276	0.7%
		Naphtha	1 686 532	34.2%
		Bitumen	567 401	11.5%
		Lubricants	169 632	3.4%
		Petroleum coke	49 264	1.0%
		Refinery feedstocks	6 735	0.1%
		Other oil	247 866	5.0%
Other liquid fossil			7 684	0.2%
Liquid fossil totals			**3 459 117**	**70.2%**
Solid fossil	Primary fuels	Anthracite	18 910	0.4%
		Coking coal	58 942	1.2%
		Other bituminous coal	131 053	2.7%
		Sub-bituminous coal	8 689	0.2%
		Lignite	256	0.01%
		Oil shale and tar sand	7 687	0.2%
		Coke oven/gas coke	527 896	10.7%
		Coal tar	24 913	0.5%
Solid fossil totals			**778 346**	**15.8%**
Gaseous fossil		Natural gas (dry)	691 769	14.0%
Gaseous fossil totals			**691 769**	**14.0%**
Waste (non-biomass fraction)			517	0.01%
Total			**4 929 232**	**100.0%**

Table **3.122**shows the associated CO_2 emissions from the NEU reported in the inventory for the year 2021. It shows that 48 % of the CO_2 emissions stem from solid fuels, 22 % from liquid fuels and 30 % from natural gas. It has to be noted that the reporting in CRF table 1A(d) is still not fully coherent and work is ongoing between the EU and its Member States in order to improve the reporting in this table.

Table 3.122 CO_2 emissions from the NEU reported in the inventory kt CO_2 and % for the EU

Fuel			kt	%
Liquid fossil	Primary fuels	Crude oil	11	0.01%
		Other kerosene	0.3	0.0003%
		Gas/diesel oil	21	0.02%
		Residual fuel oil	24	0.0%
		Liquefied petroleum gases (LPG)	2 568	2.6%
		Ethane	388	0.4%
		Naphtha	12 008	12.0%
		Bitumen	376	0.4%
		Lubricants	2 156	2.2%
		Petroleum coke	2 420	2.4%
		Other oil	2 150	2.2%
Other liquid fossil			255	0.3%
Liquid fossil totals			22 377	**22.4%**
Solid fossil	Primary fuels	Anthracite	11 170	11.2%
		Coking coal	4 411	4.4%
		Other bituminous coal	6 984	7.0%
		Sub-bituminous Coal	815	0.8%
		Coke oven/gas coke	24 465	24.5%
		Coal tar	14	0.0%
Solid fossil totals			**47 858**	**48.0%**
Gaseous fossil		Natural gas (dry)	29 499	29.6%
Gaseous fossil totals			**29 499**	**29.6%**
Waste (non-biomass fraction)			118	0.1%
Total			**99 734**	**100.0%**

Table **3.123** shows the recalculations of non-energy use of fuels for the year 2019. The main reason for recalculations id the Brexit; in 2022 the UK was included in the EU totals; in addition, for non-energy use of gasoline Germany made a large recalculation. Other reasons for recalculations are revisions in the energy balance. Across all fuels recalculations were at -10 %.

Table 3.123 Recalculations of fuel quantity for non-energy use of fuels for the inventory year 2020 submitted in 2022 and 2023

FUEL TYPE			ACTIVITY DATA AND RELATED INFORMATION			
			Fuel quantity for NEU (TJ)		Difference in TJ	Difference in %
			2022	2023		
Liquid fossil	Primary fuels	Crude oil	562	562	0	0%
		Orimulsion	IE,NO	IE,NO	0	-
		Natural gas liquids	68 100	68 100	0	0%
	Secondary fuels	Gasoline	148 551	700	-147 851	-100%
		Jet kerosene	0	0	0	-
		Other kerosene	1 932	1 932	0	0%
		Shale oil	NO	NO	0	-
		Gas/diesel oil	133 984	133 983	-1	0%
		Residual fuel oil	59 585	60 081	496	1%
		Liquefied petroleum gases (LPG)	533 753	467 918	-65 836	-12%
		Ethane	51 464	10 001	-41 463	-81%
		Naphtha	1 560 164	1 515 765	-44 399	-3%
		Bitumen	618 451	553 726	-64 725	-10%
		Lubricants	179 200	162 948	-16 252	-9%
		Petroleum coke	49 967	49 385	-582	-1%
		Refinery feedstocks	14 337	12 407	-1 930	-13%
		Other oil	255 427	253 983	-1 444	-1%
Other liquid fossil			7 254	7 254	0	0%
Liquid fossil totals			**3 682 729**	**3 298 744**	**-383 985**	**-10%**
Solid fossil	Primary fuels	Anthracite	69 080	16 606	-52 475	-76%
		Coking coal	115 681	43 425	-72 256	-62%
		Other bituminous coal	67 770	117 446	49 676	73%
		Sub-bituminous Coal	7 448	7 448	0	-
		Lignite	318	318	0	0%
		Oil shale and tar sand	9 460	10 072	611	6%
	Secondary fuels	BKB and patent fuel	NA,NO	NA,NO	0	-
		Coke oven/gas coke	463 979	457 024	-6 954	-1%
		Coal tar[7]	25 289	25 289	0	0%
Other solid fossil					0	-
		Other			0	-
Solid fossil totals			**759 025**	**677 628**	**-81 397**	**-11%**
Gaseous fossil		Natural gas (dry)	764 789	714 319	-50 470	-7%
Other gaseous fossil			NA,NO	NA,NO	0	-
Gaseous fossil totals			**764 789**	**714 319**	**-50 470**	**-7%**
Waste (non-biomass fraction)			637	637	0	0%
Other fossil fuels			NA,NO	NA,NO	0	-
Other fossil fuels totals			NA,NO	NA,NO	0	-
Total fossil fuels			**5 206 543**	**4 690 690**	**-515 852**	**-10%**

Table **3.124** provides information on feedstocks and non-energy use of fuels from Member States' NIRs.

Table 3.124 Information related to feedstocks and non-energy use from Member States' NIRs

MS	Information on feedstocks and non-energy use of fuels	Source
Austria	Non-energy use of fuels is considered in the national energy balance. Below explanations for the reported non-energy use is provided together with information on where CO_2 emissions due to the manufacture, use and disposal of carbon containing products are considered. **Lubricants** manufacture: emissions are assumed to be included in total emissions from category *1.A.1.b* petroleum refinery. use: VOC emissions from lubricants used in rolling mills are considered in category *2.C.1*. It is assumed that other uses of lubricants do not result in VOC or CO_2 emissions due to the low vapour pressure of lubricants. CO_2 from lubricants which are used in engines are considered in category *2.D.1* disposal: emissions from incineration of lubricants (waste oil) are either included in categories *1.A.1.a* and *1.A.2* if waste oil is used as fuel or to a minor degree reported under category *5.C* if energy is not recovered. **Bitumen** manufacture: emissions from the production of bitumen are assumed to be included in total emissions of category *1.A.1.b* petroleum refinery. use: indirect CO_2 emissions from the use of bitumen for road paving and roofing that should be reported in categories *2.A.5* and *2.A.6* are included in sector *3 solvent and other product use*. disposal: CO_2 emissions from the disposal from bitumen are assumed to be negligible. Recycling is not considered. **Naphtha** manufacture: Naphta is produced in the oil refinery and transferred to a petrochemical plant. Residues from the petrochemical plants are transferred back to the oil refinery steam cracker. use: Naphta is used for plastics production (e.g. ethylene). **Petroleum coke** In IEA JQ (2016) non energy use is reported for the manufacture of electrodes. manufacture: No information about emissions from manufacture of electrodes is currently available. Therefore it is not clear if emissions are not estimated or not applicable. use: Emissions from the use of electrodes are considered in category *2.B.4* carbide production and *2.C* metal production. **Residual fuel oil** use: Considerable amounts of residual fuel are used in blast furnaces. Emissions are considered in *2.C.1*. **Coking coal, Bituminous coal, Coke oven coke, Coal Tar** manufacture: emissions from the production of coke are considered in category *1.A.2.a*. use: CO_2 emissions from coal, coke and coal tar used in iron and steel industry are reported under *2.C*. **Natural Gas** use: emissions from the use of natural gas as a feedstock in ammonia production are accounted for in the industrial processes sector (category *2.B.1*). **Plastics waste** manufacture: Emissions from manufacture of plastics are considered in category *2.B.* use: plastics waste is used as a reductant in blast furnaces. Emissions are considered in *2.C.1*. Disposal: Any emissions from waste disposal are considered in category 5.A. Waste incineration with energy use is considered in *1.A – other fuels* and - to a minor degree - waste incineration without energy recovery is considered in category *5.C*. **Solvents** manufacture: emissions from the production of solvents are considered in sector *2.D.3* use: CO_2 emissions from solvent use are considered in sector *2.D.3*. disposal: emissions from the disposal of solvents are considered in 5.A. **Paraffin wax** use: CO_2 emissions from paraffin wax use are considered in sector *2.D.2*.	National Inventory Report, Chapter 3.2.3
Belgium	The emissions of non-energy use of fuels and related emissions (emissions from recovered fuels from processes) are reported under categories 2B1, 2B8 and 2B10. During the 2015 submission a re-allocation of the offgas-emissions/recovered fuels from cracking units (biggest part) plus some other processes (non-energy use) emissions (reported in the category 1A2c / other fuels before), were moved to the category 2B8b Industrial Processes and Product Use / Chemical Industry / Petrochemical and Carbon Black Production / Ethylene during this submission as prescribed in the new IPCC 2006 guidelines. In Flanders, a recalculation of the non-energy use and related CO_2 emissions was performed during the 2005 submission, based on the results of a study conducted in 2003. Belgium participated in a European network on the CO_2-emissions from non-energy use (see website http://www.chem.uu.nl/nws/www/nenergy/) and one of the conclusions of this network is that the new IPCC guidelines need to give more information on this subject. The result of the study made a recalculation possible for all years. The effect of the recalculation was greater in the more recent years because the petrochemical industry has expanded its activities in the beginning of the nineties (that's one of the reasons why this sector 2B8b is a key source for the trend assessment). Since the petrochemical industry is important in Flanders and Belgium and the emissions from the feedstocks are a key source in the Belgian inventory, the study mentioned above was conducted to get more detailed, country-specific information. A distinction is made between: 1. The use of recovered fuels from cracking units or other processes where a fuel is used as raw material and where part of this fuel (or transformed product) is recovered for energy purposes. These emissions are reported under category 2B8. This is the largest source of CO_2 emissions. This includes the recovered fuels in the steam cracking units in the petrochemical industry (approx. 2/3) and other recovered fuels from the	National Inventory Report, Chapter 3.2.3

MS	Information on feedstocks and non-energy use of fuels	Source
	chemical industry (approx. 1/3). These recovered fuels are reported directly in the yearly surveys carried out by the chemical federation in cooperation with the VITO [1] and from emission estimates from 2013 on, these emissions are taken over from the reported emissions via the ETS-Directive. 2. CO_2 emissions occurring during chemical processes, for example, the production of ammonia based on natural gas or the production ethylene oxide (and production of acrylic acid from propene, production of cyclohexanone from cyclohexane, production of paraxylene/metaxylene, etc) where CO_2 is formed in a side reaction (reported respectively under 2B1 and 2B10). These CO_2 emissions result from the same surveys in the chemical sector in Flanders as those reported under 2B8 and are taken over from the reported emissions via the ETS-Directive from emission estimates from 2013 on. Emissions of flaring activities in the chemical industry are allocated to the category 5C1.2.b (Waste Incineration / Non-biogenic / Other / Flaring in the chemical industry) since last submission. 3. Waste treatment of final products was not included in the study. This is practically impossible due to import/export of plastic products, etc. (it is also not clear if the waste phase is included in the default IPCC carbon stored % or not). The emissions of waste incineration are therefore calculated separately and are reported under the sector of waste (category 5C) or under the sector of energy (category 1A1a), depending whether or not energy recuperation takes place during the process.	
Bulgaria	Non-energy use of fuels is reported for the following fuels: • Anthracite • Coke Oven Coke • Other bituminous coal • Lubricants • Bitumen • Naphtha • Paraffin waxes • White spirit • Residual Fuel Oil • Other Oil Products • Petroleum Coke • Natural Gas as Feedstock There are some fluctuations of the reported consumption for some of the fuels during the time series due to changes in the industrial production – differences in production volume, decommissioning of installations or shift from one fuel type to another. Some discrepancies with the quantities of fuels reported as non-energy use exist in the Energy balance – for some fuels only for the latest years is reported non-energy use, in addition some industrial plants do not properly report their non-energy use of fuels. In order to improve the consistency, additional data was collected from several chemical plants regarding the annual production of ammonia, soda ash and calcium carbide. The amounts of energy and non-energy use of natural gas, anthracite, other bituminous coal and coke oven coke we reallocated according to the quantities of fuels considered as emission sources in the Industrial Processes sector. The non-energy use of fuels is on average 8.1% of the total apparent energy consumption during the period 1988-2016 and 6.3% for 2016. The apparent consumption is calculated according to Equation 6.2 in Vol. 2, Ch. 6 of the 2006 IPCC Guidelines. The most significant fuels used as feedstock are bitumen, anthracite and natural gas. The use of naphtha has been discontinued since 2010. In general, most of the non-energy use of fuels is attributed to the industrial sector (lubricants, paraffin wax), chemical and petrochemical industry (anthracite, natural gas, naphtha, white spirit and other petroleum products) and construction (bitumen). All sources of emissions due to non-energy use of fuels (natural gas) are reported under category 2B Chemical Industry. The quantities of waste oils, which are used with energy recovery in the non-metallic minerals and other industrial plants, are reported as other fuels under category 1.A.2.g Other industries.	National Inventory Report, Chapter 3.3.3
Cyprus	In Cyprus fuels that are used for non-energy uses are Lubricants and Bitumen. Bitumen/asphalt is used for road paving and roof covering where the carbon it contains remains stored for long periods of time. Consequently, there are no fuel combustion emissions arising from the deliveries of bitumen within the year of the inventory. Lubricating oil statistics usually cover not only use of lubricants in engines but also oils and greases for industrial purposes and heat transfer and cutting oils. All deliveries of lubricating oil should be excluded from the Reference Approach. Non-energy use of fuels in Cyprus refers to the consumption of lubricants in transport and bitumen in construction. Data on the non-energy consumption of fuels was obtained from the national energy balance (Gross inland deliveries (Calculated)).	National Inventory Report, Chapter 3.2.10
Croatia	Non-energy fuel consumptions (fuels used as feedstock) and appropriate emissions, where onepart or even the whole carbon is stored in product for a longer time and the other part oxidizes and goes to atmosphere, are described here. The feedstock use of energy carriers occurs in chemical industry (natural gas consumption for ammonia production, production of naphtha, ethane, paraffin and wax), construction industry (bitumen production), and other products such as motor oil, industrial oil, grease etc. As a result of non-energy use of bitumen in construction industry there is no CO_2 emission because all carbon is bound to the product.	National Inventory Report, Chapter 3.2.3

MS	Information on feedstocks and non-energy use of fuels	Source
Denmark	The consumption for non-energy purposes is subtracted in the reference approach, because non-energy use of fuels is included in other sectors (Industrial processes and Solvent use) in the Danish national approach. Three fuels are used for non-energy purposes: lubricants, bitumen and white spirit. The total consumption for non-energy purposes is relatively low – 10.5 PJ in 2016. The CO_2 emission from oxidation of lube oil during use was 31.7 Gg in 2016 and this emission is reported in the sector industrial processes and product use (sector 2.D). The reported emission corresponds to 20 % of the CO_2 emission from lube oil consumption assuming full oxidation. This is in agreement with the methodology for lube oil emissions in the 2006 IPCC Guide-lines (IPCC, 2006). Methodology and emission data for lube oil are shown in NIR Chapter 4.5.2. For white spirit the CO_2 emission is indirect as the emissions occur as NMVOC emissions from the use of white spirit as a solvent. The indirect CO_2 emission from solvent use was 57.8 Gg in 2016. The methodology and emission data for white spirit are included in NIR Chapter 4.5.4. The CO_2 emission from bitumen is included in sector 2.D.3, Road paving with asphalt and Asphalt roofing. The total CO_2 emissions for these sectors are 0.84 Gg in 2016. Methodology and emission data for non-energy use of bitumen are shown in NIR Chapter 4.5.6.	National Inventory Report, Chapter 3.4.1
Estonia	The following fuels are reported under CRF category 1.AD Feedstocks and non–energy use of fuels: Lubricants; Bitumen; Natural gas; Other/Oil shale. Activity data on lubricants and bitumen consumption is received from Statistics Estonia (Joint Questionnaire that Statistics Estonia sends to IEA annually). Data on natural gas that is used for the category non-energy use, is taken from the national energy balance sheet. Activity data on oil shale reported in the CRF 1.AD is calculated on the basis of plant-specific data. This reported amount consists of oil shale semi coke – the by-product of shale oil production which contains a small amount of organic matter (carbon). Oil shale semi-coke is stored in the oil shale waste dumps (carbon stored). Natural gas for non-energy purposes was used for ammonia production and is reported in the CRF category 2.B.1. Natural gas was only used in the company Nitrofert AS. In 2010 and 2011 the factory was temporarily closed down due to low ammonia price in the World market. In 2012 the ammonia production factory was reopened and during 2013 it was closed again and has remained closed ever since.Lubricants are used in the Energy sector for lubricating (mainly in transport and manufacturing sub-sectors). Some used lubricants (waste oils) are incinerated and corresponding emissions are taken into account in the CRF 1.A.2.f/Other fuels.	National Inventory Report, Chapter 3.2.3
Finland	The emissions from the non-specified burning of feedstocks are calculated by a separate module in ILMARI. The ILMARI system includes point source (bottom-up) data on feedstock combustion in the petrochemical industry and these emissions are reported in corresponding subcategories of 1.A.2. These specified energy uses of feedstock are subtracted from the corresponding total amounts of feedstock. For the rest of the feedstock, 100% of carbon is estimated to be stored in products (mainly plastics). Residual fuel oil and coke are used as feedstocks in the metal industry and corresponding amounts are subtracted from the reference approach. All (100%) of this carbon is estimated to be released as CO_2 during the process and emissions are reported in category 2.C.1 (see section 4.4.2). Natural gas, heavy fuel oil, LPG, naphtha and other oil products are used as feedstock in the chemical industry. Carbon included in these feedstocks is subtracted from the reference approach. Most of carbon is stored in the products, but certain process emissions are reported in sector 2.B.10 (see section 4.3.5). From other feedstocks, only carbon from paraffin waxes is estimated to oxidise and these emissions are reported in sector 2.D.2 (section 4.5.3). The ILMARI system includes point source (bottom-up) data also on waste oil combustion in different branches of industry, and these emissions are reported in corresponding subcategories of 1.A.2. For the rest of lubricants we use top-down calculation methodology, presuming that 33% of carbon is stored in products (recycled lubricants) and 67% of carbon is released as CO_2 either in burning of lubricants in motors (two-stroke oil and part of motor oil in four-stroke engines) or illegal combustion of waste oil in small boilers. These non-specified emissions from burning of lubricants (excluding above mentioned emissions reported in 1.A.2) are included in category 2.D.1 (Section 4.5.2). According to IPCC 2006 Revised Guidelines emissions from 2-stroke oil should be reported in the Energy Sector. We do not have data on sales of 2-stroke oil separately, thus we have not separated these emissions from the use of 4-stroke oil and other lubricants. However, we have made a rough estimate for 2013, showing that CO_2 emissions from 2-stroke oil might be around (less than) 7 kt. To be able to reallocate these emissions to Energy Sector, we would have to split the figure to four subsectors (road transport, residential non-road machinery, commercial non-road machinery and leisure boats). As we do not have full time series of activity data to allocate these emissions to Energy subsectors, we are not able to do the split and have included them in 2.D.1, correspondingly to the top-down calculation methodology described above. This misallocation should not result in over- or underestimation of emissions.	National Inventory Report, Chapter 3.2.3

MS	Information on feedstocks and non-energy use of fuels	Source
France	The fossil fuels are consumed for different purposes, for energy use and non-energy use (raw material, intermediate material as well as reducing agent). Emissions can occur in the sector of fuel combustion and industrial process. However, it is not always possible, partly for practical reasons, to separately report these two types of emissions. In the IPCC Guidelines, 2006, the following rule is formulated: Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source category in which the process occurs. These source categories are normally 2B and 2C. However, if the derived fuels are transferred for combustion in another source category, the emissions should be reported in the appropriate part of Energy Sector source categories (normally 1A1 or 1A2). In the French inventory, in order to preserve the coherence of the inventory of greenhouse gas emissions (under the UNFCCC) and the inventory of atmospheric pollutants (under the UNECE) on the one hand, and between the sectoral approach and the reference approach, on the other hand, it was decided to maintain the distinction between energy uses (reported in CRF 1A) and non-energy (in CRF 2). Finally, to ensure the completeness of the inventory, a feedback on total final consumption (energy + non-energy) energy balance is assured. With regard to the consumption of solid fuels (coal and coke coal) the energy balance accounts all types of use of these fuels as energy consumption and they are well distinguished after energy use and non-energy use in the inventory as well. The solid fuels which are used as reducing agents as well as intermediate material are considered in the CRF category 2C in steel and ferro-alloys production and 2B7 soda ash production. The petroleum products for non-energy use are principally consumed on site of petrochemical installations. This usage is well investigated by an exhaustive survey conducted by the national statistics authority. According to the survey approximately 14% of the consumption of petroleum products is used for non-energy use, mainly as primary material. This survey defines the quantities of different oil products that are consumed in steam crackers reported under CRF 2B (in particular naphta). Emissions from non-energy use of petroleum coke are reported in under 2C3 (aluminium production) and 2B6 (titanium dioxide production). Emissions which are related to the combustion of motor oil for 2-stroke engines are considered in CRF category 1A3 whereas emissions from 4-stroke engines are covered under 2D1. The emissions of recovered oil which is combusted during cement production are reported under category CRF 1A2. Those which are burned in waste incinerators are reported under CRF 6. The non-energy use of natural gas is mainly occurring in the ammonia and hydrogen production and is reported under CRF 2B. The emissions from energy use of natural gas in these industries is included in 1A2.	National Inventory Report, Chapter 3.2.3
Germany	The great majority of the coal, oil and gas that Germany uses is used for energy-related purposes. The remainder of the coal, oil and gas is used as feedstock for production processes. This consumption enters into the balance as "non-energy use" (NEU). In the German Energy Balance, this consumption is listed separately, in line 43. The chemical industry is the leading user of fossil fuels for non-energy-related purposes. It uses fossil fuels in steam crackers, in reforming, in synthetic-gas production and in the produciton of graphite electrodes. In crackers and reforming, the most important products resulting from such processes are ethylene, propylene, 1,3-butadiene, benzene, toluene and xylene; in production of synthetic gases, the most important such products are ammonia and methanol. Bitumen, lubricants and paraffin waxes are produced in refineries. Bitumen is used in a range of applications, including road surfaces and bitumen sheeting for roofs. Lubricants are used in road vehicles and machines (inter alia). Without suitable adjustments, the consumption figures listed in Energy Balance line 43 cannot be compared with the CO_2 and NMVOC emissions from use of fossil fuels, in non-energy-related uses, that are reported in the inventory under industrial processes. The reason is that for the industrial processes, only emissions from production or use of products are taken into account, while line 43 takes account of entire feedstocks, thereby including both product-specific emissions and the carbon quantities stored in products. The latter account for far and away the largest share of the feedstocks. Yet a more important difference is that import and export quantities are taken into account in calculation of emissions from use of products. In the interest of obtaining a complete balance, Table 477 (see below) also takes account of the fossil-fuel carbon quantities stored in products. The correlation between material-related applications and products and the various relevant fuels is oriented to Table 1.3 from Volume 3 of the 2006 IPCC GL, and is based on information provided by relevant associations, producers and experts. In some cases, we had to make our own estimates of the applicable correlation with individual fuels. The produced quantities of the products listed in the table have been obtained from data reported by the Federal Statistical Office and by the Federal Office of Economics and Export Control (BAFA) and have been converted into CO_2 equivalents. For methanol, ethylene, propylene, 1,3-butadiene, benzene, toluene and xylene, the conversions were carried out via the molar masses of the relevant products and the molar mass of CO_2. The pertinent CO_2 equivalent emissions were split among the three feedstocks used in Germany (naphta, LP gas and other petroleum products), in keeping with (internal) data provided by associations. In the case of carbon black, the product is assumed to consist of pure carbon. That carbon was also converted into CO_2 equivalents. The production quantities for bitumen, lubricants and paraffin waxes were obtained from the Official Mineral Oil Statistics, and they are based on gross refinery production. The production quantities have been converted into CO_2 equivalents with the help of the following IPCC standard values (Table 1.2 and Table 1.4 from Vol. 2 of the 2006 IPCC GL). For the year 2014, the sum of the carbon from the pertinent emissions and of the carbon stored in products amounts to 106 % of the non-energy-related consumption given in line 43 of the Energy Balance. Consequently, the relevant material-related use can clearly be shown to include the quantities listed in the Energy Balance as non-energy-related consumption. No gaps in determination of non-energy-related CO_2 emissions are apparent in the inventory.	National Inventory Report, Chapter 18.8

MS	Information on feedstocks and non-energy use of fuels	Source
Greece	Non-energy fuel use concerns the consumption of fuels as raw materials (e.g. in chemical industry, metal production) for the production of other products, or the use of fuels for non-energy purposes (e.g. bitumen). Part of the carbon content of fuels is stored in final products and is not oxidized into carbon dioxide for a certain time period. The fraction of the carbon contained in final products and the time period for which carbon is stored in them, depend on the type of fuel used and of the products produced. The oxidation of the carbon stored in final products occurs either during the use of the product (e.g. solvents) or during their decomposition (e.g. through combustion). It should be noted that emissions during production processes (e.g. ammonia and hydrogen production) should be reported under the sector of IPPU, while emissions from burning of products should be reported under the waste sector or energy sector (as long as energy exploitation takes place).Non-energy use of fuels in Greece refers to the consumption of: • naphtha, natural gas, and lignite (for the period 1990 – 1991) in chemical industry, • petroleum coke in the production of non-ferrous metals, • lubricants in transport (including off-road transportation), • bitumen in construction and • other petroleum products in the industrial and residential sectors The calculation of carbon dioxide emissions from non-energy use of fuels is based on the relevant consumption by fuel type (Table 3.9) and the fraction of the carbon stored by fuel type (Table 3.10). Data on the non-energy consumption of fuels derive from the national energy balance. However, plant specific data derived from verified ETS reports and information provided by specific greek industries resulted to the improvement of reallocation of non-energy use fuels from the energy to the industrial processes sector: • The non-energy use of natural gas for ammonia production has been reallocated to industrial processes sector since the 2012 submission, by using data from ETS reports and plant specific information. Non-energy use of lignite is accounted in the industrial processes sector and refers only to ammonia production (in one installation for 1990 and 1991) and as a result the fraction of carbon stored is equal to 0. The operation of this installation ended at 1998 while itdid not produce ammonia for the period 1992 – 1998. • The non-energy use of natural gas for hydrogen production is included in the industrial processes sector, by using data from ETS reports and information from Public Gas Corporation. The associated CO_2 emissions from hydrogen production from liquid fuels are reported under the subcategory 1.A.1.b, because while disaggregated data on the amount of liquid fuels used for hydrogen production are available from the EU ETS reports for the period 2005–2016, for the period 1990–2004 the amount of liquid fuel used for hydrogen production is reported together with the amount of fuel combusted in the refineries as provided in the national energy balance. It is therefore not possible to report these emissions separately for the period 1990–2004. • CO_2 emissions from the use of fuels as reduction agents in the iron and steel industry, are only reported under the industrial processes sector. • Solid fuels consumption in the ferroalloys production industry is included (in the national energy balance) in the solid fuels consumption of the non-ferrous metals sector. However, by using data from ETS reports and plant specific information, emissions from solid fuels for ferroalloys production are reallocated to the industrial processes sector, as from 2010 submission. • The non-energy use of petroleum coke (see Table 3.9) refers exclusively to the primary aluminium production. Given that the relevant emissions are reported under the industrial processes sector, petroleum coke consumption is not taken into account in the energy sector. Since this submission, following 2006 IPCC GLs, all fuels with non-energy use were reallocated to the IPPU sector (e.g. other petroleum products, lubricants, etc). On the basis of the abovementioned clarifications, the possibility to double-count or underestimate CO_2 emissions from the non-energy use of fuels is minor.	National Inventory Report, Chapter 3.2.3
Hungary	All the fuels regarded as NEU in IEA Energy Statistics are allocated into IPPU sectors and also some amount from the quantities regarded as energy use in order to follow the suggestion of IPCC 2006. This is the case by Natural Gas use in sector 2B1 – Ammonia, Naphtha use in 2.B.8 Petrochemical and the Coke used in 2C1 – Iron and steel. Therefore, the Fuel quantities for NEU reported in CRF Table 1.A.(d) and QA/QC check Table for NEU included in Annex of the NIR are higher than the actual quantity reported in IEA Energy Statistics. However, the differences are well-known and documented. Carbon content of all fuels which are allocated under the Industrial Processes sector is taken as stored carbon in the 1.AD sector (and in the reference approach), however the calculation of emission in the IPPU sector is not based on a default carbon-stored approach, but usually plant-specific (EU ETS) data, except for Lubricant and Paraffin wax use source categories.	National Inventory Report, Chapter 3.2.3
Ireland	This category includes fossil fuels used for non-energy purposes; without the combustion and oxidation process. There are a number of fuel types applicable in Ireland: • Lubricants – IPCC default oxidation value of 0.2 is used, see category 2.D.1; • Bitumen – IPCC default value of 1.0 is used for the proportion of carbon stored; • Paraffin wax – IPCC oxidation value of 0.9 is used for candles and 0.2 for all other paraffin wax, see category 2.D.2; • White spirit – IPCC default value of 1.0 is used for the proportion of carbon stored; • Natural Gas – a significant amount of natural gas feedstock was used in ammonia production from 1990-2003.	National Inventory Report, Chapter 3.2.3

MS	Information on feedstocks and non-energy use of fuels	Source
	Emissions from the non-energy use of fossil fuels have been included in the Industrial Processes and Product Use sector, CRF Category 2.D (Chapter 4 of this report).	
Italy	The quantities of fuels stored in products in the petrochemical plants are calculated on the basis of information contained in a detailed yearly report, the petrochemical bulletin, by Ministry of Economic development (MSE, several years [b]). The report elaborates results from a detailed questionnaire that all operators in Italy fill out monthly. The data are more detailed than those normally available by international statistics and refer to: • input to plants; • quantities of fuels returned to the market; • fuels used internally for combustion; • quantities stored in products. National petrochemical balance includes information on petrochemical input entering the process and used for the production of petrochemical products, and petrochemical plants output, returns to the market, losses and internal consumption. Due to chemical reactions in the petrochemical transformation process, the output quantity of some fuels could be greater than the input quantity; in particular it occurs for light products as LPG, gasoline and refinery gas, and for fuel oil. Therefore for these fuels it is possible to have negative values of the balance. For this matter, with the aim to allow the reporting on CRF tables, these fuels have been added to naphta. The amount of fuels recovered from the petrochemical processes and returning on the market are considered as an output, because consumed for transportation or in the industrial sectors, and no carbon is stored. In Table 3.36 and Table 3.37 the overall results and details by product are reported respectively. In Table 3.36 the breakdown of total petrochemical process is reported; the percentages referring to the “net” input are calculated on the basis of the total input subtracting the quantity of fuels as gasoil, LPG, fuel oil and gasoline which return on the market because produced from the petrochemical processes. In Table 3.37 the input to the petrochemical processes in petrochemical plants and the relevant losses, internal consumption and return to the market are reported, at fuel level, allowing the calculation of the quantity stored in products, subtracting the output (returns to the market, losses and internal consumption) from the input (petrochemical input). Carbon stored, for all the fuels, is therefore calculated from the amounts of fuels stored (in tonnes) multiplied by the relevant emission factors (tC/t) reported in Table 3.37. Non-energy products amount stored from refineries, and other manufacturers, are reported in the National Energy Balance (MSE, several years [a]) and the carbon stored is estimated with emission factors reported in Table 3.38. For lubricants the net carbon stored results from the difference between the amount of lubricants and the amount of recovered lubricant oils. The energy content has been calculated on the basis of the IPCC default values. Minor differences in the overall energy content of these products occur if the calculation is based on national parameters instead of IPCC default values. In the CRF tables the fuel input amount is reported so that the fractions of carbon stored could be derived. As these fractions are derived from actual measurements they do not correspond to any default values and may vary over time. At national level, this methodology seems the most precise according to the available data. The European Project “Non Energy use-CO_2 emissions” ENV4-CT98-0776 has analysed our methodology performing a mass balance between input fuels and output products in a sample year. The results of the project confirm the reliability of the reported data (Patel and Tosato, 1997).	National Inventory Report, Chapter 3.8
Latvia	Under this category consumption of different types of fuels used as feedstock is reported. Emissions from these fuels are reported as “CO_2 not emitted” because it is assumed that in CO_2 emissions is captured and not emitted to the air. Consumption of Bitumen, Lubricants, Coke, White spirits and Paraffin wax is reported in 1.D tables for all years in time series 1990–2016. Carbon emission factors used in 2006 IPCC Guidelines were taken for all fuel types – Bitumen (22 t/TJ), Lubricants (20 t/TJ), Coke (29.2 t/TJ), White spirits (20 t/TJ) and Paraffin waxes (20t/TJ). Activity data prepared by CSB and available on CSB on-line database were used (Table 3.14). Constant increase of bitumen use since 2004 until 2008 is explained with development of construction sector and availability of financial resources from European Union (Latvia is a member of European Union since 2004) for building and improvement of transportation infrastructure. However, during the economic crisis the funding reduced and the amounts of bitumen used decreased in 2008-2010. After 2010 increase of bitumen use can be seen, it can be explained with increased financial resource to road paving. Lubricants are mainly used in transport sector and IPPU. Coke is used as ingredient in metallurgy to produce higher quality steel. Evident decrease in coke use can be explained with changes in metallurgy. Financial crisis in 2010 and bankruptcy of “Liepājas metalurgs” is the reason of reduced metal production and use of coke. Therefore in last three years there has been no usage of coke. Paraffin waxes and white spirits mainly are used as feedstocks in chemical industry and wood processing..	National Inventory Report, Chapter 3.2.3

MS	Information on feedstocks and non-energy use of fuels	Source
Lithuania	Feedstocks and non-energy use of fuel are included in national Energy balances (see Annex III). Use of fuels for feedstocks and non-energy use is dominated by natural gas (Figure 3-14). In 2016, natural gas amounted about 80.4% in the structure of feedstocks and non-energy use of fuels. The natural gas is used for ammonia, calcium ammonium nitrate, organic products and nitric acid production in the JSC Achema. JSC Achema is a leading manufacturer of nitrogen fertilizers and chemical products in Lithuania and the Baltic states. The previous ERT recommended to cross-check the data reported as non-energy use in the energy sector and the data reported under the industrial processes as the calculated CO_2 non-emitted from the use of natural gas for non-energy purpose differs from CO_2 emissions from ammonia production. A cross-check between the natural gas data used in industrial processes and the data reported as non-energy use in the energy sector showed that difference occur due to the use of different calorific values for the natural gas. In the industrial processes sector a specific calorific value is based on average annual lower calorific value of natural gas which is calculated on the basis of reports from the natural gas supplier AB Lietuvos dujos, which measure the calorific value twice a month. In the energy sector calculations are based on the data provided by the Lithuanian Statistics where fuel consumption is calculated in terms of tonnes of oil equivalent and terajoules using the net calorific value. The data reported as non-energy use in the energy sector and the data reported under the industrial processes also differs because the data reported as non-energy use in the energy sector accounts not only feedstocks for ammonia production, but also feedstocks for calcium ammonium nitrate, organic products and nitric acid production. It is necessary to mentioned that JSC Achema revised data for non-energy use for 2005-2014 in 2016, therefore in this submission revised data are reported in CRF 1.AD Feedstocks, reductants and other non-energy use of fuels. The amounts of excluded carbon were calculated in accordance with the methodology provided in 2006 IPCC Guidelines Volume 2 (page 6.7). The amounts of excluded carbon are reported in CRF 1.AD Feedstocks, reductants and other non-energy use of fuels and linked to the CRF 1.AB Fuel Combustion - Reference Approach as excluded carbon.	National Inventory Report, Chapter 3.2.3
Luxembourg	Non-energy use of fuels is considered in the national energy balance. Below explanations for the reported non-energy use is provided together with information on where CO_2 emissions due to the manufacture, use and disposal of carbon containing products are considered. For the fraction of carbon stored, the IPCC default values are applied. Lubricants Manufacturing: manufacturing of lubricants does not occur in Luxembourg. Use: Lubricants are either used in road transportation (motor oil and greases) or in the manufacturing and construction industry (mainly greases). Emissions from lubricants use are reported under category 2D1 – Lubricant Use. Please refer to section 4.5.1 for more details on the estimation of emissions from lubricant use. Disposal: incineration of lubricants (waste oil) does not occur in Luxembourg. Waste oil is either recycled or exported. Bitumen Manufacturing: manufacturing of bitumen does not occur in Luxembourg. Use: by default the carbon contained in bitumen is considered to be entirely stored in the product, i.e. asphalt for road paving. Disposal: CO_2 emissions from the disposal of bitumen are assumed to be negligible. Recycling is not considered. Coke oven coke Manufacturing: not occurring. All coke used in the iron and steel industry is imported. Use: CO_2 emissions from coke used in iron and steel industry are reported under 2.C.1 – Iron and Steel Production. Disposal: not applicable. Other bituminous coal Manufacturing: Manufacturing of electrodes from anthracite used in the electric arc furnaces does not occur in Luxembourg. Use: Emissions from the use of electrodes in the iron and steel production are considered in category 2.C.1 – Iron and steel production. Disposal: not applicable. Other oil products Manufacturing: not occurring. All products such as white spirits, etc. are imported. Use: CO_2 emissions from solvent and other products use are considered in category 2.D.3. - Nonenergy products from fuels and solvent use – Other – Solvent use. Disposal: emissions from the disposal of plastics in landfills are considered in 6.A and emissions from incineration, with energy recovery, of waste plastics are considered in 1 A 1 a.	National Inventory Report, Chapter 3.2.3

MS	Information on feedstocks and non-energy use of fuels	Source
Malta	Activity data on feedstocks and non-energy use of fuels has been obtained from the National Statistics Office. The non-energy fuels used locally are bitumen and lubricant, which are used for asphalting and to minimise friction between moving surfaces, respectively. Emissions from Lube oil used in 2-stroke engines are estimated using the COPERT 5 model and are included under sub-category 1A3b Road Transportation.	National Inventory Report, Chapter 3.2.3
Netherlands	Table 3.2 shows that a large share of the gross national consumption of petroleum products was used in non-energy applications. These fuels were mainly used as feedstock in the petro-chemical industry (naphtha) and in products in many applications (bitumen, lubricants, etc.). Also, a fraction of the gross national consumption of natural gas (mainly in ammonia production) and coal (mainly in iron and steel production) was used in non-energy applications and hence not directly oxidized. In many cases, these products are finally oxidized in waste incinerators or during use (e.g. lubricants in two-stroke engines). In the RA, these product flows are excluded from the calculation of CO_2 emissions.	National Inventory Report, Chapter 3.2.3
Poland	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 2D Non-energy products from fuels and solvent use.For more description see chapter 4.5.	National Inventory Report, Chapter 3.2.3
Portugal	Emissions of greenhouse gas emissions from feedstock use are only clearly accounted in the inventory in the following situations: - emission of CO_2 resulting from use of feedstock sub-products as energy sources. That is the case of emissions from consumption of fuel gas in refinery and petrochemical industry; - emission of CO_2 liberated as sub-product in production processes such as ammonia production; - emission of NMVOC from fossil fuel origin, and occurring from solvent use and evaporation. Although in this case it is not possible to establish which part results from feedstock consumption in Portugal in the energy balance; However, some potential emissions are not estimated or are only partly estimated. Those that are estimated in the reference approach but not in sectoral approach are: - emissions from mineral oil use as lubricants; - emissions from wear of bitumen in roads.	National Inventory Report, Chapter 3.6.5
Romania	Non-energy use of fuels is reported in the Energy balance for the following fuels on the entire time-series: Lubricants; Bitumen; Naphtha; LPG; Refinery gas; Motor Gasoline; Kerosene Type Jet Fuel; Other Kerosene; Gas-Diesel Oil; Petroleum Coke; Residual Fuel Oil; Natural Gas as Feedstock; Other Products; Paraffin waxes; White spirit; Lignite; Brown Coal; Coal Oil and Tars (from coking coal); Other Bituminous Coal. For the liquid fuels reported on the EU-ETS, the national parameter of the NCVs were determined and used to calculate the non-energy use of the fuels: annualy for the EU-ETS period (2007-2012 years) and average of the EU-ETS period for the rest of the back time series; it is the case of the following fuels: Transport Diesel, Refinery Gas, Petroleum Coke, Residual Fuel Oil, Heating and Other Gasoil. Country specific values NCVs and CO_2 EFs have determined and used for 2015 and 2016 years. The following type of fuels have been added to the Table1.A(d), "Feedstocks, reductants and other non-energy use of fuels - Other fuels" category: Refinery gas, Paraffin waxes, White spirit. According to the IPCC 2006GL provisions, Volume 3, Chapter 5: Non-Energy Products from Fuels and Solvent Use, the following methodology to report in the CRF Table 1.A(d), Feedstocks, reductants and other non-energy use of fuels, was used: • Bitumen: the carbon is reported as being full stored in the final product; • Lubricants, Naphta, Refinery gas, Other kerosene, Gas Diesel-Oil, Petroleum Coke, Residual Fuel Oil, Other products, White spirit: the carbon was presumed that is fully emitted and not stored, having the full oxidation during use; • Paraffin Waxes: the fraction of carbon stored is 0.8, the rest of 0.2 being emitted. The non-energy use of fuels is an average of 11% from the total apparent energy consumption during the period 1999-2008, and arround 15% for the rest of the years. This could be in tight relation with the developing of the industry after 2000 until the economic crisis to have effects on the industry branches. In 2015 the share of the non-energy use of the fuels in total consumption is about 6%. In 2016 the share of the non-energy use of the fuels in total consumption is about 7%. The most significant fuels used as feedstock are natural gas, bitumen, naphtha and lubricants. Also, the Coke_Oven_Coke used as reduction agent in Blast Furnace, the associated emissions being accounted in Industrial Processes sector, represents an important non-energy use quantity. For coal oil and tars the assumption suggested in the methodology (5.91 % from the coking coal consumption is assumed to be stored in products) was applied.	National Inventory Report, Chapter 3.2.3

MS	Information on feedstocks and non-energy use of fuels	Source
Slovakia	Using the IPCC 2006 Guidelines, the quantity of carbon excluded from reference approach (carbon used for ammonia production, petrochemicals production, carbide production, hydrogen production, iron and steel production, ferroalloys production, aluminium production as well as non-energy using of lubricants) was estimated. Total carbon excluded from reference approach was 1 974.5 Gg in 2016, which represents 7 239.9 Gg of CO_2. The emissions from the carbon excluded are reported in respective categories in the IPPU sector. The major share of carbon excluded represents the carbon from coking coal, both in fuel consumption and in amount of carbon (52.1% and 51.8%, respectively) The other significant source of carbon excluded is using of natural gas (21.8% in fuel consumption and 17.8% in quantity of carbon). Details on the share in fuel units and carbon units are presented on the Figures 3.33 and 3.34. The CO_2 emissions excluded from the RA are presented in Figure 3.35 for the whole time series 1990 – 2016. Liquid fuels (natural gas liquids, naphtha, and refinery feedstocks), solid fuels (coking coal, other bituminous coal) and gaseous fuels (natural gas) are used as feedstock in Slovakia. Lubricants and bitumen (liquid fuels) are used for non-energy purposes. The respective amounts of mentioned fuels are allocated in the IPPU sector and emissions are included there. The allocation of the fuels excluded from the reference approach and included in the IPPU sector is presented in the Table 3.66 and 3.67. The plant-specific (where available) and country-specific NCVs and EFs are used for estimation the volume of carbon excluded and respective CO_2 emissions excluded from the reference approach balance. The following fuels were balanced as feedstocks and non-energy use: natural gas, natural gas liquids, naphtha, lubricants, refinery feedstocks, coking coal, other bituminous coal. The quantities of the fuels and carbon used for non-energy purposes were provided directly by the plant operators or by the Statistical Office of the Slovak Republic.	National Inventory Report, Chapter 3.4
Slovenia	The biggest fraction of non-energy usage of fuels was the consumption of natural gas for the production of methanol, amounting to 89,475 Sm3 of natural gas in 2010, when this production stopped, and there has been no methanol production in Slovenia since 2011. Natural gas was entirely used as the row material for transformation into methanol. In every cycle only a fifth of it is transformed to the product, while the remaining natural gas is returned into the process. Stored CO_2 has been calculated on the basis of the formula from IPCC guidelines. We have assumed that all methane used for methanol production is stored in the product or in CO in emitted gas. This fact was confirmed also by expert from the company Nafta-Petrochem. The remaining amount of non-energy use of natural gas is used in the chemical industry also as a row material for production of organic and inorganic chemicals and plastics. According to the Statistical data all lubricants in Slovenia have been used for non-energy purpose only. Data about different types of use are not available. Likely, the largest applications for lubricants are in the form of motor oil. After the end of use, the lubricants which have been used in the engines are collected and mostly used as a fuel. In the line with the IPCC methodology emissions from lubricants used in the 2-stroke engines are reported in energy sector under road transport, while other emissions from lubricants are reported in the IPPU sector. The remaining amount of lubricants which is not combusted or oxidised during use is collected as waste oil. Slovenia has been adhering to the basic system of collection, recovery and disposal of waste oil since 1998. Recovery is the preferred choice, if technically feasible and if its cost is not unreasonably higher than the cost of disposal One of the forms of recovery is the utilisation of waste oils for energy – co-incineration in accordance with recovery procedure R1. Records by the SEA show that most waste oils have been used for this purpose. The only evidence of such a use is in the cement production. Emissions are already included in the inventory and are reported in the CRF tables in “1.A.2.g.viii Manufacturing industry and construction/Other industries under other fossil fuels”. A small portion of collected waste oils has also been incinerated (procedure R9) or reformed and then reused (procedure D10). We reported these emissions in waste sector under waste incineration in submission 2010 for the first time. No other use of lubricants as a fuel has been recorded in Slovenia until now. The data on import and export as well as data from waste oil combusted in the industry have been obtained from SORS while the data on incineration of waste oils are from SEA. Stored CO_2 has been calculated on the basis of the formula 6.4 from 2006, IPCC guidelines, Vol. 2, Ch.6 Reference Approach. **Other fuels** Coke and petroleum coke, used in industry as reduction agent or feedstock, have been subtracted from energy sector and emissions from these fuels are presented in industrial processes sector. Before 1997, amount of coke, used for production of iron and steel, ferroalloys and carbide was reported as fuel consumption in relevant sectors. After 1997, this fuel started to be collected separately, but it took a while that all non-energy used fuel was reported correctly. Energy and non-energy use of fuel in industry have been presented separately in statistical data since 2000. To avoid double counting we have subtracted all coke used in iron and steel, ferroalloys and carbide production from energy sector except coke in iron production in the base year 1986. In that time, pig iron was still produced and disaggregated into the consumption of fuel as an additive. Thus the consumption of fuel as an energy product was impossible. For consumption of coke, the decision was taken to attribute all coke, which is consumed in the production of iron and steel in this year, to the energy sector as fuel consumption and no emissions from coke used in iron and steel production are presented in industrial processes. There are also other uses of fuel in chemical processes not emitting any GHGs, therefore no explanation is included in the CRF tables. In 2016, a small amount of fuel oil, LPG and white spirit was used, mostly for production of lacquers, paintings and other coatings. The same is valid also for bitumen which is used for road paving and for production of roofing material and during this use no GHG emissions occur.	National Inventory Report, Chapter 3.2.3

MS	Information on feedstocks and non-energy use of fuels	Source
Spain	The consumption of fuel for non-energy use is accounted for in the energy balance. The quantities of each fuel type are included in the reference approach. For each fuel type a split into two parts is given: a) the part that stays in the product and b) the part that is set free and causes the corresponding CO_2 emissions. Main sources are information directly from the plant or industry association about the use of fossil fuels, such as non-energy inputs following the sector/process to determine types of fuels, determined types of fuels from the quantity consumed for this purpose as retention carbon products, such as CO_2 emissions versus its complementing and replacing the figures reported in the above mentioned sources . Following sectors / processes - in most cases on individual plant level - are investigated: i) sodium carbonate; ii) calcium carbide and silicon ; iii) silicon ; iv) ferroalloys (ferrosilicon, ferromanganese and silicon manganese); v) ammonia ; vi) glass; vii) electrical steel mills ; viii) aluminum (anode manufacture); ix) hydrogen in the refining industry emplaced x) refinery plants. The exploitation of this information has led to a revision in the inventory figures for natural gas, petroleum coke, coal coke and coal (anthracite) and other fuels whose registered consumption for non-energy use is minor , such as coking coal , diesel , LPG, fuel oil, gas and refinery steel or wood.	National Inventory Report, Chapter 3.1.4 translation
Sweden	Activity data on feedstocks and non-energy use of fuels is collected from the environmental reports and the EU ETS statistics. Sweden uses the same data for CRF table 1.A.d, non-energy use (NEU) of fuels as for feedstocks and non-energy uses in the IPPPU sector (CRF 2) and Fugitive sector (CRF 1.B). Net calorific values and carbon emission factors are the same as in CRF 1.A.b. The parameter “fraction of carbon stored” has been set to 1.00 for all fuels, which is in line with the 2006 IPCC Guidelines. Emissions from use of fuels reported in CRF 1.B or CRF 2 is reported as “CO_2 emissions from the NEU reported in the inventory” in the CRF-tables.	National Inventory Report, Chapter 3.2.3

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF SECTOR 2)

This chapter starts with an overview on emission trends in CRF Sector 2 Industrial processes and Product Use. This sector covers the following sub-sectors:

- Mineral Industry (CRF Source Category 2.A)
- Chemical Industry (CRF Source Category 2.B)
- Metal Industry (CRF Source Category 2.C)
- Non-Energy Products from Fuels and Solvent Use (CRF Source Category 2.D)
- Electronics Industry (CRF Source Category 2.E)
- Product Uses as Substitutes for Ozone Depleting Substances (CRF Source Category 2.F)
- Other Product Manufacture and Use (CRF Source Category 2.G)
- Other (CRF Source Category 2.H)

For each Union key category, overview tables are presented including the Member States' contributions to the key categories in terms of level and trend, and information on methodologies and emission factors.

4.1 Overview of sector

CRF Sector 2 Industrial Processes and Product Use is the third largest sector contributing 10 % to total EU GHG emissions in 2021. The most important GHGs from this sector are CO_2 (7 % of total GHG emissions), HFCs (2.1 %) and N_2O (0.2 %).

The emissions from the sector Industrial Processes and Product Use decreased by 29 % from 445 Mt in 1990 to 318 Mt in 2021 (*Figure 4.1*). In 2021, the emissions increased by 4 % compared to 2020. The largest annual decrease in emissions was observed between 2008 and 2009, driven by reductions in cement production and a significant drop in the iron and steel production as a consequence of the economic crisis.

The key categories in this sector are:

- 2.A.1 Cement Production: no classification (CO_2)
- 2.A.2 Lime Production: no classification (CO_2)
- 2.A.4 Other Process Uses of Carbonates: no classification (CO_2)
- 2.B.1 Ammonia Production: no classification (CO_2)
- 2.B.10 Other chemical industry: no classification (CO_2)
- 2.B.2 Nitric Acid Production: no classification (N_2O)
- 2.B.3 Adipic Acid Production: no classification (N_2O)
- 2.B.8 Petrochemical and Carbon Black Production: no classification (CO_2)
- 2.B.9 Fluorochemical Production: no classification (HFCs)
- 2.B.9 Fluorochemical Production: no classification (Unspecified mix of HFCs and PFCs)
- 2.C.1 Iron and Steel Production: no classification (CO_2)
- 2.C.3 Aluminium Production: no classification (PFCs)
- 2.F.1 Refrigeration and Air conditioning: no classification (HFCs)

Figure 4.1: CRF Sector 2 Industrial Processes and Product Use: EUGHG emissions for 1990–2021 in CO_2 equivalents (Mt)

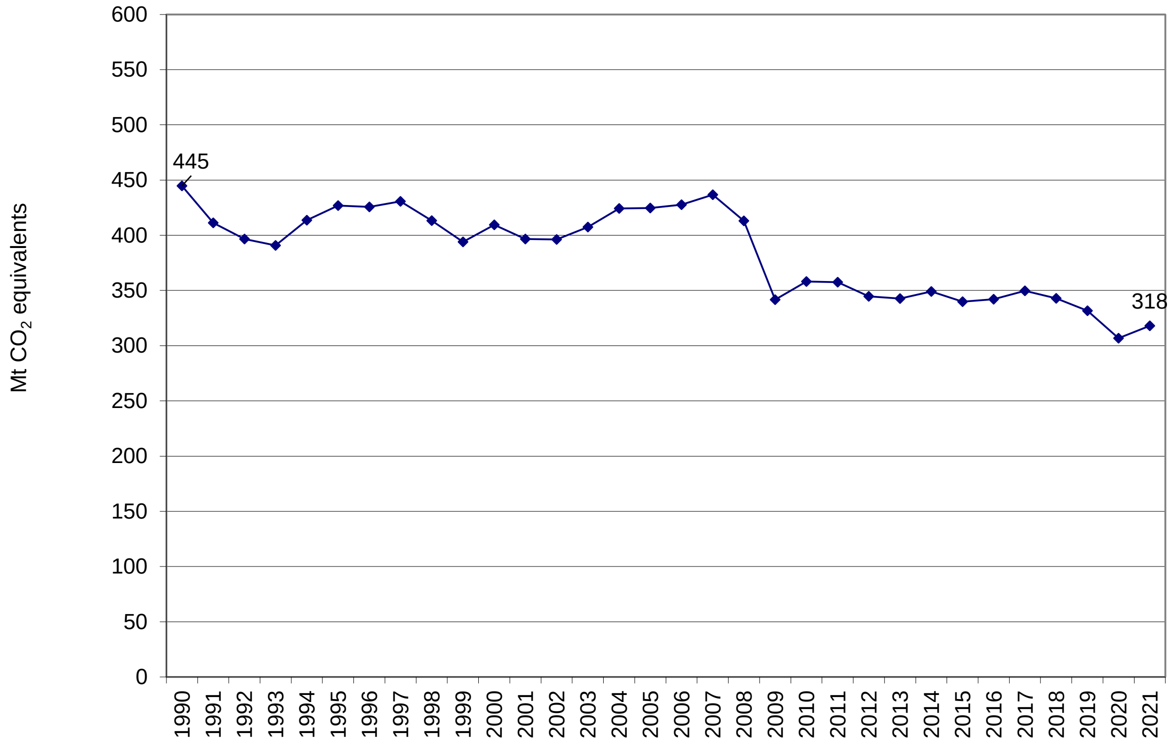
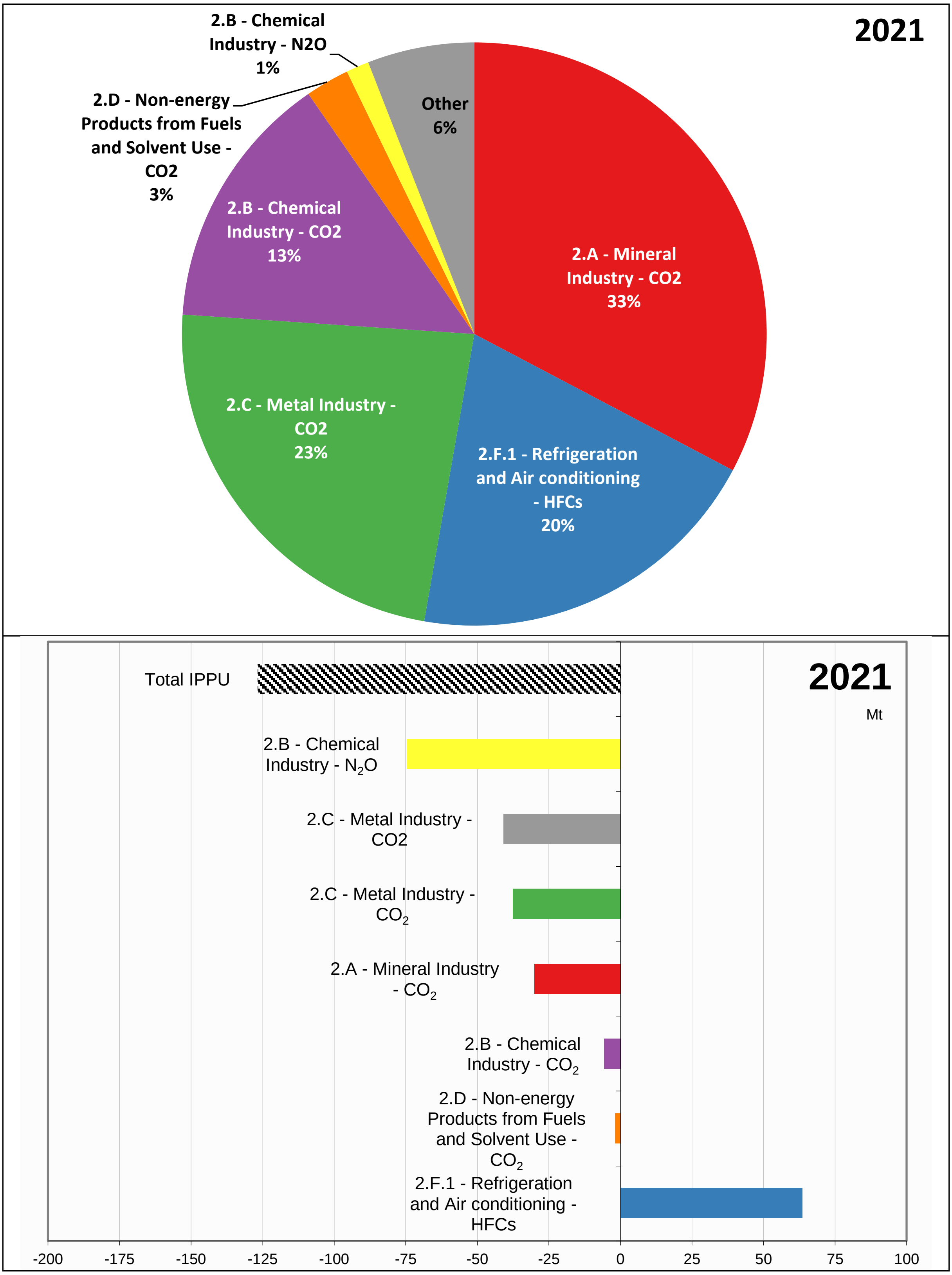


Figure 4.2: CRF Sector 2 Industrial processes and Product Use: Share of largest key categories in 2021 and absolute change of GHG emissions by large key categories 1990–2021 in CO_2 equivalents (Mt)



Note: Other is calculated by subtracting the presented categories from the sector total

4.2 Source categories and methodological issues

4.2.1 Mineral industry (CRF Source Category 2A)

The source category 2A Mineral industry includes three key categories:

Table 4.1: Key source categories for level and trend analyses and share of MS emissions using higher tier methods for sector 2A (Table excerpt)

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2020		1990	2020	
2.A.1 Cement Production (CO_2)	95237	72420	T	L	L	100 %
2.A.2 Lime Production (CO_2)	23918	17728	0	L	L	99.98 %
2.A.4 Other Process Uses of Carbonates (CO_2)	11061	9873	0	L	L	90.92 %

This sector is dominated by cement production which contributes approx. 70 % of mineral industry emissions. Cement production emissions occur during the production of clinker, an intermediate component in the cement manufacturing process. The source category 2A2 Lime production accounts for approx. 17 % of the sector where CO_2 is emitted during the calcination of the calcium in limestone or dolomite for lime production. The source category 2A4 Other process uses of carbonates accounts for 9 % of the sector and is composed of several sources with independent estimation methods. The remaining 4 % of emissions is from 2A3 Glass production. All emissions from cement production are estimated using higher tier methods. The same is true for lime production, except for Cyprus, which uses a Tier 1 method for estimating its emissions from this category. Under category 2A4, several countries use Tier 1 methods for some sub-categories, but approx. 91 % of emissions are estimated using higher tier methods.

Mineral industry emissions decreased during the 2009 economic crisis. They showed another, less pronounced decrease in 2020 as a consequence of reduced economic activities during the COVID-19 pandemic. Overall, these emissions have fallen by 22 % since 1990 (Figure **4.3**). Six countries (Croatia, Cyprus, Denmark, Ireland, Latvia and Poland) have higher Mineral industry CO_2 emissions in 2021 compared to 1990 (Table 4.2).

Figure 4.3 2A Mineral industry CO_2 emissions

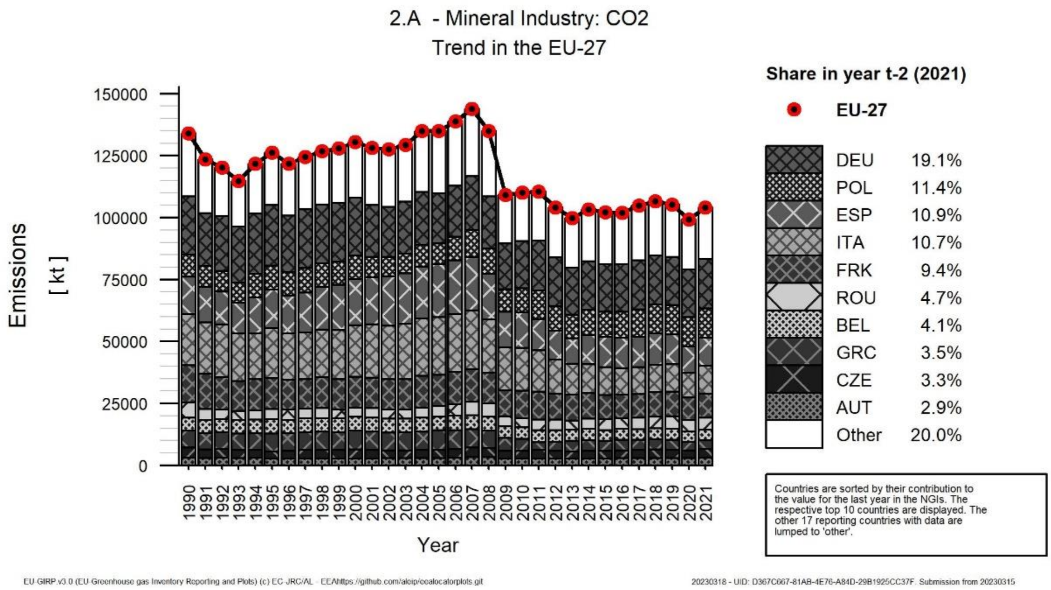


Table 4.2 2A Mineral industry: Member States total GHG and CO_2 emissions

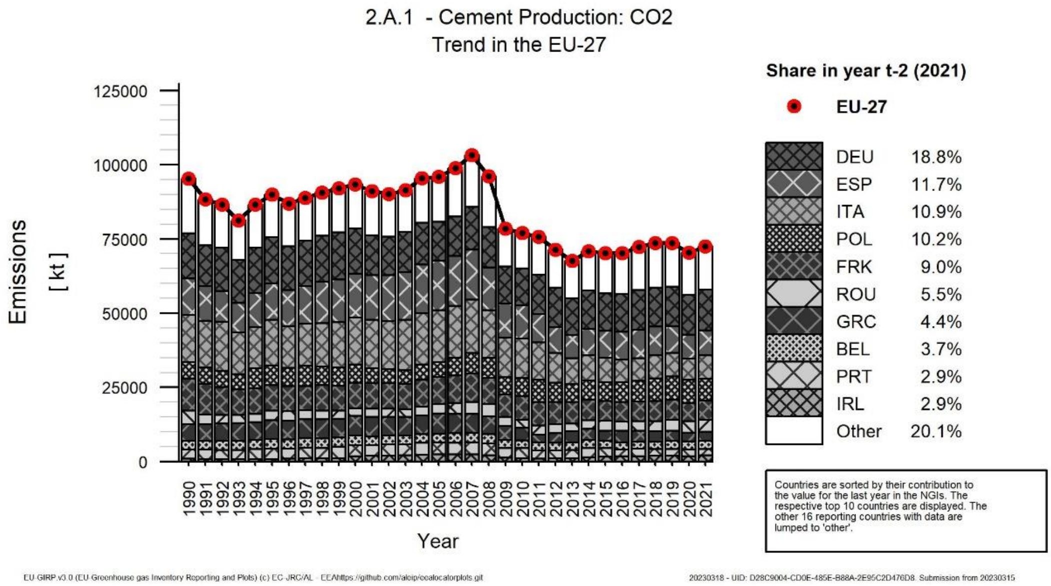
Member State	GHG emissions in kt CO2 equivalents		CO2 emissions in kt	
	1990	2021	1990	2021
Austria	3 114	3 050	3 114	3 050
Belgium	5 320	4 239	5 320	4 239
Bulgaria	3 278	2 349	3 278	2 349
Croatia	1 298	1 372	1 298	1 372
Cyprus	717	897	717	897
Czechia	4 082	3 444	4 082	3 444
Denmark	973	1 359	973	1 359
Estonia	614	59	614	59
Finland	1 218	1 017	1 218	1 017
France	14 939	9 740	14 939	9 740
Germany	23 522	19 898	23 522	19 898
Greece	6 775	3 621	6 775	3 621
Hungary	2 890	1 335	2 890	1 335
Ireland	1 117	2 257	1 117	2 257
Italy	20 720	11 146	20 720	11 146
Latvia	537	548	537	548
Lithuania	2 130	656	2 130	656
Luxembourg	593	382	593	382
Malta	1	0	1	0
Netherlands	1 411	1 133	1 411	1 133
Poland	8 855	11 915	8 855	11 915
Portugal	3 672	2 911	3 672	2 911
Romania	6 083	4 906	6 083	4 906
Slovakia	2 714	2 335	2 714	2 335
Slovenia	694	568	694	568
Spain	15 120	11 294	15 120	11 294
Sweden	1 673	1 656	1 673	1 656
EU-27	**134 061**	**104 086**	**134 061**	**104 086**

Abbreviations explained in the Chapter 'Units and abbreviations'.
For consistency with other sub-sectors this table shows both CO_2e and CO_2, however as there are no N_2O or CH_4 emissions for this category, the two sets of columns in this table show the same numbers.

4.2.1.1 2A1 Cement production

CO_2 emissions from Cement production contributed 2.1 % of total EU emissions (without LULUCF) in 2021. In that year, emissions were approx. 3 % above 2020 and approx. 24 % below 1990 levels. This source is a key category of CO_2 emissions in terms of emissions level and trend.

Figure 4.4 2A1 Cement production: EU CO_2 emissions



In 2021, Germany, Spain and Italy were the largest emitters accounting for respectively 18.8 %, 11.7 % and 10.9 % of total EU emissions from cement production (Figure 4.4 and Table 4.3). In 2021, with economic activity picking up after the COVID-19 pandemic, these emissions increased in 14 out of the 24 countries with cement production. The three countries with the largest absolute increase were Italy, Ireland and France.

Table 4.3 2A1 Cement production: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	2 033	1 821	1 889	2.6%	-145	-7%	68	4%	T3	PS
Belgium	2 824	2 634	2 659	3.7%	-165	-6%	25	1%	T3	PS
Bulgaria	2 142	1 066	1 060	1.5%	-1 082	-51%	-6	-1%	T2	PS
Croatia	1 086	1 213	1 205	1.7%	119	11%	-8	-1%	T2,T3	PS
Cyprus	668	882	879	1.2%	211	32%	-4	0%	CS	CS
Czechia	2 489	1 891	1 958	2.7%	-531	-21%	67	4%	T3	PS
Denmark	775	1 227	1 215	1.7%	440	57%	-12	-1%	T3	PS
Estonia	483	20	NO	-	-483	-100%	-20	-100%	NA	NA
Finland	729	570	623	0.9%	-107	-15%	53	9%	T3	PS
France	10 937	6 197	6 495	9.0%	-4 443	-41%	297	5%	T2,T3	CS,PS
Germany	15 297	13 357	13 640	18.8%	-1 657	-11%	283	2%	T2	CS
Greece	5 762	2 978	3 167	4.4%	-2 595	-45%	189	6%	CS	PS
Hungary	1 751	929	1 002	1.4%	-749	-43%	73	8%	T3	PS
Ireland	884	1 770	2 103	2.9%	1 219	138%	333	19%	T3	PS
Italy	15 846	7 059	7 919	10.9%	-7 927	-50%	860	12%	T2	CS,PS
Latvia	346	551	539	0.7%	193	56%	-12	-2%	T2	PS
Lithuania	1 668	557	633	0.9%	-1 035	-62%	77	14%	T2	PS
Luxembourg	539	399	351	0.5%	-189	-35%	-49	-12%	T2	CS,PS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	416	NO	NO	-	-416	-100%	-	-	NA	NA
Poland	5 453	7 691	7 366	10.2%	1 912	35%	-325	-4%	T2	CS
Portugal	3 176	2 310	2 106	2.9%	-1 070	-34%	-204	-9%	T3	PS
Romania	4 445	3 905	3 962	5.5%	-483	-11%	57	1%	CS,T2	PS
Slovakia	1 464	1 443	1 453	2.0%	-12	-1%	10	1%	T2	PS
Slovenia	470	475	469	0.6%	-2	0%	-6	-1%	T3	PS
Spain	12 279	8 192	8 472	11.7%	-3 807	-31%	280	3%	T2	CS
Sweden	1 272	1 272	1 259	1.7%	-13	-1%	-13	-1%	T3	PS
EU-27	**95 237**	**70 408**	**72 420**	**1**	**-22 817**	**-24%**	**2 011**	**3%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.
The methods provided in this table are consistent with the information submitted by Members States in their national inventory submissions. Cyprus and Greece use a country-specific method and report 'CS' accordingly. The methods used by these countries correspond to methodological Tier 3 (T3). The table lists methods and emission factors used in the latest reporting year. As Estonia and the Netherlands did not report emissions in that year, 'NA' is reported. Both countries reported emissions from cement production in 1990. The methodological tier used for that year is Tier 2 (T2) for Estonia and Tier 3 (T3) for the Netherlands.

Table 4.4 shows information on methods, activity data, and emission factors for CO_2 emissions from 2A1 Cement production for 1990 and 2021. All cement production emissions are estimated with higher Tier methods and most countries use plant-specific emission factors.

The implied emission factors per tonne of clinker produced in 2021 range from 0.49 t CO_2/t of clinker produced for Luxembourg and Slovakia to 0.55 t CO_2/t of clinker produced for Belgium, Denmark and Ireland. Countries use country-specific and plant-specific emission factors (typically based on raw meal carbon content characterization), they also provide data on clinker production which allows for the calculation of comparative IEFs. In 2021 the IEF for the whole EU amounted to 0.53 t CO_2/t of clinker.

Table 4.4 2A1 Cement production: Information on methods applied and emission factors for CO_2 emissions

Member State	1990				2021				Method	Emission Factor Informa-tion
	Activity Data		Implied Emission Factorn (t/t)	CO2 Emission (kt)	Activity Data		Implied Emission Factor (t/t)	CO2 Emission (kt)		
	Description	(kt)			Description	(kt)				
Austria	Clinker production	3 694	0.55	2 033	Clinker production	3 663	0.52	1 889	T3	PS
Belgium	Clinker production	5 292	0.53	2 824	Clinker production	4 872	0.55	2 659	T3	PS
Bulgaria	Clinker production	3 987	0.54	2 142	Clinker production	1 989	0.53	1 060	T2	PS
Croatia	Clinker production	2 062	0.53	1 086	Clinker production	2 406	0.50	1 205	T2,T3	PS
Cyprus	Clinker production	1 249	0.53	668	Clinker production	1 664	0.53	879	CS	CS
Czechia	Clinker production	4 726	0.53	2 489	Clinker production	3 673	0.53	1 958	T3	PS
Denmark	Clinker production	1 406	0.55	775	Clinker production	2 202	0.55	1 215	T3	PS
Estonia	Clinker production	790	0.61	483	Clinker production	NO	NO	NO	NA	NA
Finland	Clinker production	1 470	0.50	729	Clinker production	1 220	0.51	623	T3	PS
France	Clinker production	20 854	0.52	10 937	Clinker production	12 242	0.53	6 495	T2,T3	CS,PS
Germany	Clinker production	28 863	0.53	15 297	Clinker production	25 736	0.53	13 640	T2	CS
Greece	Clinker production	10 645	0.54	5 762	Clinker production	6 117	0.52	3 167	CS	PS
Hungary	Clinker production	3 210	0.55	1 751	Clinker production	C	C	1 002	T3	PS
Ireland	Clinker production	1 610	0.55	884	Clinker production	3 851	0.55	2 103	T3	PS
Italy	Clinker production	29 786	0.53	15 846	Clinker production	15 162	0.52	7 919	T2	CS,PS
Latvia	Clinker production	669	0.52	346	Clinker production	1 056	0.51	539	T2	PS
Lithuania	Clinker production	3 058	0.55	1 668	Clinker production	1 180	0.54	633	T2	PS
Luxembourg	Clinker production	1 048	0.51	539	Clinker production	717	0.49	351	T2	CS,PS
Malta	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Netherlands	Clinker production	770	0.54	416	Clinker production	NO	NO	NO	NA	NA
Poland	Clinker production	10 309	0.53	5 453	Clinker production	13 996	0.53	7 366	T2	CS
Portugal	Clinker production	6 128	0.52	3 176	Clinker production	4 205	0.50	2 106	T3	PS
Romania	Clinker production	8 379	0.53	4 445	Clinker production	7 725	0.51	3 962	CS,T2	PS
Slovakia	Clinker production	2 836	0.52	1 464	Clinker production	2 938	0.49	1 453	T2	PS
Slovenia	Clinker production	891	0.53	470	Clinker production	916	0.51	469	T3	PS
Spain	Clinker production	23 212	0.53	12 279	Clinker production	16 732	0.51	8 472	T2	CS
Sweden	Clinker production	2 348	0.54	1 272	Clinker production	2 405	0.52	1 259	T3	PS
EU-27	**-**	**179 290**	**0.53**	**95 237**	**-**	**136 666**	**0.53**	**72 420**	**-**	**-**

Abbreviations are explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.
The methods used by Cyprus and Greece correspond to methodological Tier 3 (T3). The table lists methods and emission factors used in the latest reporting year. Estonia and the Netherlands did not report emissions from cement production in that year but reported emissions in 1990. The methodological tier used for 1990 is Tier 2 (T2) for Estonia and Tier 3 (T3) for the Netherlands.

4.2.1.2 2A2 Lime production

CO_2 emissions from 2A2 Lime production account for 0.5 % of total EU emissions (without LULUCF) in 2021. Between 1990 and 2021, CO_2 emissions from this source decreased by 26 %. However, compared to 2020, emissions in 2021 are higher by 11 %, due to a rebound in economic activity following the COVID-19 pandemic. The largest increases between 2020 and 2021 were 344 kt in Germany, 333 kt in France and 310 kt in Italy. Increases occurred in 21 out of 24 countries with lime production (Table 4.5). Emissions from lime production typically show annual fluctuations of several percent; the largest decrease was observed between 2008 and 2009. Germany, France and Italy are the largest emitters contributing approx. 25.5 %, 13.0 % and 11.3 % of the total, respectively (Figure 4.5).

Figure 4.5 2A2 Lime production: EU CO_2 emissions

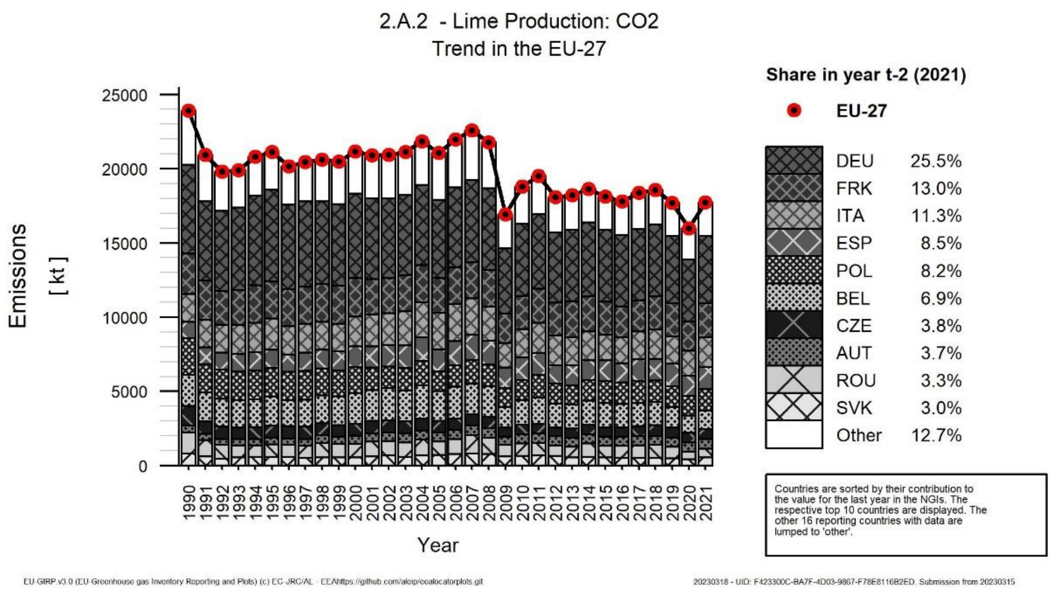


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Table 4.5 2A2 Lime production: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	439	588	663	3.7%	223	51%	75	13%	T3	PS
Belgium	2 097	1 192	1 222	6.9%	-875	-42%	30	3%	T3	PS
Bulgaria	390	201	256	1.4%	-135	-34%	55	27%	T2	D
Croatia	157	104	123	0.7%	-34	-22%	19	19%	T3	PS
Cyprus	5	3	4	0.0%	-1	-25%	1	28%	T1	D
Czechia	1 337	651	667	3.8%	-670	-50%	16	2%	T3	PS
Denmark	105	43	48	0.3%	-57	-54%	5	12%	T2	CS,PS
Estonia	130	41	47	0.3%	-83	-64%	6	15%	T2	PS
Finland	401	265	309	1.7%	-92	-23%	44	16%	T3	CS
France	2 712	1 968	2 301	13.0%	-411	-15%	333	17%	T2,T3	CS,PS
Germany	5 987	4 181	4 525	25.5%	-1 462	-24%	344	8%	T2	D
Greece	404	167	193	1.1%	-211	-52%	26	15%	CS	PS
Hungary	614	144	111	0.6%	-502	-82%	-32	-22%	T3	PS
Ireland	214	136	148	0.8%	-66	-31%	13	9%	T3	PS
Italy	1 877	1 693	2 003	11.3%	126	7%	310	18%	T2	CS,PS
Latvia	122	NO	NO	-	-122	-100%	-	-	NA	NA
Lithuania	210	2	2	0.0%	-209	-99%	0	-18%	T2	D
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	1	NO	NO	-	-1	-100%	-	-	NA	NA
Netherlands	163	181	181	1.0%	18	11%	0	0%	CS	D
Poland	2 461	1 326	1 458	8.2%	-1 004	-41%	132	10%	T2	CS
Portugal	206	383	387	2.2%	180	88%	3	1%	T3	OTH
Romania	1 450	519	585	3.3%	-865	-60%	66	13%	T2	CS,D
Slovakia	795	431	540	3.0%	-255	-32%	109	25%	T2	PS
Slovenia	200	57	67	0.4%	-133	-67%	10	18%	T3	PS
Spain	1 109	1 334	1 515	8.5%	406	37%	181	14%	T3	PS
Sweden	332	388	375	2.1%	43	13%	-13	-3%	T3	D
EU-27	**23 918**	**15 995**	**17 728**	**1**	**-6 190**	**-26%**	**1 733**	**11%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year.
Abbreviations are explained in the Chapter 'Units and abbreviations'.
The methods provided in this table are consistent with the information submitted by Members States in their national inventory submissions. Greece and the Netherlands use country-specific methods and report 'CS' accordingly. The level of complexity of the methods applied by Greece and the Netherlands is Tier 3 (T3).
The table lists methods and emission factors used in the latest inventory year. As Latvia, Luxembourg and Malta did not report emissions in that year, 'NA' is reported. Latvia and Malta reported emissions from lime production in 1990. The methodological tier used in that year is Tier 2 (T2) for Latvia and Tier 1 (T1) for Malta.

Table 4.6 shows information on the methods and emission factors for CO_2 emissions from 2A2 Lime production for 1990 and 2021. While production data is not necessarily explicitly used for emissions calculations (plant-specific emission factors are typically derived from raw meal carbon content characterization), countries that report emissions from lime production also report production activity data for calculating comparative IEFs. Lime production data is the combined figure for the three types of lime: quicklime (high-calcium lime), dolomitic lime and hydraulic lime production. The weighted average IEF in 2021 is 0.73 t CO_2/t of lime produced. The lime production activity data for each country reflect a mix of lime types, and so the implied emission factors per tonne of lime produced in 2021 range from 0.66 for France to 0.85 for Greece. Two countries report activity data other than lime production: The Netherlands report limestone used, and Portugal reports carbonate used. Of the 24 countries which report lime production emissions in 2021, all but Cyprus use higher tier methodologies (Tier 2 or Tier 3) which accounts for more than 99.9% of emissions from this category.

Table 4.6 2A2 Lime production: Information on methods applied, activity data, emission factors for CO_2 emissions

Member State	1990				2021				Method	Emission Factor Informa-tion
	Activity Data		Implied Emission	CO2 Emission (kt)	Activity Data		Implied Emission	CO2 Emission (kt)		
	Description	(kt)	Factorn (t/t)		Description	(kt)	Factor (t/t)			
Austria	Lime Production	676	0.69	439	Lime Production	997	0.69	663	T3	PS
Belgium	Lime Production	2 660	0.79	2 097	Lime Production	1 585	0.77	1 222	T3	PS
Bulgaria	Lime Production	490	0.80	390	Lime Production	328	0.78	256	T2	D
Croatia	Lime Production	219	0.72	157	Lime Production	153	0.80	123	T3	PS
Cyprus	Lime Production	7	0.73	5	Lime Production	5	0.73	4	T1	D
Czechia	Lime Production	1 823	0.73	1 337	Lime Production	948	0.70	667	T3	PS
Denmark	Lime Production	134	0.79	105	Lime Production	63	0.77	48	T2	CS,PS
Estonia	Lime Production	185	0.70	130	Lime Production	64	0.73	47	T2	PS
Finland	Lime Production	488	0.82	401	Lime Production	393	0.79	309	T3	CS
France	Lime Production	3 739	0.73	2 712	Lime Production	3 487	0.66	2 301	T2,T3	CS,PS
Germany	Lime Production	7 927	0.76	5 987	Lime Production	6 030	0.75	4 525	T2	D
Greece	Lime Production	491	0.82	404	Lime Production	226	0.85	193	CS	PS
Hungary	Lime Production	831	0.74	614	Lime Production	147	0.76	111	T3	PS
Ireland	Lime Production	255	0.84	214	Lime Production	197	0.75	148	T3	PS
Italy	Lime Production	2 583	0.73	1 877	Lime Production	2 623	0.76	2 003	T2	CS,PS
Latvia	Lime Production	225	0.54	122	Lime Production	NO	NO,NA	NO	NA	NA
Lithuania	Lime Production	288	0.73	210	Lime Production	2	0.78	2	T2	D
Luxembourg	Lime Production	NO	NO	NO	Lime Production	NO	NO	NO	NA	NA
Malta	Lime Production	2	0.75	1	Lime Production	NO	NO	NO	NA	NA
Netherlands	Limestone used	372	0.44	163	Limestone used	414	0.44	181	CS	D
Poland	Lime Production	3 464	0.71	2 461	Lime Production	1 972	0.74	1 458	T2	CS
Portugal	Carbonate used	291	0.71	206	Carbonate used	565	0.68	387	T3	OTH
Romania	Lime Production	2 025	0.72	1 450	Lime Production	783	0.75	585	T2	CS,D
Slovakia	Lime Production	1 076	0.74	795	Lime Production	696	0.78	540	T2	PS
Slovenia	Lime Production	275	0.73	200	Lime Production	89	0.75	67	T3	PS
Spain	Lime Production	1 619	0.69	1 109	Lime Production	2 183	0.69	1 515	T3	PS
Sweden	Lime Production	439	0.75	332	Lime Production	503	0.75	375	T3	D
EU-27	**-**	**NE**	**NE**	**23 918**	**-**	**24 249**	**0.73**	**17 728**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year. Not all countries show lime production as the activity data for this emissions category. Gap-filled values are shown against Lime production for EU activity and the EU IEF for 2021.
The level of complexity of the methods applied by Greece and the Netherlands is Tier 3 (T3). The methodological tier used in 1990 is Tier 2 (T2) for Latvia and Tier 1 (T1) for Malta.

4.2.1.3 2A4 Other process uses of carbonates

CO_2 emissions from 2A4 Other process uses of carbonates contributed 0.3 % of total EU emissions (without LULUCF) in 2021. Emissions from this sector in 2021 were 11 % lower than 1990 levels but 10% higher compared to 2020. It is not necessarily useful to compare specific shares of emissions due to the fact that each country's estimates are mostly composed of several sources with independent estimation methods, using partly higher tiers, partly default methods.

Table 4.7 2A4 Other process uses of carbonates: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	603	398	463	4.7%	-140	-23%	65	16%	T1,T3	D,PS
Belgium	136	198	202	2.0%	66	48%	4	2%	T3	CS,PS
Bulgaria	607	830	933	9.4%	326	54%	102	12%	T1,T2	D,PS
Croatia	11	17	16	0.2%	4	37%	-2	-9%	T3	PS
Cyprus	44	17	14	0.1%	-30	-68%	-3	-15%	CS,T1	CS,D
Czechia	114	538	675	6.8%	561	493%	137	26%	T3	PS
Denmark	77	73	85	0.9%	8	10%	11	16%	CS,T3	CS,D
Estonia	NO,IE,NA	1	1	0.0%	1	∞	1	103%	T1,T2	D,PS
Finland	67	110	83	0.8%	16	24%	-27	-24%	T1,T3	CS,D
France	488	421	430	4.4%	-58	-12%	9	2%	T1,T2,T3	CS,D,PS
Germany	1 458	807	816	8.3%	-642	-44%	9	1%	T1,T2	CS,D
Greece	590	209	245	2.5%	-345	-59%	35	17%	CS,T1	CS,D
Hungary	449	196	183	1.9%	-266	-59%	-14	-7%	T2,T3	CS,D,PS
Ireland	5	2	6	0.1%	1	15%	4	167%	T3	PS
Italy	2 544	541	609	6.2%	-1 934	-76%	68	13%	T2	CS,PS
Latvia	69	9	8	0.1%	-61	-88%	-1	-7%	T1,T2	D,PS
Lithuania	240	13	13	0.1%	-226	-95%	0	-2%	T1,T2	CS,D,PS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	0	0	0	0.0%	0	-17%	0	-20%	NA	NA
Netherlands	690	825	884	9.0%	194	28%	59	7%	CS,T1,T2	D
Poland	771	2 125	2 465	25.0%	1 694	220%	340	16%	T1,T2	CS,D
Portugal	220	218	258	2.6%	38	17%	40	18%	T1,T3	OTH
Romania	38	243	292	3.0%	254	663%	49	20%	OTH,T2,T3	D,PS
Slovakia	447	327	323	3.3%	-124	-28%	-4	-1%	T3	PS
Slovenia	20	17	17	0.2%	-3	-13%	1	3%	T2	D
Spain	1 358	818	844	8.5%	-513	-38%	26	3%	T1,T2,T3	CS,D,PS
Sweden	15	6	7	0.1%	-9	-55%	1	23%	T3	D
EU-27	**11 061**	**8 960**	**9 873**	**1**	**-1 188**	**-11%**	**914**	**10%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.

4.2.1.4 Non-key sources

Glass production is the only non-key source in the mineral industry. CO_2 emissions from 2A3 Glass production contributed to only 0.1% of total EU emissions (without LULUCF) in 2021. Emissions in that year were 6 % above 1990 levels and 8 % higher than in 2020.

Table 4.9 shows information on the methods applied, activity data, and the emission factors for CO_2 emissions from 2A3 Glass production for 1990 and 2021.

Table 4.8 2A3 Glass production: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	39	39	36	0.9%	-3	-7%	-3	-9%	T3	PS
Belgium	263	108	156	3.8%	-107	-41%	47	44%	T3	CS,PS
Bulgaria	138	85	100	2.5%	-38	-28%	15	18%	T1	CS
Croatia	43	26	29	0.7%	-14	-33%	3	13%	T3	PS
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	143	139	144	3.5%	1	1%	5	4%	T3	PS
Denmark	16	10	11	0.3%	-5	-32%	1	15%	T3	PS
Estonia	1	9	11	0.3%	10	799%	2	22%	T3	PS
Finland	21	2	2	0.0%	-19	-91%	0	12%	T3	CS
France	802	469	515	12.7%	-287	-36%	46	10%	T2,T3	CS,PS
Germany	780	856	917	22.6%	136	17%	60	7%	T2	CS
Greece	20	17	17	0.4%	-4	-17%	0	1%	CS	CS
Hungary	77	43	40	1.0%	-37	-48%	-4	-8%	T3	CS,PS
Ireland	13	NO	NO	-	-13	-100%	-	-	NA	NA
Italy	453	569	614	15.1%	161	35%	45	8%	T2	CS,PS
Latvia	0	1	1	0.0%	0	102%	0	5%	T3	D,PS
Lithuania	12	7	7	0.2%	-4	-36%	0	0%	T2	D
Luxembourg	54	34	31	0.8%	-22	-41%	-3	-8%	CS	PS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	142	64	68	1.7%	-74	-52%	4	7%	T3	PS
Poland	169	598	627	15.4%	458	270%	29	5%	T2	D
Portugal	69	156	160	3.9%	91	132%	4	3%	T3	OTH
Romania	150	55	67	1.6%	-83	-55%	12	21%	T2	CS,D
Slovakia	8	18	20	0.5%	12	150%	1	7%	T3	PS
Slovenia	3	11	14	0.4%	11	337%	3	26%	T3	D
Spain	374	440	464	11.4%	89	24%	24	5%	T3	CS,D,PS
Sweden	54	16	15	0.4%	-38	-72%	0	-3%	T3	CS,D
EU-27	**3 845**	**3 772**	**4 065**	**1**	**220**	**6%**	**293**	**8%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.
The methods provided in this table are consistent with the information submitted by Members States in their national inventory submissions. Greece and Luxembourg use country-specific methods and report 'CS' accordingly. The level of complexity of the methods is Tier 3 (T3) for Greece and Tier 2 (T2) for Luxembourg.

The table below shows that while most countries report glass production as activity data under this category, some report inputs (carbonate use). Due to the different types of activity data, no overall implied emission factor for the EU is available.

Table 4.9 2A3 Glass production: Information on methods applied, activity data, emission factors for CO_2 emissions

Member State	1990				2021				Method	Emission Factor Informa-tion
	Activity Data		Implied Emission Factorn	CO2 Emission (kt)	Activity Data		Implied Emission Factor	CO2 Emission (kt)		
	Description	(kt)			Description	(kt)				
Austria	Glass Production	399	0.10	39	Glass Production	510	0.07	36	T3	PS
Belgium	Glass Production	1 993	0.13	263	Glass Production	1 536	0.10	156	T3	CS,PS
Bulgaria	-	818	0.17	138	-	764	0.13	100	T1	CS
Croatia	Glass Production	99	0.44	43	Glass Production	67	0.43	29	T3	PS
Cyprus	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Czechia	Glass Production	1 237	0.12	143	Glass Production	1 201	0.12	144	T3	PS
Denmark	Glass Production	200	0.08	16	Glass Production	207	0.05	11	T3	PS
Estonia	Glass Production	12	0.10	1	Glass Production	77	0.14	11	T3	PS
Finland	Used Carbonates	45	0.47	21	Used Carbonates	5	0.40	2	T3	CS
France	Glass Production	4 333	0.19	802	Glass Production	3 458	0.15	515	T2,T3	CS,PS
Germany	Glass Production	6 562	0.12	780	Glass Production	7 803	0.12	917	T2	CS
Greece	Glass Production	135	0.15	20	Glass Production	120	0.14	17	CS	CS
Hungary	Glass Production	418	0.18	77	Glass Production	319	0.12	40	T3	CS,PS
Ireland	Carbonate Use	64	0.21	13	Carbonate Use	NO	NO	NO	NA	NA
Italy	Glass Production	3 779	0.12	453	Glass Production	6 453	0.10	614	T2	CS,PS
Latvia	Glass Production	44	0.01	0	Glass Production	C	C	1	T3	D,PS
Lithuania	Glass Production	66	0.18	12	Glass Production	51	0.15	7	T2	D
Luxembourg	Glass Production	377	0.14	54	Glass Production	219	0.14	31	CS	PS
Malta	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Netherlands	-	1 095	0.13	142	-	1 650	0.04	68	T3	PS
Poland	Glass Production	1 058	0.16	169	Glass Production	3 919	0.16	627	T2	D
Portugal	-	626	0.11	69	-	1 796	0.09	160	T3	OTH
Romania	Glass Production	926	0.16	150	Glass Production	464	0.14	67	T2	CS,D
Slovakia	Used Carbonates	18	0.44	8	Used Carbonates	47	0.42	20	T3	PS
Slovenia	Glass Production	25	0.13	3	Glass Production	101	0.14	14	T3	D
Spain	Glass Production	2 866	0.13	374	Glass Production	4 871	0.10	464	T3	CS,D,PS
Sweden	-	NA	NA	54	-	NA	NA	15	T3	CS,D
EU-27	**-**	**NE**	**NE**	**3 845**	**-**	**NE**	**NE**	**4 065**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.
The level of complexity of the methods is Tier 3 (T3) for Greece and Tier 2 (T2) for Luxembourg.

4.2.2 Chemical industry (CRF Source Category 2B)

The chemical industry includes seven key categories, which are presented in ***Table** 4.10*.

Table 4.10: Key source categories for level and trend analyses and share of MS emissions using higher tier methods for sector 2B (Table excerpt)

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
2.B.1 Ammonia Production: no classification (CO_2)	30591	19299	0	L	L	100 %
2.B.2 Nitric Acid Production: no classification (N_2O)	40718	2398	T	L	0	100 %
2.B.3 Adipic Acid Production: no classification (N_2O)	33454	120	T	L	0	100 %
2.B.8 Petrochemical and Carbon Black Production: no classification (CO_2)	10029	11945	T	L	L	92.6 %
2.B.9 Fluorochemical Production: no classification (HFCs)	12809	392	T	L	0	100 %
2.B.9 Fluorochemical Production: no classification (Unspecified mix of HFCs and PFCs)	4670	46	T	0	0	100 %
2.B.10 Other chemical industry: no classification (CO_2)	6849	12096	T	0	L	84.8 %

The key category 2B1 Ammonia production accounts for approx. 38 % of total GHG emissions in the chemical industry, followed by 2B8 Petrochemical and Carbon Black Production (23 %), which includes the CO_2 emissions associated with the production of a wide range of petrochemicals including methanol, ethylene and carbon black. The category 2B10 Other chemical industry (23 %) is the third most important category. Higher tier methods are used by most countries. However, as categories 2B8 and 2B10 comprise a variety of emission sources, including minor ones, several countries use Tier 1 methods to estimate emissions from some of these sources.

Figure **4.6** shows chemical industry CO_2 emissions while *Table 4.11* presents a summary of emissions of CO_2, N_2O, CH_4 and total emissions as CO_2 equivalents.

Figure 4.6 2B Chemical industry CO_2 emissions

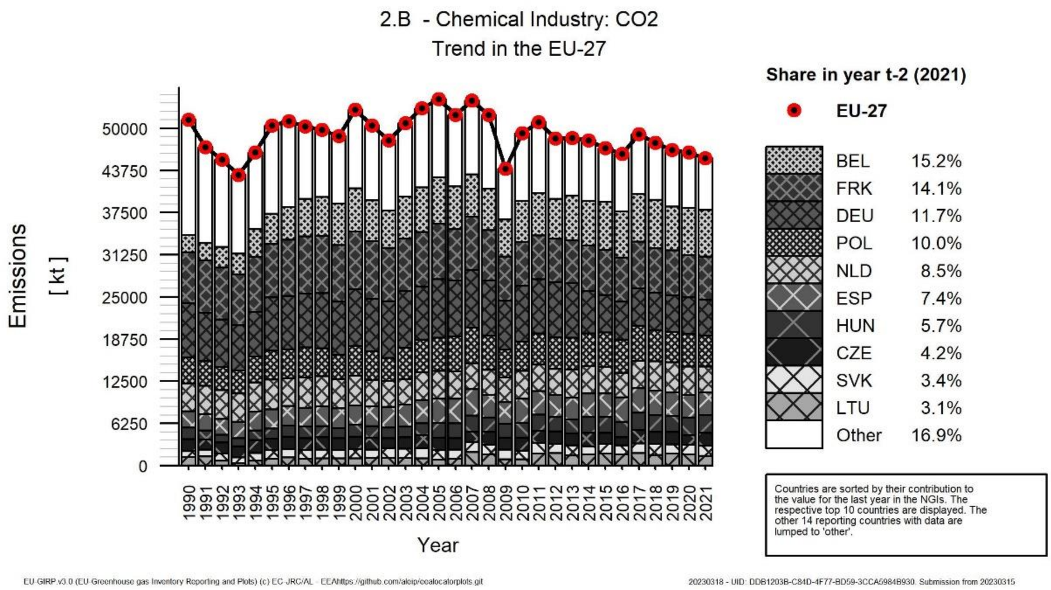


Table 4.11 shows chemical industry CO_2, CH_4, N_2O and total GHG emissions (which includes F-gases) as CO_2e. Between 1990 and 2021 overall GHG emissions from the chemical industry sector have decreased markedly, largely due to the significant reduction in N_2O emissions which have decreased by approx. 95 %. The greatest absolute decreases in N_2O emissions over the period were observed in France and Germany.

Table 4.11 2B Chemical industry: EU CO_2, N_2O, CH_4 and total emissions as CO_2 equivalents

Member State	GHG emissions in kt CO2 equivalents		CO2 emissions in kt		N2O emissions in kt CO2 equivalents		CH4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021	1990	2021
Austria	1 463	784	644	688	780	41	39	54
Belgium	9 563	7 786	2 590	6 908	3 385	585	20	18
Bulgaria	4 762	1 240	3 283	1 175	1 465	65	15	NO,NA
Croatia	1 428	402	751	365	671	36	6	NO,NE,IE
Cyprus	NO	NO	NO	NO	NO	NO	NO	NO
Czechia	2 825	2 134	1 783	1 909	1 002	172	41	53
Denmark	892	1	1	1	892	NO,NA	NO,NA	NO,NA
Estonia	308	NO	308	NO	NO	NO	NO	NO
Finland	1 691	1 190	270	969	1 415	219	5	2
France	34 133	7 054	7 542	6 421	21 083	397	87	35
Germany	32 257	6 429	8 058	5 337	18 972	411	440	635
Greece	2 621	685	681	679	948	5	1	NO,NA
Hungary	4 472	2 689	1 704	2 606	2 748	29	20	53
Ireland	1 875	NO	990	NO	885	NO	NO	NO
Italy	9 626	1 728	2 524	1 403	5 707	59	69	4
Latvia	NA,NO	NA,NO	NO	NO	NO	NO	NO	NO
Lithuania	2 061	1 551	1 261	1 413	794	139	6	NO
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO
Malta	0	0	0	0	NO,NA	NO,NA	NO,NA	NO,NA
Netherlands	15 417	5 384	4 132	3 857	6 286	902	302	358
Poland	6 991	5 058	3 802	4 553	3 144	459	45	45
Portugal	1 898	701	1 409	638	460	33	29	30
Romania	9 309	855	5 576	767	3 677	77	56	11
Slovakia	1 893	1 585	878	1 527	1 015	57	0	1
Slovenia	88	65	83	65	NO,NA	NO,NA	5	NO,NA
Spain	7 610	3 782	2 430	3 351	2 539	321	94	109
Sweden	1 297	942	582	930	714	11	1	1
EU-27	**154 480**	**52 045**	**51 281**	**45 566**	**78 581**	**4 019**	**1 280**	**1 409**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'. Note that emissions from F-gases are included in the total.

4.2.2.1 2B1 Ammonia production

In most facilities, anhydrous ammonia is produced by catalytic steam reforming of natural gas (CH_4) or fuel oil. At plants using this process, CO_2 is primarily released during regeneration of the CO_2 scrubbing solution, with additional but relatively minor emissions resulting from condensate stripping.

CO_2 emissions from ammonia production contributed 0.6 % of total EU emissions (without LULUCF) in 2021. Emissions have decreased by approx. 37 % since 1990 and by approx. 7 % since 2020.

Figure 4.7 2B1 Ammonia production: CO_2 emissions

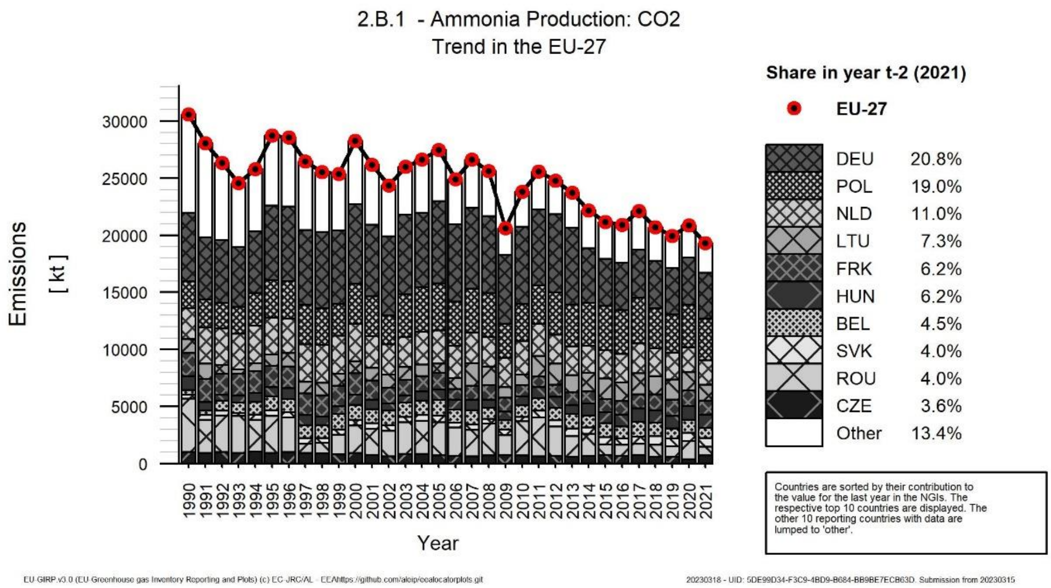


Figure 4.7 and Table 4.12 show that in 2021 Germany was responsible for 20.8 % of this category's emissions. The next largest contributors are Poland and the Netherlands which contribute 19.0 % and 11.0 % respectively.

Bulgaria, Germany, Italy, Ireland and Romania have all had large reductions in absolute terms compared to 1990. The reasons for these reductions include shifting to low emitting technology and production decreases and the cessation of production in Ireland. The largest growth in absolute terms in emissions between 1990 and 2021 occurred in Belgium, Lithuania, Poland and Slovakia.

Table 4.12 2B1 Ammonia production: Member States' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	467	491	500	2.6%	33	7%	10	2%	T2	PS
Belgium	423	1 137	862	4.5%	440	104%	-274	-24%	T3	D,PS
Bulgaria	2 508	593	595	3.1%	-1 913	-76%	2	0%	T2	PS
Croatia	559	535	365	1.9%	-193	-35%	-170	-32%	T3	PS
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	991	382	701	3.6%	-289	-29%	320	84%	T2	CS
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	308	NO	NO	-	-308	-100%	-	-	NA	NA
Finland	93	NO	NO	-	-93	-100%	-	-	NA	NA
France	2 019	1 325	1 202	6.2%	-818	-40%	-123	-9%	T1,T2,T3	CS,D,PS
Germany	6 025	4 133	4 012	20.8%	-2 013	-33%	-121	-3%	T3	PS
Greece	652	196	196	1.0%	-456	-70%	0	0%	T1a	CS
Hungary	1 200	1 239	1 201	6.2%	1	0%	-38	-3%	T3	PS
Ireland	990	NO	NO	-	-990	-100%	-	-	NA	NA
Italy	1 892	658	631	3.3%	-1 260	-67%	-27	-4%	T2	PS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	1 237	1 629	1 413	7.3%	176	14%	-217	-13%	T3	CS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	2 695	2 199	2 132	11.0%	-563	-21%	-68	-3%	T3	CS
Poland	2 344	3 700	3 665	19.0%	1 321	56%	-35	-1%	T2	CS
Portugal	763	NO	NO	-	-763	-100%	-	-	NA	NA
Romania	4 693	1 586	763	4.0%	-3 931	-84%	-824	-52%	T3	PS
Slovakia	332	703	769	4.0%	437	132%	66	9%	T3	PS
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	400	339	291	1.5%	-109	-27%	-49	-14%	T3	PS
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**30 591**	**20 847**	**19 299**	**1**	**-11 292**	**-37%**	**-1 548**	**-7%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'.
The table lists methods and emission factors used in the latest inventory year. Estonia, Finland, Ireland and Portugal did not report emissions in that year, but they reported emissions in 1990. The methodological tier used in 1990 is Tier 3 (T3) for Estonia and Tier 1 (T1) for Finland, Ireland and Portugal.

In line with the IPCC guidelines all emissions (energy and non-energy use of feedstocks/fuels) from ammonia production should be reported in category 2B1. In a review of the inventory submission of the European Union, the ERT recommended that the European Union include in the NIR a table that includes the potentially combustion-related EU ETS emission values rather than only the process-related emissions reported for ammonia production. Table 4.13 aligns 2B1 Ammonia production against EU ETS reported emissions for Production of ammonia (EU ETS activity sector code 41). Of the seventeen countries which report emissions under 2B1 Ammonia production thirteen report against EU ETS activity Production of Ammonia and of these eleven report higher levels to the EU ETS than is reported in the inventory. The column labelled 'Potentially combustion related' shows differences between IPPU 2B1 and ETS reported emissions from production of ammonia where the ETS figure is greater.

Table 4.13 2B1 Ammonia production: inventory and relevant EU ETS reported CO_2 emissions for 2021 (kt CO_2 emissions)

Member State	IPPU 2B1. Ammonia production	EU ETS: Production of ammonia	Potentially combustion related [1]	EU ETS: Production of hydrogen and synthesis gas
Austria	500	876	376	-
Belgium	862	-	-	1 028
Bulgaria	595	681	86	-
Croatia	365	833	467	-
Cyprus	NO	-	-	-
Czech Republic	701	-	-	-
Denmark	NO	-	-	-
Estonia	NO	-	-	-
Finland	NO	-	-	-
France	1 202	1 069	-	518
Germany	4 012	4 627	615	2 753
Greece	196	201	5	-
Hungary	1 201	903	-	153
Ireland	NO	-	-	-
Italy	631	-	-	490
Latvia	NO	-	-	-
Lithuania	NO	2 209	-	-
Luxembourg	1 413	-	-	-
Malta	NO	-	-	-
Netherlands	2 132	3 190	1 058	1 237
Poland	3 665	1 615	-	-
Portugal	NO	-	-	66
Romania	763	-	-	54
Slovakia	769	1 067	298	-
Slovenia	NO	-	-	-
Spain	291	576	285	796
Sweden	NO	-	-	-
EU	19 299	17 848	3 191	7 096

[1] Potentially combustion related: difference between IPPU 2B1 and EU ETS reported emissions from production of ammonia where the ETS figure is greater.
EU ETS data from: www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1

The different scopes, reporting thresholds and reporting obligations mean that it is not possible to make a detailed analysis of the differences visible in Table 4.13. To analyse the consistency between EU ETS and inventory data would require a detailed analysis of the data reported by each ETS installation to the national competent authorities and the allocation to the specific CRF categories, including the methods, activity data and calculation parameters used. Please refer to chapter 1.4.1 on ‘the use of data from EU ETS for the purposes of the national GHG inventories’. See also the mapping table (Table 1.10 in section 1.4.1) between ETS activities and CRF categories (including on ammonia production).

It is worth observing that the EU ETS activity sector: Production of hydrogen and synthesis gas (code 43) does not have a direct counterpart in the inventory and is included here to illustrate the difficulty of comparing UNFCCC and EU ETS reported emissions. Note also that ammonia can be produced using hydrogen supplied by another company and that not all hydrogen producers are obliged to report within the framework of EU ETS.

Table 4.14 shows information on methods applied, activity data and emission factors for CO_2 emissions from 2B1 Ammonia production for 1990 and 2021. Many countries show ammonia production as activity data, but some use different data types. Hence no overall implied emission factor was determined for the EU. For 2021, 100 % of emissions from ammonia production were estimated using higher Tier methods.

Table 4.14 2B1 Ammonia production: Information on methods applied, activity data, emission factors for CO_2 emissions

Member State	1990				2021				Method	Emission Factor Informa-tion
	Activity Data		Implied Emission Factorn (t/t)	CO2 Emission (kt)	Activity Data		Implied Emission Factor (t/t)	CO2 Emission (kt)		
	Description	(kt)			Description	(kt)				
Austria	Ammonia Production	461	1.22	467	Ammonia Production	528	1.22	500	T2	PS
Belgium	Ammonia Production	360	1.17	423	Ammonia Production	830	1.17	862	T3	D,PS
Bulgaria	-	C	C	2 508	-	C	C	595	T2	PS
Croatia	Ammonia Production	345	2.24	559	Ammonia Production	288	2.08	365	T3	PS
Cyprus	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Czechia	Ammonia Production	336	3.27	991	Ammonia Production	214	3.27	701	T2	CS
Denmark	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Estonia	Ammonia Production	294	1.44	308	Ammonia Production	NO	NO	NO	NA	NA
Finland	Ammonia Production	28	3.27	93	Ammonia Production	NO	NO	NO	NA	NA
France	Ammonia Production	1 928	1.14	2 019	Ammonia Production	916	1.56	1 202	T1,T2,T3	CS,D,PS
Germany	Ammonia Production	2 705	2.41	6 025	Ammonia Production	2 892	1.81	4 012	T3	PS
Greece	Ammonia Production	313	2.08	652	Ammonia Production	115	1.71	196	T1a	CS
Hungary	Natural Gas Consumption	25 334	0.06	1 200	Natural Gas Consumption	22 201	0.06	1 201	T3	PS
Ireland	Natural Gas Feedstocks	430	2.30	990	Natural Gas Feedstocks	NO	NO	NO	NA	NA
Italy	Ammonia Production	1 455	1.94	1 892	Ammonia Production	532	1.98	631	T2	PS
Latvia	Ammonia Production	NO	NO	NO	Ammonia Production	NO	NO	NO	NA	NA
Lithuania	Ammonia Production	568	2.27	1 237	Ammonia Production	870	2.06	1 413	T3	CS
Luxembourg	Ammonia Production	NO	NO	NO	Ammonia Production	NO	NO	NO	NA	NA
Malta	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Netherlands	-	C	C	2 695	-	C	C	2 132	T3	CS
Poland	Ammonia Production	1 532	1.90	2 344	Ammonia Production	2 598	1.75	3 665	T2	CS
Portugal	-	C	C	763	-	NO	NO	NO	NA	NA
Romania	Natural Gas Consumption	2 101	2.29	4 693	Natural Gas Consumption	C	C	763	T3	PS
Slovakia	Ammonia Production	360	1.71	332	Ammonia Production	581	1.60	769	T3	PS
Slovenia	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Spain	Ammonia Production	C	C	400	Ammonia Production	C	C	291	T3	PS
Sweden	-	NO	NO	NO	-	NO	NO	NO	NA	NA
EU-27	**-**	**NE**	**NE**	**30 591**	**-**	**13 691**	**1.41**	**19 299**	**-**	**-**

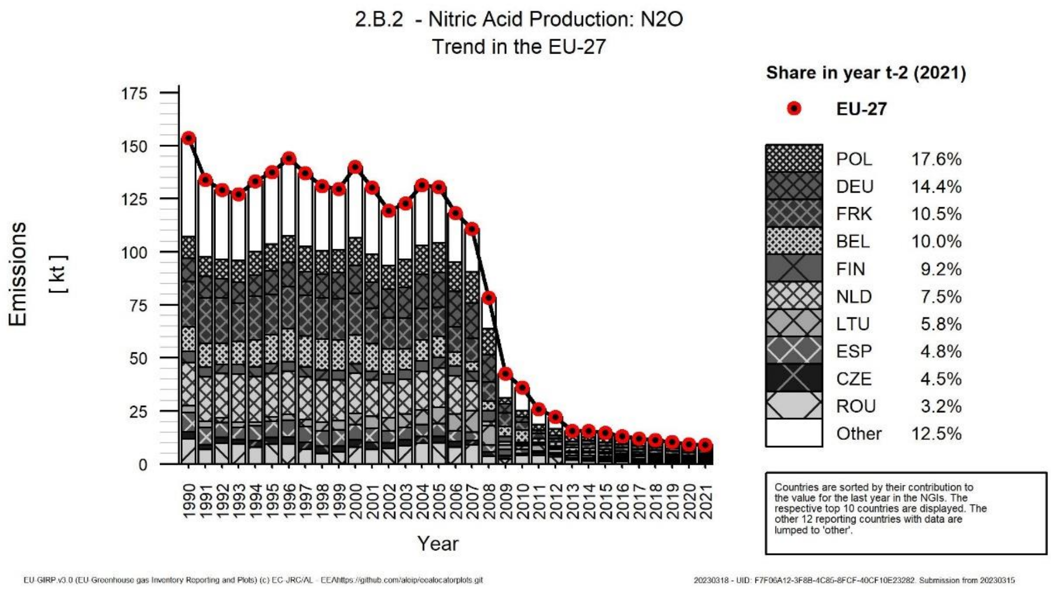
Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.
The table lists methods and emission factors used in the latest inventory year. Estonia, Finland, Ireland and Portugal did not report emissions in that year, but they reported emissions in 1990. The methodological tier used in 1990 is Tier 3 (T3) for Estonia and Tier 1 (T1) for Finland, Ireland and Portugal.

4.2.2.2 2B2 Nitric acid production

N_2O can be emitted in the production of nitric acid as a by-product of the high temperature catalytic oxidation of ammonia (NH_3). Emissions have decreased by 94 % since 1990. All countries have had marked reductions from this source notably post 2007 when pollution control measures were introduced and post 2013 under EU ETS reporting obligations. Between 2020 and 2021, emissions decreased by 2 %.

N_2O emissions from nitric acid production contributed less than 0.1 % of total EU emissions (without LULUCF) in 2021 (Figure **4.8** and Table 4.15). France and the Netherlands have had the greatest reductions in absolute terms, due to the implementation of technical measures at all Dutch nitric acid plants and due to the improvement of the process and catalyst efficiency in France. Production stopped in Denmark in 2004 and in Ireland in 2002.

Figure 4.8 2B2 Nitric acid production N_2O emissions



The substantial decrease in N_2O emissions seen since 2007 is largely due to technical measures that have been implemented at all nitric acid plants. Special catalysts and improvement of the process efficiency led to a continuation of the declining trend in emissions. This trend has slowed in recent years. Twenty countries reported these emissions in 2021, eight of which reported emissions increases compared to the previous year.

Table 4.15 2B2 Nitric acid production: Member States' contributions to N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	780	47	41	1.7%	-738	-95%	-5	-11%	T3	PS
Belgium	3 043	248	240	10.0%	-2 802	-92%	-7	-3%	T3	PS
Bulgaria	1 465	73	65	2.7%	-1 400	-96%	-8	-11%	T3	PS
Croatia	671	58	36	1.5%	-634	-95%	-22	-37%	T3	PS
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	933	64	108	4.5%	-825	-88%	44	68%	T3	PS
Denmark	892	NO	NO	-	-892	-100%	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	1 415	201	219	9.2%	-1 196	-84%	18	9%	T3	PS
France	5 663	385	252	10.5%	-5 411	-96%	-132	-34%	T2,T3	CS,D,PS
Germany	2 897	336	344	14.4%	-2 552	-88%	8	2%	T3	PS
Greece	948	17	5	0.2%	-943	-99%	-12	-69%	CS	CS
Hungary	2 748	29	29	1.2%	-2 718	-99%	0	-1%	T3	PS
Ireland	885	NO	NO	-	-885	-100%	-	-	NA	NA
Italy	1 783	35	23	1.0%	-1 760	-99%	-12	-34%	T3	D,PS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	794	138	139	5.8%	-655	-83%	1	1%	T3	PS
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	5 411	178	180	7.5%	-5 231	-97%	2	1%	T2	PS
Poland	2 704	344	423	17.6%	-2 281	-84%	79	23%	T2	CS
Portugal	460	30	33	1.4%	-427	-93%	3	11%	T3	PS
Romania	3 089	82	77	3.2%	-3 012	-98%	-5	-7%	T3	PS
Slovakia	1 015	68	57	2.4%	-958	-94%	-11	-16%	T3	PS
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	2 428	121	116	4.8%	-2 312	-95%	-6	-5%	T3	PS
Sweden	696	5	10	0.4%	-686	-99%	5	103%	T2	PS
EU-27	**40 718**	**2 457**	**2 398**	**1**	**-38 321**	**-94%**	**-60**	**-2%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.
The methods provided in this table are consistent with the information submitted by Members States in their national inventory submissions. Greece uses a country-specific method and reports 'CS' accordingly. The level of complexity of the method applied by Greece is Tier 3 (T3).
The table lists methods and emission factors used in the latest inventory year. As Cyprus, Denmark, Estonia, Ireland, Latvia, Luxembourg, Malta, Slovenia and Iceland did not report emissions in that year, 'NA' is reported. Denmark and Ireland reported emissions from nitric acid production in 1990. The methodological tier used in that year is Tier 2 (T2) for Denmark and Tier 3 (T3) for Ireland.

Table 4.16 shows information on methods applied, activity data and emission factors for N_2O emissions from 2B2 Nitric acid production for 1990 and 2021. The table shows that while most countries report nitric acid production as activity data, for some countries this information is confidential. The IEFs are shown as kg N_2O per tonne of production. The low IEFs in 2021 are mainly due to the implementation of improved abatement technologies in the various Member States and the closure of some older plants. All countries estimate emissions using higher tier methods (Tier 2 or Tier 3).

Table 4.16 2B2 Nitric acid production: Information on methods applied, activity data, emission factors for N_2O emissions

Member State	1990				2021				Method	Emission Factor Informa-tion
	Activity Data		Implied Emission Factor (t/t)	N2O Emissions (kt CO2 equiv.)	Activity Data		Implied Emission Factor (t/t)	N2O Emissions (kt CO2 equiv.)		
	Description	(kt)			Description	(kt)				
Austria	Nitric Acid Production	530	0.01	780	Nitric Acid Production	520	0.00	41	T3	PS
Belgium	Nitric Acid Production	1436	0.01	3043	Nitric Acid Production	2208	0.00	240	T3	PS
Bulgaria	-	C	C	1465	-	C	C	65	T3	PS
Croatia	Nitric Acid Production	332	0.01	671	Nitric Acid Production	160	0.00	36	T3	PS
Cyprus	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Czechia	Nitric Acid Production	530	0.01	933	Nitric Acid Production	602	0.00	108	T3	PS
Denmark	-	450	0.01	892	-	NO	NO	NO	NA	NA
Estonia	Nitric Acid Production	NO	NO	NO	Nitric Acid Production	NO	NO	NO	NA	NA
Finland	Nitric Acid Production	549	0.01	1415	Nitric Acid Production	654	0.00	219	T3	PS
France	Nitric Acid Production	3200	0.01	5663	Nitric Acid Production	1688	0.00	252	T2,T3	CS,D,PS
Germany	Nitric Acid Production	1698	0.01	2897	Nitric Acid Production	2480	0.00	344	T3	PS
Greece	Nitric Acid Production	511	0.01	948	Nitric Acid Production	176	0.00	5	CS	CS
Hungary	Nitric Acid Production	732	0.01	2748	Nitric Acid Production	847	0.00	29	T3	PS
Ireland	Nitric Acid Production	339	0.01	885	Nitric Acid Production	NO	NO	NO	NA	NA
Italy	Nitric Acid Production	1037	0.01	1783	Nitric Acid Production	402	0.00	23	T3	D,PS
Latvia	Nitric Acid Production	NO	NO	NO	Nitric Acid Production	NO	NO	NO	NA	NA
Lithuania	Nitric Acid Production	355	0.01	794	Nitric Acid Production	949	0.00	139	T3	PS
Luxembourg	Nitric Acid Production	NO	NO	NO	Nitric Acid Production	NO	NO	NO	NA	NA
Malta	-	NO	NO	NO	-	NO	NO	NO	NA	NA
Netherlands	-	C	C	5411	-	C	C	180	T2	PS
Poland	Nitric Acid Production	1577	0.01	2704	Nitric Acid Production	2460	0.00	423	T2	CS
Portugal	-	C	C	460	-	C	C	33	T3	PS
Romania	Nitric Acid Production	1261	0.01	3089	Nitric Acid Production	C	C	77	T3	PS
Slovakia	Nitric Acid Production	401	0.01	1015	Nitric Acid Production	636	0.00	57	T3	PS
Slovenia	Nitric Acid Production	NO	NO	NO	Nitric Acid Production	NO	NO	NO	NA	NA
Spain	Nitric Acid Production	1329	0.01	2428	Nitric Acid Production	666	0.00	116	T3	PS
Sweden	Nitric Acid Production	374	0.01	696	Nitric Acid Production	280	0.00	10	T2	PS
EU-27	**-**	**NE**	**NE**	**40718**	**-**	**NE**	**NE**	**2398**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.
The level of complexity of the method applied by Greece is Tier 3 (T3). The table lists methods and emission factors used in the latest inventory year. The methodological tier used in 1990 is Tier 2 (T2) for Denmark and Tier 3 (T3) for Ireland.

4.2.2.3 2B3 Adipic acid production

Adipic acid production emits N_2O as a by-product when a cyclohexanone/cyclohexanol mixture is oxidized by nitric acid. N_2O emissions from adipic acid production now account for less than 0.01% of total EU emissions (without LULUCF). Between 1990 and 2021, N_2O emissions from this source decreased by 99.6 % (Figure 4.9 and Table 4.17), and Emission in 2021 were 52 % lower than in 2020. Only Germany, Italy and France continue to produce adipic acid.

Figure 4.9 2B3 Adipic acid production N_2O emissions

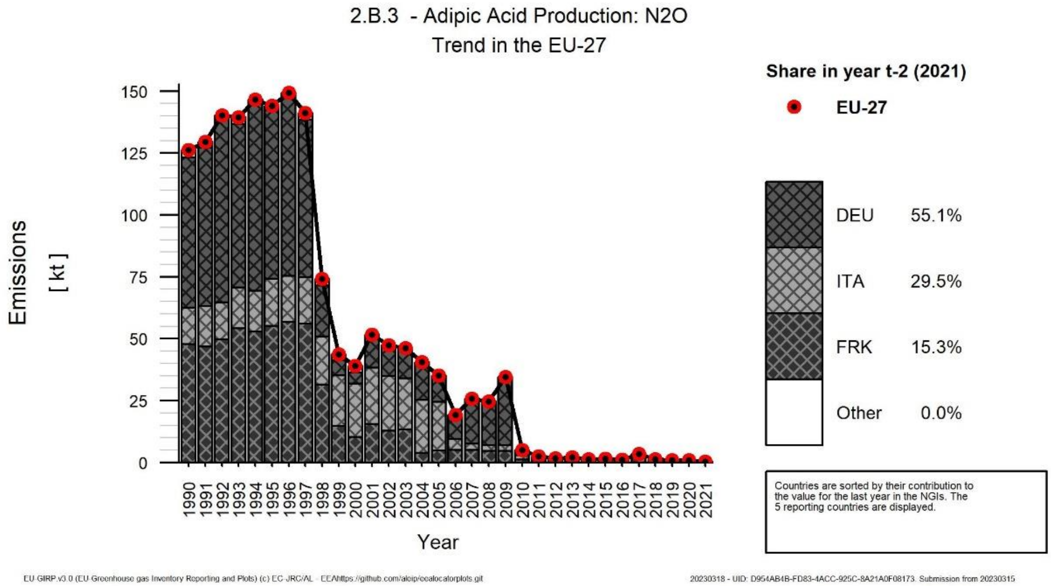


Table 4.17 2B3 Adipic acid production: Member States' contributions to N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
France	12 656	9	18	15.3%	-12 638	-100%	9	102%	T2,T3	CS,D,PS
Germany	16 075	168	66	55.1%	-16 009	-100%	-102	-61%	T3	PS
Italy	3 914	71	35	29.5%	-3 879	-99%	-36	-50%	T3	D,PS
Poland	318	NO	NO	-	-318	-100%	-	-	NA	NA
Romania	490	NO	NO	-	-490	-100%	-	-	NA	NA
EU-27	**33 454**	**248**	**120**	**1**	**-33 334**	**-100%**	**-128**	**-52%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.
The table lists methods and emission factors used in the latest inventory year. Poland and Romania did not report emissions from this category in 2021, but in 1990. The methodological tier used in that year is Tier 1 (T1) for Poland and Romania.

Table 4.18 shows information on methods applied, activity data and emission factors for N_2O emissions from 2B3 Adipic acid production for 1990 to 2021. Adipic acid production is used as activity data, but the information is confidential in France and Germany. The implied emission factors per tonne of adipic acid produced is only provided by Italy with 0.3 t/t for 1990 and 0.004 t/t for 2021. In 2021 all emissions are estimated with higher Tier methods.

Table 4.18 2B3 Adipic acid production: methods, activity data, emission factors for N_2O emissions

Member State	1990				2021				Method	Emission Factor Informa-tion
	Activity Data		Implied Emission Factorn (t/t)	N2O Emissions (kt CO2 equiv.)	Activity Data		Implied Emission Factor (t/t)	N2O Emissions (kt CO2 equiv.)		
	Description	(kt)			Description	(kt)				
France	Adipic Acid Production	C	C	12 656	Adipic Acid Production	C	C	18	T2,T3	CS,D,PS
Germany	Adipic Acid Production	C	C	16 074	Adipic Acid Production	C	C	66	T3	PS
Italy	Adipic Acid Production	49	0.30	3 914	Adipic Acid Production	73	0.00	35	T3	D,PS
Poland	Adipic Acid Production	4	0.30	318	Adipic Acid Production	NO	NO,NA	NO	NA	NA
Romania	Adipic Acid Production	6	0.30	490	Adipic Acid Production	NO	NO	NO	NA	NA
EU-27	**-**	**NE**	**NE**	**33 454**	**-**	**NE**	**NE**	**120**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.
The methodological tier used in 1990 is Tier 1 (T1) for Poland and Romania.

4.2.2.4 2B8 Petrochemical and carbon black production

Europe has a significant petrochemical industry, with production of all of the chemicals that are in the 2006 IPCC Guidelines. Eighteen countries report CO_2 emissions from this category for at least part of the period 1990-2021 with this source being a key category of CO_2 emissions in terms of emissions level and trend.

CO_2 emissions from 2B8 Petrochemical and carbon black production increased by 0.8 % between 2020 and 2021 and are now approx. 19 % above 1990 levels. They contributed 0.3 % of total EU emissions (without LULUCF) in 2021. Belgium, Spain and Hungary contribute the largest share of emissions, respectively 30.0 %, 16.1 % and 11.8 %. Trends vary widely between countries, due to increases and decreases in production of the various chemicals over the 30-year period.

Figure 4.10 2B8 Petrochemical and carbon black production: EU CO_2 emissions

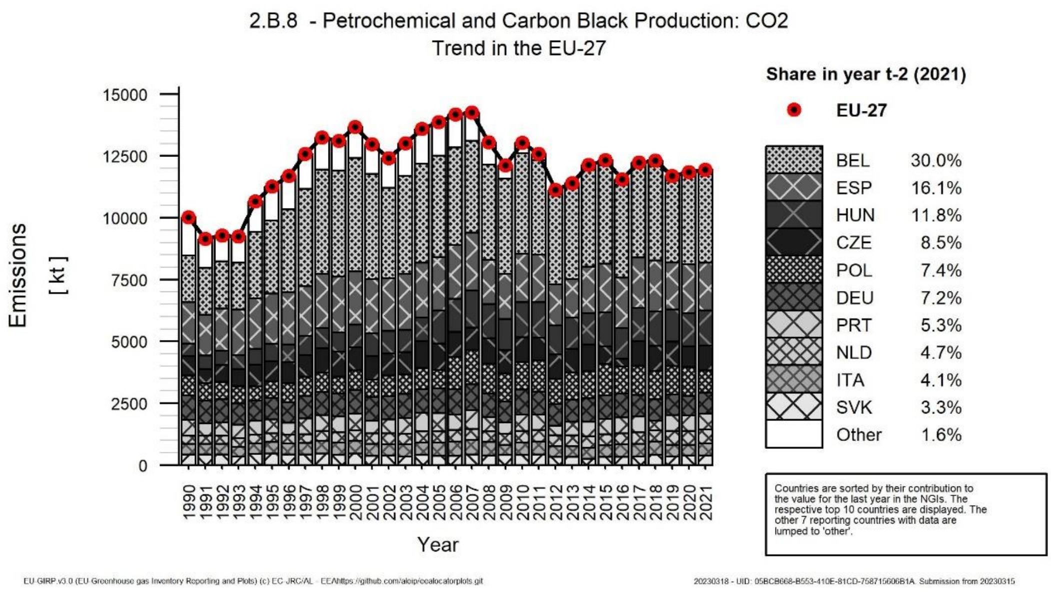


Table 4.19: 2B8 Petrochemical and carbon black production: Member States' contribution to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
Belgium	1 882	3 590	3 581	30.0%	1 698	90%	-10	0%	T3	PS
Bulgaria	346	NO,NA	NO,NA	-	-346	-100%	-	-	NA	NA
Croatia	192	NO,IE	NO,IE	-	-192	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	792	839	1 016	8.5%	224	28%	177	21%	T1,T3	D,PS
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO,IE	NO,IE	NO,IE	-	-	-	-	-	NA	NA
France	376	142	194	1.6%	-182	-49%	52	36%	T1,T2,T3	CS,D,PS
Germany	974	793	862	7.2%	-112	-12%	69	9%	T1,T2	CS,D
Greece	29	NO,NA	NO,NA	-	-29	-100%	-	-	NA	NA
Hungary	504	1 340	1 405	11.8%	901	179%	65	5%	T3	PS
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	422	426	487	4.1%	65	15%	60	14%	T2	CR,PS
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	24	NO	NO	-	-24	-100%	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	336	574	556	4.7%	221	66%	-17	-3%	CS	CS
Poland	806	1 167	888	7.4%	82	10%	-279	-24%	T1	D
Portugal	645	623	638	5.3%	-8	-1%	15	2%	NO	NO
Romania	571	NO	NO	-	-571	-100%	-	-	NA	NA
Slovakia	429	382	395	3.3%	-33	-8%	14	4%	T2	CS,PS
Slovenia	16	NO	NO	-	-16	-100%	-	-	NA	NA
Spain	1 684	1 972	1 924	16.1%	241	14%	-47	-2%	T1,T3	D,PS
Sweden	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-	NA	NA
EU-27	**10 029**	**11 846**	**11 945**	**100%**	**1 917**	**19%**	**99**	**0.8%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.
The methods provided in this table are consistent with the information submitted by Member States in their national inventory submissions. The Netherlands use a country-specific method and report 'CS' accordingly. The level of complexity of the method applied by the Netherlands is Tier 1 (T1).
The table lists methods and emission factors used in the latest inventory year. Bulgaria, Croatia, Greece, Lithuania, Romania and Slovenia reported emissions from petrochemical and carbon black production in 1990. The methodological tier used in that year is Tier 1 (T1) for Bulgaria, Greece, Lithuania and Slovenia and Tier 2 (T2) for Croatia. Romania reported a default ('D') method for 1990, which corresponds to Tier 1 (T1).

4.2.2.5 Chemical industry – Fluorochemical production (CRF Source Category 2.B.9)

Table 4.20 Key categories for sector 2B9 (Table excerpt)

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
2.B.9 Fluorochemical Production: no classification (HFCs)	12809	392	T	L	0	
2.B.9 Fluorochemical Production: no classification (Unspecified mix of HFCs and PFCs)	4670	46	T	0	0	

In this subcategory, by-product emissions and fugitive emissions are to be reported.

As regards by-product emissions, the generation of HFC-23 as a by-product during the manufacture of HCFC-22, HFC-32 and other fluorocarbons is particularly relevant due to its high global warming potential of 14,800. HFC-23 is primarily generated during the fluorination of chloroform (trichloromethane, CHCl3 or R20). Since chloroform is a feedstock for chlorodifluoromethane (HCFC-22 or R22), HFC-23 is a by-product during the manufacture of this chemical which is nowadays mainly used as feedstock. The HFC-23 yield amounts to 2-3% of the amount of R22 produced. In addition, where R22 is used as an intermediate product or feedstock this may also lead to HFC-23 byproduction. This is the case e.g. for some production pathways of difluoromethane (HFC-32 or R32). HFC-32 is widely used as a single substance refrigerant, especially in stationary air conditioning systems, but is also a component of several frequently used refrigerant blends such as the R407 series (10-30% R32) and R410A (50% R32). Production of these blends may therefore also involve HFC-23 by-production. (EU Commission, 2015)

It is estimated that in 1990 the HFC-23 released from HCFC-22 plants was at most 4 percent of the global production of HCFC-22 (U.S. EPA, 2001), in the absence of abatement measures. Before the mid-1990s, ten HCFC-22 plants were operated in Europe. At that time, HFC-23 by-product emissions were partly captured and processed but emissions were also high. In the late 1990s, HFC-23 emissions accounted for about half of the EU's F-gas emissions. Due to the closure of several HCFC production plants and the installation of abatement systems in the remaining facilities, HFC-23 emissions were significantly reduced.

In fluorochemical manufacture also other fluorinated greenhouse gases can occur as by-products including e.g. CF4, C2F6, C3F8, C4F10, C5F12, C6F14 as well as SF_6. The type and amount of these by-product emissions depends on the applied production pathway and installed abatement technology.

The ERT (2015, 2016, 2018) recommended the EU to provide an explanation in the NIR on how CF4 emissions from the production of HCFC-22 occur and work with Italy to allocate these emissions under the subcategory fluorochemical production – by-product emissions (other) (2.B.9.a.2) instead of the subcategory fluorochemical production – by-product emissions (production of HCFC-22) (2.B.9.a.1). The plant where the production of HCFC-22 and other fluorocarbons occurs in Italy, is an integrated plant and all emissions from the different production lines are collected and treated in a centralized abatement unit: The specific design (refractory walls of combustion chamber, particular residence time) leads to specific thermodynamic conditions so that CF4 is formed and escapes. Thus, it is not possible to separate the share of CF4 emissions formed directly during HCFC-22 production and the quota of CF4 to be attributed to fluoropolymers or others. CF4 emissions are allocated under the sub-category 2.B.9.a.1 "By-product emissions – Production of HCFC-22", also because without the production of HCFC-22, no other production could occur.

Fugitive emissions are also released during the production process of F-gases. Hence certain amounts of emissions of all types of F-gases that are manufactured in the EU are reported in this subcategory. In the last decades, the production processes have been optimized in all facilities so that this type of emissions has been significantly reduced.

Several Member States report "unspecified mix of HFCs and PFCs" from 2.B.9 since the waste gases still contain F-gas emissions after the abatement process.

Table 4.21: 2B9 Fluorochemical production – HFCs: Countries' contributions to HFC emissions and information on method applied, activity data and emission factor

Member State	HFCs Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	-	-	-	-	-	-	-	-	-	-
Belgium	NO	674	112	28.5%	112	∞	-562	-83%	NA	NA
Bulgaria	NA	NA	NA	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	4 202	86	35	9.0%	-4 167	-99%	-51	-59%	T3	PS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	991	NO	NO	-	-991	-100%	-	-	NA	NA
Hungary	NO	NO	NO	-	-	-	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	372	1	1	0.2%	-371	-100%	0	20%	CS	PS
Latvia	NA	NA	NA	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	4 697	101	245	62.4%	-4 453	-95%	143	141%	T2	CS
Poland	NO	NO	NO	-	-	-	-	-	NA	NA
Portugal	NO,NA	NO	NO	-	-	-	-	-	NA	NA
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	2 547	NO	NO	-	-2 547	-100%	-	-	NA	NA
Sweden	-	-	-	-	-	-	-	-	-	-
EU-27	**12 809**	**862**	**392**	**100%**	**-12 417**	**-97%**	**-470**	**-54%**	**-**	**-**

Table 4.22: 2B9 Fluorochemical production: Countries' contributions to Unspecified mix of HFC and PFC emissions and information on method applied, activity data and emission factor

Member State	Unspecified mix of HFCs and PFCs Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	-	-	-	-	-	-	-	-	-	-
Belgium	-	-	-	-	-	-	-	-	NA	NA
Bulgaria	NA	NA	NA	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	NO,NA	NO,NA	NO,NA	-	-	-	-	-	NA	NA
Germany	4 670	46	46	100.0%	-4 624	-99%	0	0%	T3	PS
Greece	NO	NO	NO	-	-	-	-	-	NA	NA
Hungary	NO	NO	NO	-	-	-	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	-	-	-	-	-	-	-	-	-	-
Latvia	NA	NA	NA	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	-	-	-	-	-	-	-	-	-	-
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	NO	NO	NO	-	-	-	-	-	NO	NO
Portugal	NO,NA	NO	NO	-	-	-	-	-	NA	NA
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	NO	NO	NO	-	-	-	-	-	NA	NA
Sweden	-	-	-	-	-	-	-	-	-	-
EU-27	**4 670**	**46**	**46**	**100%**	**-4 624**	**-99%**	**0**	**0%**	**-**	**-**

4.2.2.6 2B10 Other chemical industry

Thirteen countries reported CO_2, CH_4 or N_2O emissions in this category in 2021 which contributed 12.8 Mt of CO_2e or 0.3 % of total EU (without LULUCF) emissions.

Between 1990 and 2021, CO_2 emissions from this source increased by 63 % (Table 4.24) while CH_4 and N_2O emissions decreased by about 29 % and 35 % respectively. This category contains a wide range of emissions and sources as shown in the tables below.

Table 4.23 2B10 Other: CO_2, CH_4 and N_2O emissions for 1990 and 2021

Member State	2.B.10 Other	CO_2 emissions [kt]	CH_4 emissions [kt CO_2 equ]	N_2O emissions [kt CO_2 equ]	Total emissions [kt CO_2 equ]	CO_2 emissions [kt]	CH_4 emissions [kt CO_2 equ]	N_2O emissions [kt CO_2 equ]	Total emissions [kt CO_2 equ]
		1990	**1990**	**1990**	**1990**	**2021**	**2021**	**2021**	**2021**
AUT	10. Other (please specify)	138.56	8.17	NA	146.73	143.65	11.04	NA	154.68
	CO_2 from Nitric Acid Production	0.41	NA	NA	0.41	0.39	NA	NA	0.39
	Other chemical bulk production	138.15	8.17	NA	146.32	143.26	11.04	NA	154.30
BEL	10. Other (please specify)	285.15	19.80	24.38	329.32	2399.83	17.79	55.39	2473.01
	Other non-specified	285.15	19.80	27.42	332.36	2399.83	17.79	55.39	2473.01
BGR	10. Other (please specify)	NA	NA	NA		NA	NA	NA	
CYP	10. Other (please specify)	NO	NO	NO		NO	NO	NO	
CZE	10. Other (please specify)	IE	NO	NO		191.45	NO	NO	191.45
	Other non energy use in chemical industry	IE	NO	NO		175.35	NO	NO	175.35
	Non selective catalytic reduction	IE	NO	NO		16.10	NO	NO	16.10
DEU	10. Other (please specify)	NA	66.65	IE	66.65	NA	65.04	IE	65.04
	Other	NA	66.65	IE	66.65	NA	65.04	IE	65.04
DNM	10. Other (please specify)	0.57	NA	NA	0.57	1.23	NA	NA	1.23
	Production of catalysts	0.57	NA	NA	0.57	1.23	NA	NA	1.23
ESP	10. Other (please specify)	NO,NA	NA	NA		795.92	NA	NA	795.92

Member State	2.B.10 Other	CO_2 emissions [kt]	CH_4 emissions [kt CO_2 equ]	N_2O emissions [kt CO_2 equ]	Total emissions [kt CO_2 equ]	CO_2 emissions [kt]	CH_4 emissions [kt CO_2 equ]	N_2O emissions [kt CO_2 equ]	Total emissions [kt CO_2 equ]
		1990	1990	1990	1990	2021	2021	2021	2021
	Other No-Specify	NO	NA	NA		795.92	NA	NA	795.92
EST	10. Other (please specify)	NO	NO	NO		NO	NO	NO	
FIN	10. Other (please specify)	177.28	NO	NO	177.28	968.84	NO	NO	968.84
	Phosphoric Acid Production	24.54	NO	NO	24.54	35.67	NO	NO	35.67
	Hydrogen Production	116.22	NO	NO	116.22	850.01	NO	NO	850.01
	Limestone and Dolomite Use	36.52	NO	NO	36.52	83.16	NO	NO	83.16
	Chemicals Production	NO	NO	NO		NO	NO	NO	
FRK	10. Other (please specify)	4561.05	86.18	475.08	5122.32	4726.70	34.31	53.55	4814.56
GRC	10. Other (please specify)	NO	NO			NO	NO		
	Sulfuric acid	NA	NA			NA	NA		
	Hydrogen production	NA,NO	NA	NA		483.23	NA	NA	483.23
HRV	10. Other (please specify)	66.36	NA		66.36	NO	NO		
HUN	10. Other (please specify)	NO	NO	NO		NO	NO	NO	
IRL	10. Other (please specify)	NO	NO			NO	NO		
ITA	10. Other (please specify)	NA	NA	NA		NA	NA	NA	
	other (indirect emissions)	NA	1.841882		1.841882	NA	1.29		1.29

Member State	2.B.10 Other	CO_2 emissions [kt]	CH_4 emissions [kt CO_2 equ]	N_2O emissions [kt CO_2 equ]	Total emissions [kt CO_2 equ]	CO_2 emissions [kt]	CH_4 emissions [kt CO_2 equ]	N_2O emissions [kt CO_2 equ]	Total emissions [kt CO_2 equ]
		1990	**1990**	**1990**	**1990**	**2021**	**2021**	**2021**	**2021**
	Soda Ash (CO emissions only)	NA	NA	NA		NA	NA	NA	
LTU	10. Other (please specify)	NO	NO			NO	NO		
	Sulfuric acid production	NO	NO			NO	NO		
LUX	10. Other (please specify)	NO	NO			NO	NO		
LVA	10. Other (please specify)	NO	NO			NO	NO		
MLT	10. Other (please specify)	NO	NO			NO	NO		
	Carbide use								
NLD	10. Other (please specify)	1037.63	NO	217.15	1254.78	1169.39	NO	355.68	1525.07
	Other process emissions	335.61	301.79		637.40	556.47	357.78		914.26
POL	10. Other (please specify)	NO	NO	NO		NO	NO	NO	
PRT	10. Other (please specify)	NO	NO			NO	NO		
	2.B.10.a Sulphuric Acid	1.41	NO		1.41	3.63	NO		3.63
	2.B.10.c Explosives	NO,NA	NO,NA	NO,NA		NO,NA	NO,NA	NO,NA	
	2.B.10.d Solvent use in plastic products manufacturing	NO	NO	NO		NO	NO	NO	
ROU	10. Other (please specify)	NO	NO			NO	NO		
	Other - non-specified	NO	NO			NO	NO		

Member State	2.B.10 Other	CO_2 emissions [kt]	CH_4 emissions [kt CO_2 equ]	N_2O emissions [kt CO_2 equ]	Total emissions [kt CO_2 equ]	CO_2 emissions [kt]	CH_4 emissions [kt CO_2 equ]	N_2O emissions [kt CO_2 equ]	Total emissions [kt CO_2 equ]
		1990	1990	1990	1990	2021	2021	2021	2021
SVK	10. Other (please specify)	NO	NO			NO	NO		
	Hydrogen Production	NO	NO			NO	NO		
SVN	10. Other (please specify)	NO	NO			NO	NO		
SWE	10. Other (please specify)	NA	IE			NA	IE		
	Pharmaceutical industry	IE	IE			IE	IE		
	Other non-specified	514.02	0.79	18.43	533.24	886.47	0.90	0.76	888.14
	Other organic chemical products	NA	NE	13.25	13.25	NA	NE	NE	
	Base chemicals for plastic industry	NE	NE	NE		NE	NE	NE	
	Other inorganic chemical products	456.91	0.71	0.00	457.62	734.85	0.80	0.02	735.67
	Sulphuric acid production	16.23	0.01	3.16	19.39	22.53	0.01	0.01	22.55
EU		**6267**	**181**	**717**	**7164**	**10206**	**128**	**465**	**10798**

Abbreviations explained in the Chapter 'Units and abbreviations'.

Table **4.24** provides an overview of changes in CO_2 emissions between 1990 and 2021 at an aggregated level. The diverging trends can be explained by various increases and decreases in the production of chemicals between 1990 and 2021. The same holds true for N_2O (Table **4.25**) and CH_4 (***Table** 4.26*).

Table 4.24 2B10 Other: CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	139	146	144	1.2%	5	4%	-3	-2%	T3	PS
Belgium	285	2 161	2 400	19.8%	2 115	742%	239	11%	T3	PS
Bulgaria	NA	NA	NA	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	IE	222	191	1.6%	191	∞	-30	-14%	T1	CS
Denmark	1	1	1	0.0%	1	117%	0	-14%	T2	PS
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	177	1 050	969	8.0%	792	447%	-81	-8%	CS,T2,T3	CS,PS
France	4 561	4 532	4 727	39.1%	166	4%	195	4%	T1,T2,T3	CS,D,PS
Germany	NA	NA	NA	-	-	-	-	-	NA	NA
Greece	NA,NO	649	483	4.0%	483	∞	-166	-26%	T1	CS
Hungary	NO	NO	NO	-	-	-	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	NA	NA	NA	-	-	-	-	-	NA	NA
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	0	0	0	0.0%	0	-100%	0	0%	-	-
Netherlands	1 038	1 407	1 169	9.7%	132	13%	-237	-17%	T1	D
Poland	NO	NO	NO	-	-	-	-	-	NA	NA
Portugal	NO,NA	NO,NA	NO,NA	-	-	-	-	-	NA	NA
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	117	307	316	2.6%	199	170%	9	3%	T3	CS
Slovenia	17	12	13	0.1%	-4	-23%	1	10%	T2	CS
Spain	NO,NA	772	796	6.6%	796	∞	23	3%	T3	PS
Sweden	514	480	886	7.3%	372	72%	407	85%	T3	PS
EU-27	**6 849**	**11 738**	**12 096**	**100%**	**5 247**	**77%**	**357**	**3.0%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.

Table 4.25 2B10 Other: N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	NA	NA	NA	-	-	-	-	-	NA	NA
Belgium	24	54	55	11.9%	31	127%	2	3%	T3	PS
Bulgaria	NA	NA	NA	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NA	NA	NA	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	475	53	54	11.5%	-422	-89%	1	1%	T2,T3	CS,D,PS
Germany	IE	IE	IE	-	-	-	-	-	NA	NA
Greece	NA	NA	NA	-	-	-	-	-	NA	NA
Hungary	NO	NO	NO	-	-	-	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	NA	NA	NA	-	-	-	-	-	NA	NA
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NA	NA	NA	-	-	-	-	-	NA	NA
Netherlands	217	376	356	76.4%	139	64%	-20	-5%	T1	CS
Poland	NO	NO	NO	-	-	-	-	-	NA	NA
Portugal	NO,NA	NO,NA	NO,NA	-	-	-	-	-	NA	NA
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	0	0	0	0.0%	0	175%	0	3%	T3	D
Slovenia	NA	NA	NA	-	-	-	-	-	NA	NA
Spain	NA	NA	NA	-	-	-	-	-	NA	NA
Sweden	18	1	1	0.2%	-18	-96%	0	15%	T2,T3	CS,PS
EU-27	**735**	**483**	**466**	**100%**	**-270**	**-37%**	**-18**	**-3.7%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.

Table 4.26: 2B10 Other: CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	8.2	11.2	11.0	8.5%	3	35%	-0.1	-1%	T3	PS
Belgium	19.8	18.4	17.8	13.8%	-2	-10%	-0.6	-3%	T3	PS
Bulgaria	NA	NA	NA	-	-	-	-	-	NA	NA
Croatia	NO	NO	NO	-	-	-	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NA	NA	NA	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	86.2	34.8	34.3	26.5%	-52	-60%	-0.5	-1%	T2,T3	CS,D,PS
Germany	66.6	66.6	65.0	50.3%	-2	-2%	-1.6	-2%	T2	CS
Greece	NA	NA	NA	-	-	-	-	-	NA	NA
Hungary	NO	NO	NO	-	-	-	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	NA	NA	NA	-	-	-	-	-	NA	NA
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NA	NA	NA	-	-	-	-	-	NA	NA
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	NO	NO	NO	-	-	-	-	-	NA	NA
Portugal	NO,NA	NO,NA	NO,NA	-	-	-	-	-	NA	NA
Romania	NO	NO	NO	-	-	-	-	-	NA	NA
Slovakia	0.1	0.2	0.2	0.1%	0	175%	0.0	3%	T3	D
Slovenia	NA	NA	NA	-	-	-	-	-	NA	NA
Spain	NA	NA	NA	-	-	-	-	-	NA	NA
Sweden	0.8	0.9	0.9	0.7%	0	14%	0.0	1%	T1,T2,T3	CS,D,PS
EU-27	**182**	**132**	**129**	**100%**	**-52**	**-29%**	**-2.8**	**-2.1%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year. Abbreviations explained in the Chapter 'Units and abbreviations'.

The methods provided in this table are consistent with the information submitted by Members States in their national inventory submissions.

Table 4.27 provides an overview of all sources reported under 2B10 Other Chemical Industry for all gases for the year 2021. The largest contributors to total emissions in that year are France, Belgium and the Netherlands.

Table 4.27 2B10 Other: Overview of sources reported under this source category for 2021

Member State	2.B.10 Other Chemical Industry	CO2 emissions [kt]	CH4 emissions [kt]	N2O emissions [kt]	Total emissions [kt CO2 equivalents]	Share in EU-27 Total
		2021	2021	2021	2021	2021
Austria	10. Other (please specify), CO2 from Nitric Acid Production, Other chemical bulk production	144	0.39	NA	155	1%
Belgium	10. Other (please specify), Other non-specified	2400	0.64	0.21	2473	19%
Bulgaria	10. Other (please specify)	NA	NA	NA	-	-
Croatia	10. Other (please specify)	NO	NO	NO	-	-
Cyprus	10. Other (please specify)	NO	NO	NO	-	-
Czech Republic	10. Other (please specify), Other non energy use in chemical industry, Non selective catalytic reduction	191	NO	NO	191	2%
Denmark	10. Other (please specify), Production of catalysts	1	NA	NA	1	0.01%
Estonia	10. Other (please specify)	NO	NO	NO	-	-
Finland	10. Other (please specify), Phosphoric Acid Production, Hydrogen Production, Limestone and Dolomite Use, Chemicals Production	969	NO	NO	969	8%
France	10. Other (please specify)	4727	1	0.20	4815	38%
Germany	10. Other (please specify), Other	NA	2	IE	65	1%
Greece	10. Other (please specify), Sulfuric acid, Hydrogen production	483	NA	NA	483	4%
Hungary	10. Other (please specify)	NO	NO	NO	-	-
Ireland	10. Other (please specify)	NO	NO	NO	-	-
Italy	10. Other (please specify), other (indirect emissions), Soda Ash (CO emissions only)	NA	NA	NA	-	-
Latvia	10. Other (please specify)	NO	NO	NO	-	-
Lithuania	10. Other (please specify), Sulfuric acid production	NO	NO	NO	-	-
Luxembourg	10. Other (please specify)	NO	NO	NO	-	-
Malta	10. Other (please specify)	0.00	NA	NA	0	0.0000%
Netherlands	10. Other (please specify), Other process emissions	1169	NO	1	1525	12%
Poland	10. Other (please specify)	NO	NO	NO	-	-
Portugal	10. Other (please specify), 2.B.10.a Sulphuric Acid, 2.B.10.c Explosives, 2.B.10.d Solvent use in plastic products manufacturing	NO,NA	NO,NA	NO,NA	-	-
Romania	10. Other (please specify), Other - non-specified	NO	NO	NO	-	-
Slovakia	10. Other (please specify), Hydrogen Production	316	0	0	316	2%
Slovenia	10. Other (please specify)	13	NA	NA	13	0.1%
Spain	10. Other (please specify), Other No-Specify	796	NA	NA	796	6%
Sweden	10. Other (please specify), Pharmaceutical industry, Other non-specified, Other organic chemical products, Base chemicals for plastic industry, Other inorganic chemical products, Sulphuric acid production	886	0	0	888	7%
EU-27		**12096**	**5**	**2**	**12691**	**100%**

Abbreviations explained in the Chapter 'Units and abbreviations'.

4.2.2.7 Non-key sources

Non key sources in the chemical industry sector include: 2B4 Caprolactam, glyoxal and glyoxylic acid production; 2B5 Carbide production; 2B6 Titanium dioxide production and 2B7 Soda ash production. They also include emissions of CH_4 and N_2O from 2B1 Ammonia Production, CO_2 emissions from 2B3 Adipic Acid Production, CH_4 from 2B8 Petrochemical and carbon black production, and PFC and SF_6 emissions from 2B9 Fluorochemical production. In 2021 emissions from these categories contributed 5.7 Mt of CO_2 equivalent or 0.2 % of total EU emissions (without LULUCF).

Table 4.28 2B: Emissions from non-key categories in the chemical industry

EU	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 2. IPPU in 2021	Change 1990-2021		Change 2019-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
2.B.1 Ammonia Production: no classification (CH_4)	2.1	2.4	1.8	0.00%	-0.2	-11%	-0.6	-24%
2.B.1 Ammonia Production: no classification (N_2O)	0.3	0.4	0.4	0.00%	0.2	54%	0.0	5%
2.B.10 Other chemical industry: no classification (CH_4)	181.6	132.0	129.2	0.04%	-52.4	-29%	-2.8	-2%
2.B.10 Other chemical industry: no classification (HFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.10 Other chemical industry: no classification (N_2O)	735.1	483.4	465.5	0.15%	-269.6	-37%	-17.9	-4%
2.B.10 Other chemical industry: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.10 Other chemical industry: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.10 Other chemical industry: no classification (SF_6)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.10 Other chemical industry: no classification (Unspecified mix of HFCs and PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.3 Adipic Acid Production: no classification (CO_2)	26.5	14.2	23.6	0.01%	-2.9	-11%	9.4	66%
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production: no classification (CO_2)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production: no classification (N_2O)	3 673.7	1 267.7	1 035.4	0.33%	-2 638.3	-72%	-232.3	-18%
2.B.5 Carbide Production: no classification (CH_4)	6.2	9.5	15.6	0.00%	9.3	150%	6.0	63%
2.B.5 Carbide Production: no classification (CO_2)	1 798.9	211.0	246.5	0.08%	-1 552.4	-86%	35.5	17%
2.B.6 Titanium Dioxide Production: no classification (CO_2)	21.5	116.6	123.5	0.04%	102.0	474%	6.9	6%
2.B.7 Soda Ash Production: no classification (CO_2)	1 966.0	1 672.1	1 832.2	0.58%	-133.8	-7%	160.0	10%
2.B.8 Petrochemical and Carbon Black Production: no classification (CH_4)	1 090.5	1 268.8	1 262.2	0.40%	171.7	16%	-6.6	-1%
2.B.9 Fluorochemical Production: no classification (NF_3)	0.0	7.1	4.3	0.00%	4.3	100%	-2.8	-39%
2.B.9 Fluorochemical Production: no classification (PFCs)	3 955.4	541.3	440.4	0.14%	-3 515.0	-89%	-100.8	-19%
2.B.9 Fluorochemical Production: no classification (SF_6)	1 902.2	163.0	168.5	0.05%	-1 733.7	-91%	5.5	3%

4.2.3 Metal Industry (CRF Source Category 2C)

This source category includes two key sources for level and trend, namely CO_2 emissions from 2C1 Iron and Steel Production and PFC emissions from 2C3 Aluminium Production (*Table 4.29*).

Table 4.29: Key source categories for level and trend analyses and share of MS emissions using higher tier methods for sector 2C (Table excerpt).

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
2.C.1 Iron and Steel Production: no classification (CO_2)	103475	67285	T	L	L	100%
2.C.3 Aluminium Production: no classification (PFCs)	17303	283	T	L	0	100%

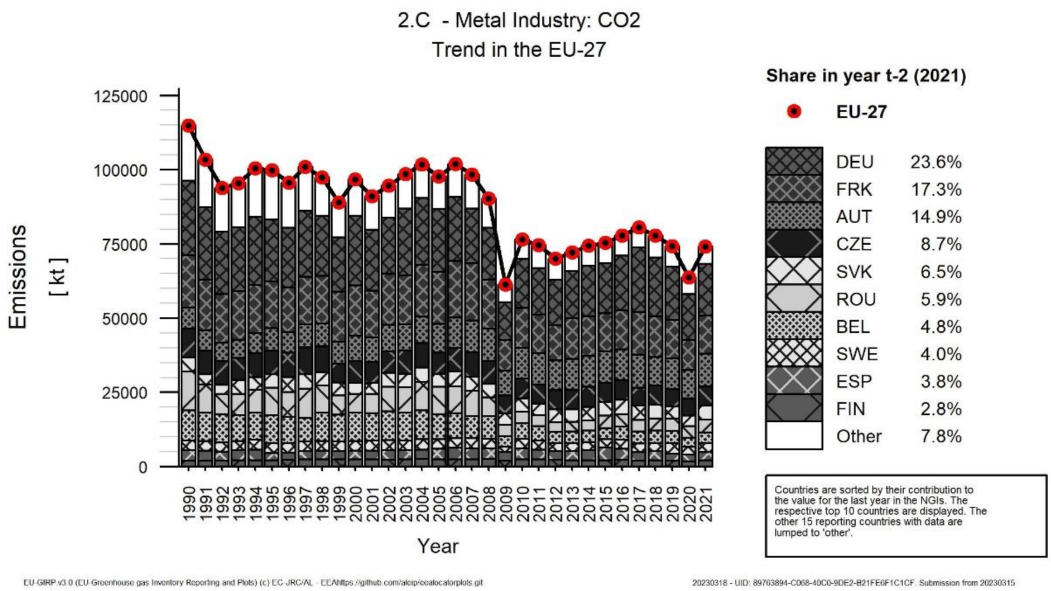
Table 4.30 summarises information by countries on total GHG emissions, CO_2, N_2O, CH_4 and HFC, PFC, NF_3 and SF_6 emissions from Metal Production. Between 1990 and 2021, GHG emissions decreased by 44% and CO_2 emissions from 2C Metal Production decreased by 35%. The absolute decrease of GHG emissions was largest in Romania, Germany, France, and Belgium (in decending order).

Table 4.30 2C Metal Industry: Countries' contributions to total GHG, CO_2, HFC, PFC and SF_6 emissions

Member State	GHG emissions in kt CO2 equivalents		CO2 emissions in kt		N2O emissions in kt CO2 equivalents		CH4 emissions in kt CO2 equivalents		HFC emissions in kt CO2 equivalents		PFC emissions in kt CO2 equivalents		NF3 emissions in kt CO2 equivalents		SF6 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021	1990	2021	1990	2021	1990	2021	1990	2021	1990	2021
Austria	8 304	11 039	7 016	11 031	NO	NO	6	4	-	-	1 032	NO	-	-	249	5
Belgium	10 107	3 571	10 092	3 566	NO	NO	15	4	-	-	-	-	-	-	-	-
Bulgaria	1 633	133	1 603	133	NA	NA	30	NO,NA	NA	NA	NA	NA	NA	NA	NA	NA
Croatia	1 458	14	336	14	NO	NO	4	NO,NA	NO	NO	1 117	NO	NO	NO	NO	NO
Cyprus	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Czechia	9 812	6 448	9 795	6 432	NA	NA	17	16	NO	NO	NO	NO	NO	NO	NO	NO
Denmark	61	0	30	0	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	31	NO
Estonia	1	3	1	3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Finland	1 976	2 094	1 976	2 094	NO	NO	0	0	NO	-	NO	-	NO	-	NO	NO
France	21 789	12 887	17 678	12 802	NO	NO	158	39	NO,IE	NO,IE	3 211	38	-	-	743	8
Germany	27 901	17 612	25 080	17 475	24	12	15	7	NA	8	2 597	59	-	-	186	52
Greece	1 183	711	1 012	625	NO	NO	0	0	NO	NO	171	86	NO	NO	NO	NO
Hungary	3 663	842	3 317	838	NO	NO	8	3	NO	NO	338	NO	NO	NO	NO	NO
Ireland	26	NO	26	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Italy	6 232	1 713	4 378	1 668	NA	NO	76	41	NO	4	1 778	NO	-	-	NO	NO
Latvia	70	NO	70	NO	NO	NO	0	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lithuania	17	0	17	0	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	985	92	985	92	NO	NO	NO	NO	-	-	-	-	-	-	-	-
Malta	NO	NO	NO	NO	-	-	NO	NO	-	-	-	-	-	-	NO	-
Netherlands	2 826	180	452	166	NO	NO	NO,IE	NO,IE,NA	NO	NO	2 374	15	-	-	NO	NO
Poland	5 805	2 085	5 652	2 073	NA	NA	26	12	NA	NA	127	NO,NA	NA	NA	NA,NO	NO,NA
Portugal	447	78	446	78	NO	NO	1	NO,NE	NA	NO	NO,NA	NO	-	-	NO,NA	NO
Romania	15 782	4 367	13 228	4 359	NO	NO	24	5	NO	NO	2 530	3	NO	NO	NA,NO	NO,NA
Slovakia	4 869	4 792	4 586	4 785	NO	NO	NO,NE,NA	1	NO	NO	283	5	NO	NO	NO	NO
Slovenia	530	129	343	122	NO	NO	0	NO,NA	NO	NO	187	7	NO	NO	NO	NO
Spain	4 615	2 880	3 537	2 829	NA	NA	32	23	NO,NA	NO,NA	1 046	28	NA	NA	NO,NA	NO,NA
Sweden	3 819	2 994	3 262	2 952	NA	NA	22	0	NO	1	511	42	-	-	24	NO
EU-27	**133 911**	**74 664**	**114 918**	**74 135**	**24**	**12**	**435**	**157**	**NA,IE,NO**	**12**	**17 303**	**283**	**NA,NO**	**NA,NO**	**1 232**	**64**

Presented methods and emission factor information refer to the last inventory year.
Note: Total GHG emissions given in this table include CO_2, N_2O, CH_4, HFC, PFC and SF_6.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 4.11: 2C Metal Industry CO_2 – Trend in EU-27



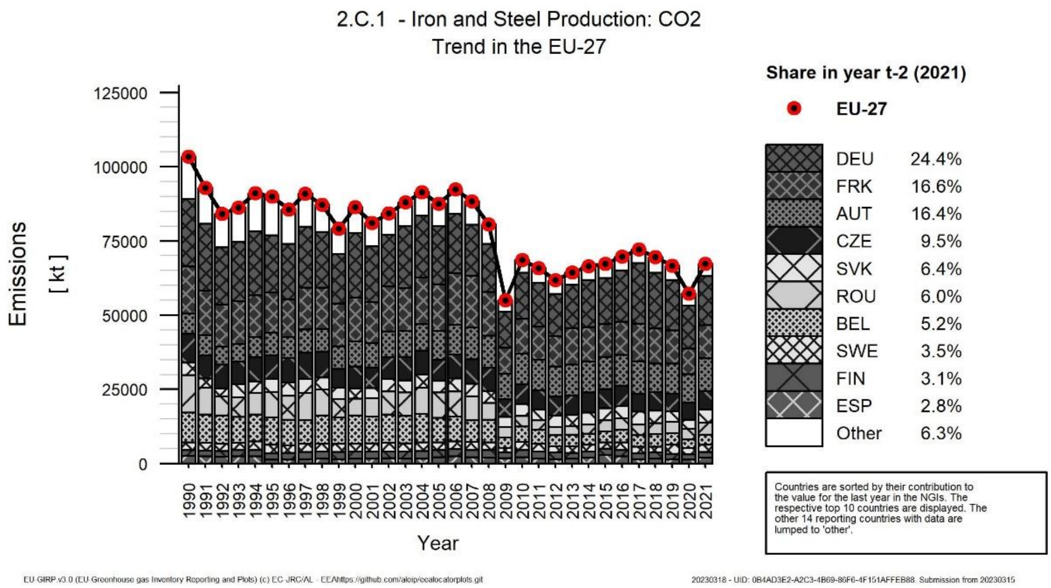
4.2.3.1 2C1 Iron and steel production

This source category includes emissions from the iron and steel industry. Crude iron is produced by the reduction of iron oxide ores mostly in blast furnaces, using coke or other forms of carbon as fuel and reducing agent. In most iron furnaces, the process is aided by the use of carbonate fluxes (limestone). Additional emissions occur as the limestone or dolomite flux releases CO_2 during reduction of pig iron in the blast furnace. Coke plays the dual role of fuel and reducing agent. Countries use different methods for the allocation of emissions that are described in Table **4.32**.

CO_2 emissions from 2C1 Iron and Steel Production amounted to approximately 1.9 % of total GHG emissions (including indirect CO_2, with LULUCF, with international aviation) in 2021. Germany accounts for 24.4% of these emissions in the EU KP, and France for 16.6% in 2021. Romania had the largest decrease in absolute terms between 1990 and 2021. Increases were encountered (in order of magnitude) in Austria, and Finland between 1990 and 2021.

The overall emission trend between 1990 and 2021 roughly follows the trend of emissions that fluctuates due to varying production figures. Between 1990 and 2021, overall CO_2 emissions from iron and steel production decreased by 35% (Table 4.31). Between 2020 and 2021, emissions increased by 17.6%.

Figure 4.12 2C1 Iron and Steel Production: CO_2 emissions – Trend in EU-27



CO_2 emissions from iron and steel industry are reported by all countries except Cyprus, Estonia and Malta. Denmark, Ireland and Latvia reported emissions from this sector in 1990, but no more from 2019. All follow higher-tier methods and most use country or plant specific methods (see Table **4.31**).

Table 4.31 2C1 Iron and Steel Production: Countries' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	6 840	9 482	11 002	16.4%	4 161	61%	1 520	16%	T3	CS,PS
Belgium	10 048	2 961	3 474	5.2%	-6 574	-65%	512	17%	CS,T3	PS
Bulgaria	1 283	22	11	0.0%	-1 272	-99%	-11	-51%	T2	CS
Croatia	44	5	14	0.0%	-30	-67%	9	189%	T3	PS
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	9 782	5 772	6 420	9.5%	-3 362	-34%	647	11%	CS,T2	CS,D,PS
Denmark	30	NO	NO	-	-30	-100%	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	1 967	1 732	2 075	3.1%	108	5%	343	20%	CS,T3	CS
France	15 788	8 677	11 172	16.6%	-4 615	-29%	2 496	29%	T2	CS
Germany	22 810	14 442	16 419	24.4%	-6 391	-28%	1 977	14%	T2	CS
Greece	105	74	84	0.1%	-21	-20%	10	14%	CS	PS
Hungary	3 155	1 110	838	1.2%	-2 316	-73%	-271	-24%	T3	PS
Ireland	26	NO	NO	-	-26	-100%	-	-	NA	NA
Italy	3 124	1 215	1 423	2.1%	-1 701	-54%	208	17%	T2	CR,CS,PS
Latvia	70	NO	NO	-	-70	-100%	-	-	NA	NA
Lithuania	17	0	0	0.0%	-17	-100%	0	-9%	T2	D
Luxembourg	985	96	90	0.1%	-895	-91%	-6	-7%	CS,T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	44	17	83	0.1%	40	91%	66	387%	T2	PS
Poland	4 959	1 368	1 566	2.3%	-3 393	-68%	198	14%	T2	CS
Portugal	440	84	65	0.1%	-375	-85%	-19	-23%	T1,T3	D,PS
Romania	12 621	3 513	4 014	6.0%	-8 607	-68%	501	14%	T3	CS
Slovakia	4 168	3 146	4 275	6.4%	107	3%	1 129	36%	T2	PS
Slovenia	44	53	58	0.1%	14	33%	5	8%	T3	PS
Spain	2 501	1 346	1 865	2.8%	-636	-25%	519	39%	T2	CS,PS
Sweden	2 626	2 090	2 337	3.5%	-289	-11%	247	12%	T3	PS
EU-27	**103 475**	**57 204**	**67 285**	**100%**	**-36 190**	**-35%**	**10 081**	**17.6%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

For this category (2C1 – Iron and steel), it is not relevant to analyse an average IEF across countries because of their varying emission allocation (the split between process and combustion related emissions for pig iron production, which is an important sub-category). Activity data, implied emission factors and CO_2 emissions for the various countries and sub-categories are provided in Table **4.32**.

*Table4.13	2C1 Iron and Steel Production: Implied emission factors*

Member State	1990				Member State	2021				Method	Emission factor information
	category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		
Austria	**Iron and steel production**			6840	**Austria**	**Iron and steel production**	-	-	11002		
	Steel	3921	1.74	6821		Steel	7195	1.52	10962	T3	CS,PS
	Pig Iron	3444	NO,IE	IE		Pig Iron	6131	NO,IE	IE	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	IE	NO,IE	IE		Sinter	IE	NO,IE	IE	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			20		Other	-	-	40		
	Electric Furnace Steel	370	0	20		Electric Furnace Steel	687	0.06	40	T3	PS
Belgium	**Iron and steel production**			10048	**Belgium**	**Iron and steel production**	-	-	3474		
	Steel	11570	0.73	8445		Steel	6910	0.49	3391	CS,T3	PS
	Pig Iron	9415	NA,IE	IE		Pig Iron	4199	IE,NA	IE	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	13075	0.12	1589		Sinter	4262	0.02	76	CS,T3	PS
	Pellet	660	NO,IE	IE		Pellet	NO	NO	NO	NA	NA
	Other			14		Other	-	-	7		
	Use of electrodes	NA	NO,IE	IE		Use of electrodes	1899	0.00	7	CS,T3	PS
Bulgaria	**Iron and steel production**			1283	**Bulgaria**	**Iron and steel production**	-	-	11		
	Steel	2180	0.59	1283		Steel	618	0.02	11	T2	CS
	Pig Iron	1143	NO,IE	IE		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	C	NO,IE	IE		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NA		Other	-	-	NA		

Member State	1990 category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)	Member State	2021 category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)	Method	Emission factor information
Croatia	**Iron and steel production**			44	**Croatia**	**Iron and steel production**	-	-	14		
	Steel	424	0.05	20		Steel	185	0.08	14	T3	PS
	Pig Iron	209	0.12	24		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Cyprus	**Iron and steel production**			NO	**Cyprus**	**Iron and steel production**	-	-	NO		
	Steel	NO	NO	NO		Steel	NO	NO	NO	NA	NA
	Pig Iron	NO	NO	NO		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Czechia	**Iron and steel production**			9782	**Czechia**	**Iron and steel production**	-	-	6420		
	Steel	8190	IE,NA	IE		Steel	4801	IE,NA	IE	NA	NA
	Pig Iron	6106	IE,NA	IE		Pig Iron	3885	IE,NA	IE	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	8469	IE,NA	IE		Sinter	5524	IE,NA	IE	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			9782		Other	-	-	6420		
	Use of limestone and dolomite	1380	0	602		Use of limestone and dolomite	2577	2.35	371	CS	PS
	Metallurgical coke	7125	1	9180		Metallurgical coke	2577	2.35	371	T2	CS,D

Member State	1990				Member State	2021				Method	Emission factor information
	category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		
Denmark	**Iron and steel production**			30	Denmark	**Iron and steel production**	-	-	NO		
	Steel	614	0.05	30		Steel	NO	NO	NO	NA	NA
	Pig Iron	NO	NO	NO		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Estonia	**Iron and steel production**			NO	Estonia	**Iron and steel production**	-	-	NO		
	Steel	NO	NO	NO		Steel	NO	NO	NO	NA	NA
	Pig Iron	NO	NO	NO		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Finland	**Iron and steel production**			1967	Finland	**Iron and steel production**	-	-	2075		
	Steel	2861	0.69	1967		Steel	4279	0.49	2075	CS,T3	CS
	Pig Iron	NO	NO,IE	IE		Pig Iron	NO	NO,IE	IE	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NA	IE,NO	IE		Sinter	NA	NO,IE	IE	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
	Other Iron and Steel Production.Other non-specified	487	NO	NO		Other Iron and Steel Production.Other non-specified	835	NO	NO	NA	NA

Member State	1990				Member State	2021				Method	Emission factor information
	category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		
France	**Iron and steel production**			15788	France	**Iron and steel production**	-	-	11172		
	Steel	19073	0.83	15788		Steel	13542	0.82	11137	T2	CS
	Pig Iron	IE	IE	IE		Pig Iron	IE	IE	IE	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	IE	IE	IE		Sinter	IE	IE	IE	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	35		
Germany	**Iron and steel production**			22810	Germany	**Iron and steel production**	-	-	16419		
	Steel	43939	0.52	22810		Steel	40241	0.41	16419	T2	CS
	Pig Iron	32263	IE	IE		Pig Iron	26187	IE	IE	NA	NA
	Direct reduced iron	IE	IE	IE		Direct reduced iron	IE	IE	IE	NA	NA
	Sinter	IE	IE	IE		Sinter	IE	IE	IE	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Greece	**Iron and steel production**			105	Greece	**Iron and steel production**	-	-	84		
	Steel	999	0.10	105		Steel	1606	0.05	84	CS	PS
	Pig Iron	NO	NO	NO		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		

Member State	1990 category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)	Member State	2021 category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)	Method	Emission factor information
Hungary	**Iron and steel production**			3155	Hungary	**Iron and steel production**	-	-	838		
	Steel	2963	0.12	348		Steel	1110	0.09	96	T3	PS
	Pig Iron	1697	1.65	2427		Pig Iron	621	1.90	553	T3	PS
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	72	5.28	380		Sinter	35	5.38	190	T3	PS
	Pellet	IE	IE	IE		Pellet	IE	IE	IE	NA	NA
	Other			NO		Other	-	-	NO		
Ireland	**Iron and steel production**			26	Ireland	**Iron and steel production**	-	-	NO		
	Steel	326	0.08	26		Steel	NO	NO	NO	NA	NA
	Pig Iron	NO	NO	NO		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Italy	**Iron and steel production**			3124	Italy	**Iron and steel production**	-	-	1423		
	Steel	25467	0.05	1346		Steel	24412	0.04	1077	T2	CR,CS,PS
	Pig Iron	11852	0.15	1778		Pig Iron	4111	0.08	346	T2	CR,CS,PS
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	13577	NO,NA	NA		Sinter	4589	NO,NA	NA	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		

Member State	1990				Member State	2021				Method	Emission factor information
	category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		
Latvia	**Iron and steel production**			70	**Latvia**	**Iron and steel production**	-	-	NO		
	Steel	550	0.13	70		Steel	NO	NO	NO	NA	NA
	Pig Iron	NO	NO	NO		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Lithuania	**Iron and steel production**			17	**Lithuania**	**Iron and steel production**	-	-	0		
	Steel	NO	NO	NO		Steel	NO	NO	NO	NA	NA
	Pig Iron	NO	NO	NO		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			17		Other	-	-	0		
	Cast Iron	106	0	17		Cast Iron	2	0.02	0	T2	D
Luxem-bourg	**Iron and steel production**			985	**Luxem-bourg**	**Iron and steel production**	-	-	90		
	Steel	3506	0.12	404		Steel	2078	0.04	90	CS,T2	CS
	Pig Iron	2645	0.08	200		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	4804	0.08	380		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		

Member State	1990				Member State	2021				Method	Emission factor information
	category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		
Malta	**Iron and steel production**			NO	Malta	**Iron and steel production**	-	-	NO		
	Steel	NO	NO	NO		Steel	NO	NO	NO	NA	NA
	Pig Iron	NO	NO	NO		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			-		Other	-	-	-		
Nether-lands	**Iron and steel production**			44	Nether-lands	**Iron and steel production**	-	-	83		
	Steel	5162	0.01	43		Steel	6821	0.01	83	T2	PS
	Pig Iron	NA	NO,IE	IE		Pig Iron	NA	NO,IE	IE	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NA	NO,IE	IE		Sinter	NA	NO,IE	IE	NA	NA
	Pellet	NA	NO,IE	IE		Pellet	NA	NO,IE	IE	NA	NA
	Other			1		Other	-	-	NO		
	Other Iron and Steel Production.Other non-specified	NA	NA	1		Other Iron and Steel Production.Other non-specified	NA	NO	NO	NA	NA

Member State	1990				Member State	2021				Method	Emission factor information
	category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		
Poland	**Iron and steel production**			4959	**Poland**	**Iron and steel production**	-	-	1566		
	Steel	IE	IE	IE		Steel	IE	IE	IE	NA	NA
	Pig Iron	8657	0.12	1043		Pig Iron	3587	0.14	505	T2	CS
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	11779	0.07	841		Sinter	5021	0.06	280	T2	CS
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			3075		Other	-	-	781		
	Basic Oxygen Furnace Steel	7207	0	929		Basic Oxygen Furnace Steel	4469	NO,NA	NO	T2	CS
	Electric Furnace Steel	2309	0	85		Electric Furnace Steel	4469	NO,NA	NO	T2	CS
	Open-hearth Steel	3945	1	2060		Open-hearth Steel	4469	NO,NA	NO	NA	NA
Portugal	**Iron and steel production**			440	**Portugal**	**Iron and steel production**	-	-	65		
	Steel	746	0.10	73		Steel	1953	0.03	65	T1,T3	D,PS
	Pig Iron	339	0.88	298		Pig Iron	NO	NO	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	344	0.20	69		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Romania	**Iron and steel production**			12621	**Romania**	**Iron and steel production**	-	-	4014		
	Steel	9769	1.29	12621		Steel	3468	1.16	4014	T3	CS
	Pig Iron	5916	NO,IE	IE		Pig Iron	C	IE,NO	IE	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	11357	NO,IE	IE		Sinter	2466	NO,IE	IE	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		

Member State	1990				Member State	2021				Method	Emission factor information
	category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		
Slovakia	**Iron and steel production**			4168	**Slovakia**	**Iron and steel production**	-	-	4275		
	Steel	3562	1.17	4150		Steel	4560	0.94	4264	T2	PS
	Pig Iron	17	NO,IE	IE		Pig Iron	32	NO,IE	IE	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	5352	NO,IE	IE		Sinter	7206	NO,IE	IE	NA	NA
	Pellet	IE	NO,IE	IE		Pellet	IE	NO,IE	IE	NA	NA
	Other			18		Other	-	-	10		
	EAF production of steel	311	0	18		EAF production of steel	370	0.03	10	T2	PS
Slovenia	**Iron and steel production**			44	**Slovenia**	**Iron and steel production**	-	-	58		
	Steel	632	0.07	44		Steel	683	0.08	58	T3	PS
	Pig Iron	NO	NO,NA	NO		Pig Iron	NO	NO,NA	NO	NA	NA
	Direct reduced iron	NO	NO	NO		Direct reduced iron	NO	NO	NO	NA	NA
	Sinter	NO	NO	NO		Sinter	NO	NO	NO	NA	NA
	Pellet	NO	NO	NO		Pellet	NO	NO	NO	NA	NA
	Other			NO		Other	-	-	NO		
Spain	**Iron and steel production**			2501	**Spain**	**Iron and steel production**	-	-	1865		
	Steel	13163	0.08	1045		Steel	14151	0.05	654	T2	CS,PS
	Pig Iron	C	C	246		Pig Iron	C	C	620	T2	CS
	Direct reduced iron	IE	IE,NA	IE		Direct reduced iron	IE	IE,NA	IE	NA	NA
	Sinter	C	C	538		Sinter	C	C	194	T2	CS
	Pellet	IE	IE,NA	IE		Pellet	IE	IE,NA	IE	NA	NA
	Other			672		Other	-	-	396		
	Flaring in iron and steel production	C	C	672		Flaring in iron and steel production	C	C	396	T2	PS

Member State	1990				Member State	2021				Method	Emission factor information
	category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		category	Activity data (kt)	Implied Emission Factor (t/t)	CO_2 Emissions (kt)		
Sweden	**Iron and steel production**			2626	Sweden	**Iron and steel production**	-	-	2337		
	Steel	1755	0.09	158		Steel	1855	0.09	164	T3	PS
	Pig Iron	2736	0.77	2094		Pig Iron	2992	0.64	1911	T3	PS
	Direct reduced iron	109	1.19	129		Direct reduced iron	111	1.37	153	T3	PS
	Sinter	1058	0.20	212		Sinter	NO	NO	NO	NA	NA
	Pellet	13079	0.00	33		Pellet	23700	0.00	109	T3	PS
	Other			NA		Other	-	-	NA		

Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

As shown in the table, several countries use the notation IE for some categories. This can be explained by the fact that they make use of carbon balances and several processes occur within the same industrial plant, which makes differentiation into the various sub-categories difficult. For example, several countries include emissions from the production of pig iron (which occurs at integrated iron and steel production plants) under “steel production”.

According to the 2006 IPCC guidelines, all emissions from iron and steel production should be reported under category 2.C.1, irrespective of their role as reducing agent or fuel for energy use.

However, some countries report emissions from blast furnace gas and from basic oxygen furnace gas under 1A2a instead of 2C1 because this can be interpreted as emissions from energy supply.

Thus, for an overview of total emissions it seems to be more convenient to take into account all emissions covered by the combined category 1A2a + 2C1. Resulting emissions for this combined category are given in Table 4.32.

Table 4.32 CO_2 Emissions (2021) from iron and steel production: 1A2a, 2C1 and combined (sum of both categories). The column “Share 2C1” denotes the ratio of emissions under 2C1 and combined emissions.

Member State	CO_2 emissions in kt			Share in EU-27 emissions in 2021	Share 2C1
	1A2a	2C1	Combined		
Austria	1 774	11 002	12 776	9%	86%
Belgium	1 251	3 474	4 725	3%	74%
Bulgaria	123	11	134	0%	8%
Croatia	56	14	71	0%	20%
Cyprus	NO	NO	-	-	-
Czech Republic	2 111	6 420	8 531	6%	75%
Denmark	95	NO	95	0%	-
Estonia	1	NO	1	0%	-
Finland	890	2 075	2 965	2%	70%
France	4 223	11 172	15 396	11%	73%
Germany	37 835	16 419	54 254	37%	30%
Greece	116	84	200	0%	42%
Hungary	146	838	985	1%	85%
Ireland	2	NO	2	0%	-
Italy	9 590	1 423	11 013	8%	13%
Latvia	0	NO	0	0%	-
Lithuania	NO	0	0	0%	100%
Luxembourg	308	90	398	0%	23%
Malta	NO	NO	-	-	-
Netherlands	4 400	83	4 484	3%	2%
Poland	4 103	1 566	5 669	4%	28%
Portugal	85	65	150	0%	43%
Romania	870	4 014	4 884	3%	82%
Slovakia	3 164	4 275	7 439	5%	57%
Slovenia	212	58	270	0%	21%
Spain	6 548	1 865	8 413	6%	22%
Sweden	1 341	2 337	3 678	3%	64%
EU-27	**79248**	**67285**	**146533**	**100%**	**46%**

Abbreviations explained in the Chapter ‘Units and abbreviations’.

It can be seen that the ratio of emissions under 2C1 and combined emissions (see column "Share 2C1" in Table **4.32**) varies across countries. This indicates that the boundary between 1A2a and 2C1 is not uniformly interpreted by countries. The nine countries with largest CO_2 emissions from iron and steel production allocate their emissions in the following ways in 2021:

- Germany: Approximately 30% of emissions are reported under 2C1. This category comprises process-related CO_2 emissions (including emissions from carbonate use). However, emissions from energy-related use of top gas and converter gas are reported under the respective sub-categories of sector 1.
- France: From the 2019 inventory onwards, France changes its methodology of estimating and allocating CO_2 emissions in the iron and steel sector sub-categories (process and combustion), to be more compliant with the 2006 IPCC Guideines. While major share of emissions (84%) was reported under 1A2a in the 2018 inventory, 73% are allocated in 2C1 in the 2021 inventory. Emissions from sinter production are reported under 1A2a.
- Austria: 86% of emissions are reported under 2C1. Generally, all emissions from iron and steel production are reported under this category, irrespective of their role as reducing agent or fuel, but emissions related to the coke oven and to on-site power plants are reported under category 1A2a.
- Italy: Major share of emissions (87%) is reported under 1A2a. CO_2 emissions due to the consumption of coke, coal and other reducing agents used in the iron and steel industry have been accounted for as fuel consumption and reported in the energy sector. In sector 2C1, emissions are reported from carbonates used in sinter plants and in basic oxygen furnaces, emissions related to steel and pig iron scraps and emissions from graphite electrodes consumed in electric arc furnaces.
- Czech Republic: 75% of emissions are reported under category 2C1. It also includes emissions from limestone and dolomite use.
- Spain: Major share of emissions (78%) is reported under 1A2a, including emissions from coke production.
- Slovakia: 57% of emissions are reported in 2C1. Category iron and steel production includes following processes: steel production, pig iron production, sinter production and steel production in electric arc furnaces. Due to the difficult disaggregation between emissions originated from pig iron and from steel production, total CO_2 emissions from total production processes were allocated directly in steel production category.
- Poland: 28% of CO_2 emissions are reported in 2C1, including steel production (basic oxygen furnaces and electric arc furnaces), pig iron production, sinter production.

4.2.3.2 2C3 Aluminium production

This category includes PFC emissions from aluminium production. Two PFCs, tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6), are known to be emitted from the process of primary aluminium smelting. These PFCs are formed during the phenomenon known as the anode effect, when the aluminium oxide concentration in the reduction cell electrolyte is low.

Information on CO_2 emissions from Aluminium production can be found at the end of this section.

Table 4.33 summarises information by countries on emission trends for the key source PFCs from 2C3 Aluminium Production. PFC emissions from 2C3 Aluminium production account for 0.009 % of total EU GHG emissions (including indirect CO_2, with LULUCF and with international aviation) in 2021. Between 1990 and 2021, PFC emissions from this source decreased by 98 %. In 2021, Germany contributed the highest share among the EU, amounting to 23.5 % of overall GHG emissions, followed by France (22.6 %), Greece (12 %), Spain (11.3 %) and Romania (11.3%). Of the nine countries reporting PFC emissions under this category in 2021, seven use plant or country-specifc emission factors.

Table 4.33 2C3 Aluminium Production: Countries' contributions to PFC emissions and information on method applied and emission factor

Member State	PFCs Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	1 032	NO	NO	-	-1 032	-100%	-	-	NA	NA
Belgium	-	-	-	-	-	-	-	-	NA	NA
Bulgaria	-	-	-	-	-	-	-	-	NA	NA
Croatia	1 117	NO	NO	-	-1 117	-100%	-	-	NA	NA
Cyprus	-	-	-	-	-	-	-	-	NA	NA
Czechia	-	-	-	-	-	-	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	-	-	-	-	-	-	-	NA	NA
Finland	NO	-	-	-	-	-	-	-	NA	NA
France	3 211	55	38	13.5%	-3 173	-99%	-17	-30%	T2,T3	CS,PS
Germany	2 597	69	59	20.8%	-2 538	-98%	-10	-14%	T3	CS
Greece	171	107	86	30.3%	-85	-50%	-21	-20%	T3	PS
Hungary	338	NO	NO	-	-338	-100%	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	1 778	NO	NO	-	-1 778	-100%	-	-	NA	NA
Latvia	-	-	-	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	-	-	-	-	-	-	-	-	NA	NA
Malta	-	-	-	-	-	-	-	-	-	-
Netherlands	2 374	24	15	5.1%	-2 359	-99%	-9	-39%	T2	CS
Poland	127	NO	NO	-	-127	-100%	-	-	NA	NA
Portugal	NO,NA	NO	NO	-	-	-	-	-	NA	NA
Romania	2 530	3	3	1.2%	-2 527	-100%	0	7%	T2	D,PS
Slovakia	283	5	5	1.9%	-278	-98%	0	6%	T2	PS
Slovenia	187	9	7	2.5%	-180	-96%	-2	-19%	T3	D,PS
Spain	1 046	22	28	10.0%	-1 018	-97%	6	28%	T2	D
Sweden	511	59	42	14.7%	-469	-92%	-17	-29%	NA,T3	D,NA
EU-27	**17 303**	**352**	**283**	**100%**	**-17 019**	**-98%**	**-68**	**-19.5%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

All countries reduced their PFC emissions from this source between 1990 and 2021. France, Germany, Romania, and the Netherlands, had the largest decreases in absolute terms. The decreasing trend of PFC emissions from this key source between 1990 and 2021 is due to production stop or decline and due to process improvements. The emission peak in 2002 (see Figure 4.14) can be explained by technological changes and sub-optimal conditions of operation (in France and in the Netherlands).

In the review of the 2014 inventory submission of the European Union, the ERT recommended that the European Union provide in the NIR adequate methodology overviews to enable the ERT to make a thorough review of the AD and EF used in the aluminium production emission estimations provided by Greece, the Netherlands and Sweden. This information is provided below. Additional information can be found in the individual NIRs (Greece: section 4.13, Netherlands: section 4.4, Sweden: section 4.4.3). An overview of methods can also be found in Annex III to this year's inventory submission.

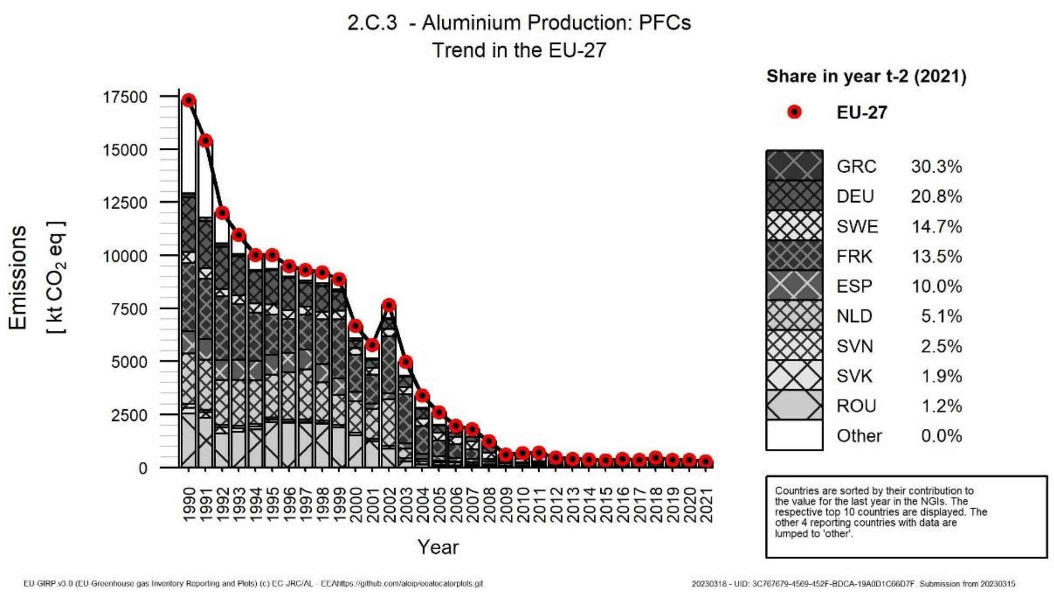
Greece: The estimation of emissions from aluminium production is performed in close collaboration with the sole plant operating in Greece and since 2013 ETS verified reports are also provided to the inventory team. Carbon dioxide emissions from primary aluminium production are calculated using a highly detailed methodology, tracking the carbon content throughout the process. The methodology is based on the 2006 IPCC Tier 3 method, with small interventions that increase the certainty of the estimations. The equations are described in Greece's NIR. Data are provided by the plant for years

2005-2012. Since detailed data for the previous years are not available, emissions of years 1990-2004 have been recalculated using the Overlap method in line with the IPCC GPG. It should be noted that the production methodology applied is Centre Worked Prebake with Feed Point System (PFPB methodology). Data since 2013 are provided by the verified ETS reports. Aluminium production data are directly provided by the plant and are considered confidential. However, publicly available data from the US Geological Survey, the UN Commodity Statistics Database and the Greek Mining Enterprises Association are also used for QA/QC reasons. According to the recommendation made by the previous ERTs, Greece is reporting aluminium production based on these data, although the estimations are based on the more detailed and accurate production quantities provided directly by the plant. It should be mentioned that the reported values are the ones provided by the US Geological Survey, since they cover the whole of the time-series. PFC emissions estimates are based on anode effect performance by calculating the anode effect overvoltage statistic (Overvoltage method) and are provided directly to the inventory team by the sole plant operating in Greece. This methodology concerns measurements and recordings that are being performed concerning the parameters of the equation used for the CF4 emission’s calculation, namely the overvoltage and the aluminium production process current efficiency. The EF is estimated based on EF=Over-Voltage Coefficient*AEO/CE. The Over-Voltage Coefficient value used by the plant is 1.16 (the updated default one of 2006 IPCC Guidelines), while the Anode Effect Overvoltage (AEO) and Current Efficiency (CE) are measured for each series of electrolytic cells (there are three series).

The Netherlands: Estimations of the PFC emissions from primary aluminium production reported by these two facilities are based on the IPCC Tier 2 method for the complete period 1990‐2017. Emission factors are plant-specific and confidential and are based on measured data. Since emission year 2018 the emission data is taken from the ETS reports.

Sweden: The two different processes for aluminium production, prebaked (CWPB) and Söderberg (VSS), have substantially different emission factors for PFCs. Estimates of emissions are based on the number of ovens and the number and duration of anode effects. This activity data is considered to be of good quality. Activity data used for the PFC emission calculations, anode effects in min/oven day and production statistics, were provided by the company, and specified for the prebaked and Söderberg processes. The activity data and emissions can be found in Sweden’s NIR 2022.

Figure 4.14 2C3 Aluminium Production: PFC emissions



Besides PFC emissions, aluminium production is a source of CO_2 emissions. Of the ten countries which reported CO_2 emissions from aluminium production for 2021, one uses a Tier 1 method, two use a Tier 2 method, six use a Tier 3 method and one uses a country-specific method. One country uses the default emission factor, two use country-specific emission factors and seven use plant-specifc emission factors (Table **4.34**). Information on the reported CO_2 emissions can be found in the overview table in chapter 4.2.3. Information on activity data can be found in the CRF tables. Further details, e.g. on assumptions made by the various countries, can be found in the countries' NIRs.

Table 4.34 2C3 Aluminium Production: Countries' contributions to CO_2 emissions and information on method applied and emission factor

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	150	5	6	0.2%	-144	-96%	1	28%	T3	PS
Belgium	NO	NO	NO	-	-	-	-	-	NA	NA
Bulgaria	NO	NO	NO	-	-	-	-	-	NA	NA
Croatia	119	NO	NO	-	-119	-100%	-	-	NA	NA
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	NO	NO	NO	-	-	-	-	-	NA	NA
France	534	670	690	23.5%	156	29%	20	3%	T3	PS
Germany	1 012	723	696	23.7%	-316	-31%	-27	-4%	T3	CS
Greece	225	294	299	10.2%	73	32%	4	2%	CS	CS
Hungary	128	NO	NO	-	-128	-100%	-	-	NA	NA
Ireland	NO	NO	NO	-	-	-	-	-	NA	NA
Italy	359	NO	NO	-	-359	-100%	-	-	NA	NA
Latvia	NO	NO	NO	-	-	-	-	-	NA	NA
Lithuania	NO	NO	NO	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	408	115	82	2.8%	-326	-80%	-32	-28%	T1a	D
Poland	78	NO	NO	-	-78	-100%	-	-	NA	NA
Portugal	NO	NO	NO	-	-	-	-	-	NA	NA
Romania	268	315	337	11.5%	69	26%	22	7%	T3	PS
Slovakia	121	239	259	8.8%	137	113%	20	8%	T3	PS
Slovenia	170	73	56	1.9%	-114	-67%	-17	-23%	T2	D,PS
Spain	610	354	334	11.4%	-276	-45%	-20	-6%	T2,T3	D,PS
Sweden	133	172	174	5.9%	41	31%	1	1%	T3	PS
EU-27	**4 317**	**2 960**	**2 932**	**100%**	**-1 384**	**-32%**	**-28**	**-0.9%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'

4.2.3.3 2C7 Other

Under this category, various emissions are reported which cannot be attributed to another category under 2C. Specifically, this includes the process emissions from the non-ferro sector (including lead and zinc) in Belgium, Silicium production in Spain, Copper and nickel smelting in Finland, emissions of CO_2 from one plant producing copper, lead and zinc, and one metal recycling plant mainly producing lead by melting used batteries and recovering the lead in Sweden and CO_2 emissions from anode burn-off during the baking process of anodes (used for aluminium production) in Slovenia.

Information on the emissions from this category is given in the overview table in chapter 4.2.3

4.2.4 Non-energy products from fuels and solvent use (CRF Source Category 2D)

This source category includes greenhouse gas emissions from non-energy products from fuel and solvent use. In 2021, this source category is not a key-category. However, this sector used to be a key category therefore this section is kept in the EU NIR. Table 4.30 **2C Metal Industry: Countries' contributions to** total GHG, CO2, HFC, PFC and SF6 emissions

summarises information by countries on total GHG emissions. Between 1990 and 2021, GHG emissions from 2D non-energy products from fuels and solvent use decreased by 18.7 %. The absolute decrease of GHG emissions was largest in Germany and Italy.

Table 4.35: 2D Non-energy products from fuels and solvent use: countries' contributions to total GHG, CO_2, N_2O- and CH_4 emissions

Member State	GHG emissions in kt CO2 equivalents		CO2 emissions in kt		N2O emissions in kt CO2 equivalents		CH4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021	1990	2021
Austria	349	165	349	165	NA	NA	NA	NA
Belgium	202	118	202	118	NO,NA	NO,NA	NO,NA	NO,NA
Bulgaria	82	16	82	16	NO,NA	NO,NA	NO,NA	NO,NA
Croatia	176	82	176	82	NA	NA	NA	NA
Cyprus	4	5	4	5	NE,NA	NE,NA	NE,NA	NE,NA
Czechia	126	139	126	139	NA,NO	NO,NA	NA,NO	NO,NA
Denmark	166	179	166	178	0	0	0	1
Estonia	36	38	36	38	NO	NO	NO	NO
Finland	220	154	218	153	1	1	0	0
France	1 054	1 007	1 051	1 005	1	2	2	0
Germany	2 983	2 031	2 982	2 029	1	1	NA	NA
Greece	130	59	130	59	NA,NO	NO,NA	NA,NO	NO,NA
Hungary	202	103	202	103	NA,NO	NO,NA	NA,NO	NO,NA
Ireland	95	114	95	114	NO	NO	NO	NO
Italy	1 681	1 004	1 681	1 004	NA,NO	NO,NA	NA,NO	NO,NA
Latvia	45	55	45	55	NO,NA	NO,NA	NO,NA	NO,NA
Lithuania	7	20	7	20	NO	NO	NO	NO
Luxembourg	21	34	21	34	NO	NO	NO	NO
Malta	4	5	4	5	NA	NA	NA	NA
Netherlands	187	340	187	340	NO,NA	NO,NA	0	0
Poland	213	341	213	341	NA,NO	NO,NA	NA,NO	NO,NA
Portugal	242	205	242	205	NO,NA	NO,NA	NO,NE,NA	NO,NE,NA
Romania	632	707	632	707	NO,NA	NO,NA	NO,NE,NA	NO,NE,NA
Slovakia	50	34	50	34	NO,NA,NE	NO,NE,NA	NO,NA,NE	NO,NE,NA
Slovenia	8	35	8	35	NA	NA	NA	NA
Spain	193	396	193	396	NO,NA	NA	NO,NA	NA
Sweden	393	337	393	337	NA	NA	NA	NA
EU-27	**9 501**	**7 723**	**9 495**	**7 718**	**3**	**4**	**2**	**1**

Abbreviations explained in the Chapter 'Units and abbreviations'.

4.2.4.1 2D1 Lubricant Use

CO_2 emissions from this sector amounted to approximately 0.06% of total GHG emissions in 2021. CO_2 emissions from this sector decreased by 35.4% since 1990.

4.2.4.2 2D3 Other non-energy products from fuels and solvent use

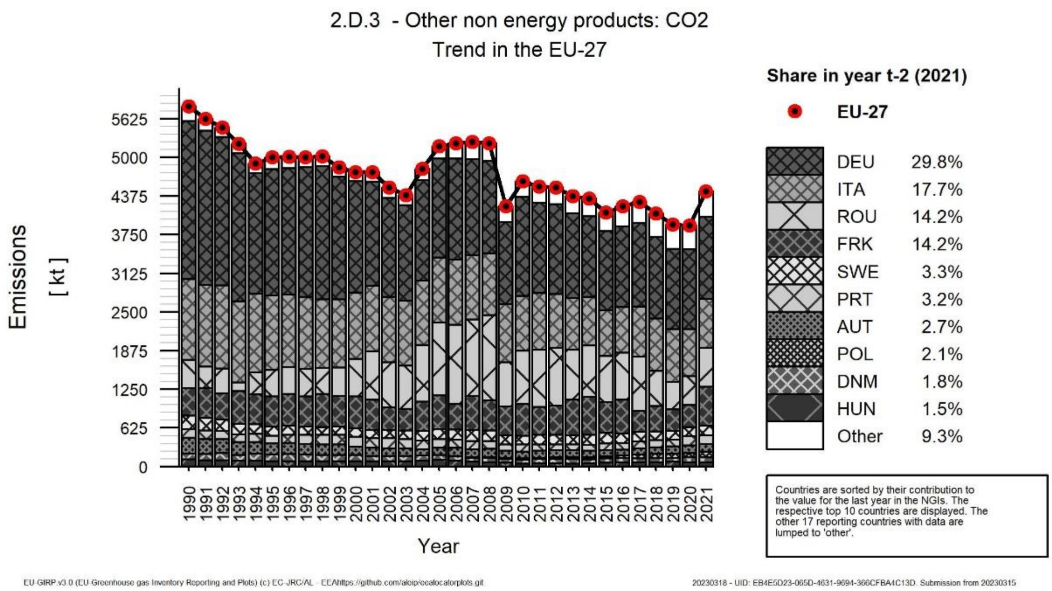
CO_2 emissions from this sector amounted to approximately 0.14% of total GHG emissions in 2021. France, Germany, Italy and Romania together account for 76% of all emissions in the EU. CO_2 emissions from this sector decreased by 20.3% since 1990, the biggest reductions in absolute terms occurred in Germany and Italy (respectively -1222 and -522 kt). CO_2 emissions decreased in eight countries between 1990 and 2021. Some countries do not report emissions in this category for 1990, but report emissions, mainly from urea use in the transport sector, for more recent years.

Table 4.36 2D3 Other non-energy products from fuels and solvent use: countries' contributions to CO_2 emissions

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2	%	kt CO2	%		
Austria	252	121	121	2.7%	-130	-1	1	1%	T1	D
Belgium	NO,NA	32	34	0.8%	34	∞	2	5%	M,T3	CS,OTH
Bulgaria	NO,NA	4	4	0.1%	4	∞	0	0%	T2	NA
Croatia	135	67	62	1.4%	-73	-1	-5	-8%	OTH	D
Cyprus	NO,NE,IE	1	1	0.0%	1	∞	0	-3%	D	D
Czechia	NO,NA	25	27	0.6%	27	∞	2	8%	NA	D
Denmark	94	79	81	1.8%	-14	0	2	2%	CS,T2,T3	OTH
Estonia	18	25	32	0.7%	14	1	7	29%	D,T2	D
Finland	NO	16	19	0.4%	19	∞	3	18%	T1,T2	NA
France	438	359	631	14.2%	193	0	272	76%	NA	NA
Germany	2 551	1 292	1 329	29.8%	-1 222	0	37	3%	CS,D,M	D
Greece	NO,NA	7	9	0.2%	9	∞	2	27%	NA	NA
Hungary	116	71	69	1.5%	-47	0	-2	-3%	T1,T2	D
Ireland	52	52	54	1.2%	2	0	2	4%	T1,T2	D
Italy	1 311	761	789	17.7%	-522	0	28	4%	NA	M,PS
Latvia	22	31	33	0.7%	11	1	2	7%	CS,D,T1,T3	D,PS
Lithuania	NO	1	2	0.0%	2	∞	1	57%	T3	NA
Luxembourg	14	24	26	0.6%	12	1	2	10%	M	CS,D
Malta	0	1	1	0.0%	1	31	0	8%	-	-
Netherlands	NO	32	34	0.8%	34	∞	2	6%	T3	CS
Poland	NO,IE	71	94	2.1%	94	∞	23	32%	NA	NA
Portugal	146	147	142	3.2%	-4	0	-4	-3%	CR,NO,T2	CS,NO,OTH
Romania	457	466	634	14.2%	177	0	168	36%	CR,D,OTH	CS,OTH
Slovakia	NO	8	10	0.2%	10	∞	1	17%	CS	CS
Slovenia	NO,NA	6	6	0.1%	6	∞	0	9%	M	M
Spain	NA	56	60	1.3%	60	∞	4	7%	NA	NA
Sweden	217	147	149	3.3%	-69	0	1	1%	NA	NA
EU-27	**5 824**	**3 901**	**4 452**	**100%**	**-1 372**	**0**	**551**	**14%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 4.15 2D3 Other non-energy products from fuels and solvent use: CO_2 emissions



For this category, it is not useful to give an average EF across the countries because of the different methods used, and because of the fact that this category is split into many subcategories with varying EFs. Table **4.36** provides an overview of countries' reporting of CO_2 emissions from 2D3 in 2021.

Table 4.37 2D3 Other non-energy products from fuels and solvent use: Reporting of CO_2 emissions by countries

MS	Category	kt
AUT	3. Other (please specify)	121.45
	Solvent use	75.65
	Road paving with asphalt	NA
	Asphalt roofing	NA
	Urea used as a catalyst	45.79
BEL	3. Other (please specify)	33.53
	Solvent use	NA
	Road paving with asphalt	NA
	Asphalt roofing	NA
	Urea used as a catalyst	33.53
	Unspecified	NO
BGR	3. Other (please specify)	3.91
	Solvent use	NO
	Road paving with asphalt	NA
	Asphalt roofing	NA
	Other chemical products	3.91
CYP	Other (please specify)	0.51
	Dry cleaning	IE
	Coating applications	IE
	Chemical products	IE
	Asphalt roofing	IE
	Domestic solvent use including fungicides	IE
	Road paving with asphalt	IE
	Printing	IE
	Urea-based catalysts	0.51
	Other	IE

MS	Category	kt
EST	3. Other (please specify)	31.97
	Solvent use	30.55
	Road paving with asphalt	0.04
	Urea based catalysts for motor vehicles	1.38
FIN	3. Other (please specify)	18.52
	Solvent use	NO
	Road paving with asphalt	NO
	Asphalt roofing	NO
	Use of urea-based catalysts	16.84
	Use of urea in NO_X control in the energy industry	1.68
FRK	3. Other (please specify)	631.36
	Solvent use	NO
	Road paving with asphalt	NA
	Asphalt roofing	NE
	Other incl. urea use in SCR	631.36
GRC	3. Other (please specify)	9.39
	Solvent use	NA
	Road paving with asphalt	NO
	Asphalt roofing	NO
	Urea used as a catalyst	9.39
HRV	3. Other (please specify)	61.94
	Solvent use	55.16
	Road paving with asphalt	0.07
	Asphalt roofing	0.01
	Urea based CC	6.71
HUN	3. Other (please specify)	69.01

MS	Category	kt
LVA	3. Other (please specify)	33.31
	Urea use	1.40
	Solvent Use	31.75
	Asphalt roofing	0.07
	Road paving with asphalt	0.08
MLT	3. Other (please specify)	0.75
	Solvent use	NA
	Road paving with asphalt	0.01
	Urea for deNO_Xification	0.74
NLD	3. Other *(please specify)*	34.25
	Ureum use in SCR	34.25
POL	3. Other (please specify)	93.63
	Solvent use	IE
	Urea used as catalyst	93.63
PRT	3. Other (please specify)	142.45
	Solvent use	132.15
	Road paving with asphalt	0.01
	Urea-based catalysts	10.30
ROU	3. Other (please specify)	634.16
	Solvent use	80.23
	Road paving with asphalt	NE
	Asphalt roofing	NE
	Petroleum coke use	552.80
	Urea use	1.13
SVK	3. Other (please specify)	9.70
	Solvent use	NO

MS	Category	kt
CZE	3. Other (please specify)	26.85
	Solvent use	NO
	Road paving with asphalt	NA
	Urea used as catalyst	26.85
DEU	3. Other (please specify)	1328.78
	Solvent use	1038.69
	Road paving with asphalt	NE
	Asphalt roofing	NE
	AdBlue	290.09
DNM	3. Other (please specify)	80.82
	Solvent use	70.42
	Road paving with asphalt	0.83
	Asphalt roofing	0.03
	Urea used in catalysts	9.54
ESP	3. Other (please specify)	59.82
	Solvent use	NA
	Road paving with asphalt	NA
	Asphalt roofing	NA
	Urea-based catalytic converter	59.82

MS	Category	kt
	Indirect CO_2 from solvents	59.33
	Urea based catalysts	9.67
IRL	3. Other (please specify)	54.17
	Solvent use	40.39
	Urea used as a catalyst	13.78
ITA	3. Other (please specify)	789.45
	Solvent use	702.80
	Road paving with asphalt	NA
	Asphalt roofing	NA
	Urea used in power plants	8.32
	Urea used in engines	78.33
LTU	3. Other (please specify)	1.66
	Solvent use	NO
	Road paving with asphalt	NO
	Asphalt roofing	NO
	Urea-based catalyst	1.66
LUX	3. Other (please specify)	25.94
	Solvent use	12.89
	Urea-based catalysts	13.05

MS	Category	kt
	Road paving with asphalt	NO
	Asphalt roofing	NO
	Urea catalytic converters	9.70
SVN	3. Other (please specify)	6.18
	Asphalt roofing	NA
	Road paving	NA
	Solvent use	NA
	Urea based catalyst	6.18
SWE	3. Other (please specify)	148.55
	Road paving with asphalt	NA
	Asphalt roofing	NA
	Solvent use - dry cleaning	0.10
	Urea used as catalyst	36.72
	Solvent use - printing	1.30
	Solvent use - other solvent use	60.27
	Solvent use - degreasing	0.02
	Solvent use - coating applications	22.48
	Solvent use - chemical products manufacture and processing	2.13
	Solvent use - domestic use	25.54

4.2.5 Electronics Industry (CRF Source Category 2.E)

2.E Electronics Industry includes the following subcategories: 2.E.1 Integrated Circuit or Semiconductor, 2.E.2 TFT Flat Panel Display, 2.E.3 Photovoltaics, 2.E.4 Heat Transfer Fluid and 2.E.5 Other. Out of these, the most important emission source in Europe is the production of integrated circuits and semiconductors (2.E.1), which relates to highly specialized industrial processes. F-gases are used for plasma etching and wafer cleaning as well as cleaning of the chamber walls of thin-film deposition (TFD) and diffusion tools after processing substrates.

Emissions from photovoltaics industry and heat transfer fluids (HTFs) are reported by very few Member States only. Manufacture of TFT (thin-film transistors) Flat Panel Displays does currently not take place in the EU.

The gases emitted include in particular PFCs, SF_6 and NF_3 while HFC emissions occur to relatively small extent only. Attempts have been made in recent years to reduce emissions through process optimization and replacement of certain high-GWP gases, when feasible. However, recent supply chain considerations might result in strengthening of the EU electronics industry and related increase of emissions in the near future.

4.2.6 Product uses as substitutes for ODS (CRF Source Category 2.F)

This emission source category relates to the consumption of halocarbons (HFCs and PFCs) in different applications.

HFCs are predominantly serving as alternatives to ozone depleting substances (ODS) that are being phased out under the Montreal Protocol. They were first introduced to the EU market at the end of 1990. Due to their high global warming potentials, HFCs are addressed by the so-called MAC Directive, which bans the use of HFCs with a GWP >150 in new passenger cars since 2017, and the EU F-gas Regulation No. 517/2014, which establishes a phase down scheme for HFCs and other measures to limit use and emissions of F-gases. The EU F-gas Regulation is currently subject to review again and new measures are expected from ca. 2024 onwards.

The main applications of halocarbons include refrigeration and air conditioning, foam blowing, fire protection, aerosols, solvents as well as some other applications. PFCs are used to minor extent in this subcategory nowadays but mainly in semiconductor manufacture (2.E.1).

The source category 2.F Product uses as substitutes for ODS includes two key categories which occur in all countries: Refrigeration and air conditioning (2.F.1) and aerosols (2.F.4, KC only with LULUCF), especially MDIs. The use of HFCs as fire extinguishing agents (2.F.3) was common but decreased widely in recent years due to restrictions at EU level through the F-gas Regulation and national rules.

Table 4.38: Key categories for sector 2F (Table excerpt)

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
2.F.1 Refrigeration and Air conditioning: no classification (HFCs)	5	63612	T	0	L	100%

For 2.F Product uses as substitutes for ODS, table 1 summarizes information by Member States on emission trends of total GHG emissions, HFCs and PFCs. SF_6 and NF_3 are not used in this subcategory. It should be noted that the amounts reported as “unspecified mix of HFCs and PFCs” are not shown in the table but also need to be taken into account in the total greenhouse gas emission estimates.

Table.4.39 2F Product uses as substitutes for ODS in 1990 and 2021: Member States and EU GHG emissions from this category and their split into HFC and PFC emissions

Member State	GHG emissions in kt CO2 equivalents		HFC emissions in kt CO2 equivalents		PFC emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021
Austria	NO	1 483	NO	1 483	NO	NO,IE
Belgium	NO	2 284	NO	2 284	NO	0
Bulgaria	NO	739	NO	739	NO	0
Croatia	NO	1 699	NO	1 699	NO	NO
Cyprus	NE,NO	353	NO,NE	353	NO	NO
Czechia	NO	3 711	NO	3 710	NO	0
Denmark	NO	275	NO	275	NO	0
Estonia	NO	190	NO	190	NO	-
Finland	0	834	0	833	NO	1
France	IE,NO	9 859	NO,IE	9 859	-	-
Germany	NA,IE,NO	8 038	NO,IE,NA	8 035	IE,NA	3
Greece	NO	4 701	NO	4 675	NO	25
Hungary	0	1 864	0	1 862	NO	2
Ireland	NO	669	NO	669	NO	NO
Italy	NO	15 375	NO	15 375	NO	NO
Latvia	NO	250	NO	250	NO	NO
Lithuania	NO	513	NO	513	NO	NO
Luxembourg	0	40	0	40	-	-
Malta	NE,IE,NO	229	NO,NE,IE	229	NO	0
Netherlands	IE,NO	928	NO,IE	928	IE	IE
Poland	NO	4 947	NO	4 937	NO	10
Portugal	NA,NO	3 186	NO,NA	3 159	NA	27
Romania	0	1 908	0	1 908	NO	0
Slovakia	NO	672	NO	672	NO	0
Slovenia	NO	267	NO	267	NO	NO
Spain	NO	4 986	NO	3 613	NO	23
Sweden	6	840	6	840	NO	NO
EU-27	**6**	**70 842**	**6**	**69 400**	**NA,IE,NO**	**91**

Abbreviations explained in the Chapter 'Units and abbreviations'. Spain also reports emissions of "unspecified mix of HFCs and PFCs" for 2.F.1.a Commercial refrigeration and 2.F.1.c Industrial refrigeration in 2021 .In Spain, Law 16/2013 created a national Tax on Fluorinated Greenhouse Gases. The tax rate depends on the GWP of the employed gas or gas blend. This Tax scheme foresees codes for many blends of refrigerants, but the new ones do not have an assigned code, and their data are registered as "unspecified mix of HFCs and PFCs". By knowing the total tax payments under "unspecified mix of HFCs and PFCs" and the total quantity of "unspecified mix", the yearly average GWP for the "unspecified mix of HFCs and PFCs" can be calculated. This average GWP allows to estimate the emissions in CO_2 equivalents, but these cannot be split into individual gases in the CRF tables, because they come from a mix of different blends, with different compositions. Spain is the only country reporting this and therefore no extra column for the mix of HFC and PFC emissions have been included in the table. Pease note that consequently HFC and PFC emissions for the year 2021 do not add up to the total GHG emissions for Spain and EU-27.In 2022, a new law amending the law on F-gas taxation entered into force which will allow for further disaggregation of the substances. However, the first set of data under the new scheme will relate to the year 2023 only.

F-gas emissions from 2.F Product uses as substitutes for ODS account for 2.4% of total EU-27 GHG emissions (without LULUCF) in 2021. HFC emissions account for almost all of 2.F emissions (98%) and were about 5700 times higher in 2021 than in 1990. The main reason for this is the phase-out of ODS such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons under the Montreal Protocol and the subsequent replacement of these substances by HFCs (mainly in refrigeration, air conditioning, foam production, fire protection and as aerosol propellants). Moreover, refrigeration and air conditioning sectors have grown in Europe in the last decades.

Table**.4.39** shows the sub-categories of HFC-gas emissions from 2.F Product uses as substitutes for ODS by countries. It highlights that 2.F.1 Refrigeration and Air Conditioning is by far the largest sub-category accounting for ca. 92% (EU-27) of HFC emissions from this source category. While ODS were formerly widely used as aerosols and foam blowing agents, the subcategories 2.F.4 Aerosols/Metered Dose Inhalers contribute today 2.3% and 2.F.2 Foam blowing agents approximately 2.4%. Emissions from fire protection relate to 3.4% of HFC emissions from 2.F in 2021.

The EU F-gas Regulation 517/2014 sets out several measures to reduce use and emissions of F-gases with a focus on HFCs. These measures include restrictions of the bulk supply of HFCs on the EU market (the so called HFC phase down) starting from 2015. The following schedule for supply reductions was established: 100% of the average usage of the years 2009-2012 in 2015, 93% in 2016-2017, 63% in 2018-2020, 45% in 2021-2023, 31% in 2024-2026, 24% in 2027-2029, 21% in 2030. This mechanism led to significant price increases for HFCs on the EU market. Together with further restrictions, the HFC phase-down is promoting the uptake of alternatives to HFCs in many applications.

Other important measures of the F-gas Regulation relate to placing on the market bans for certain products (Annex III), for example stationary refrigeration equipment containing high-GWP gases, which were partly implemented by industry ahead of the prohibition dates and possibly due to the price increases under the HFC phase down scheme.

Table.4.40 2F Product uses as substitutes for ODS: Countries' sub-categories of HFC emissions (kt CO_2 equivalents)

Member State	**2.F Product uses as substitutes**	2.F.1 Refrigeration and air conditioning	2.F.2 Foam blowing agents	2.F.3 Fire protection	2.F.4 Aerosols	2.F.5 Solvents	2.F.6 Other applications
Austria	**1 483**	1 431	18	11	23	NO	-
Belgium	**2 284**	2 183	46	10	45		NO
Bulgaria	**739**	716	NO	13	10	-	-
Croatia	**1 699**	1 667	17	6	10	-	-
Cyprus	**353**	337	1	12	4	-	-
Czech Republic	**3 710**	3 676	1	30	2	0	-
Denmark	**275**	264	1	NO	10	NO	NO
Estonia	**190**	183	2	2	3		0
Finland	**833**	811	4	NO,IE,NA	18	0	0
France	**9 859**	9 138	189	36	467	30	NO,IE
Germany	**8 035**	7 274	343	95	323	IE	-
Greece	**4 675**	4 287	189	159	41	-	-
Hungary	**1 862**	1 655	165	12	31	NO	NO
Ireland	**669**	573	NO	34	63	NO	NO
Italy	**15 375**	13 105	429	1 656	185	-	-
Latvia	**250**	244	0	0	6	-	-
Lithuania	**513**	459	41	4	9	NO	NO
Luxembourg	**40**	39	0	-	1	-	-
Malta	**229**	225	1	1	1	NO	NO
Netherlands	**928**	798	NO	-	IE	-	130
Poland	**4 937**	4 771	75	91	0	0	-
Portugal	**3 159**	2 992	52	99	16	NO	NO
Romania	**1 908**	1 866	1	3	39	NO	NO
Slovakia	**672**	643	2	19	9	NO	NO
Slovenia	**267**	261	1	0	5		-
Spain	**3 613**	3 204	40	81	288	NO	NO
Sweden	**840**	811	16	0	14	-	-
EU-27	**69 400**	**63 612**	**1 635**	**2 373**	**1 620**	**31**	**130**

Abbreviations explained in the Chapter 'Units and abbreviations'. Note: NLD reports HFC emissions from 2.F.2, 2.F.3, 2.F.4 and 2.F.5 in 2.F.6.

Table **4.41** to Table.**4.44** shows the contribution of each country to EU-27 HFC emissions from 2.F.1 as well as information on the method applied, activity data and emission factor.

Table 4.41 2F1 Refrigeration and Air conditioning: Member States' contributions to HFC emissions and information on method applied, activity data and emission factor

Member State	HFCs Emissions in kt CO2 equiv.				Share in EU-27 Emissions in 2021	Change 1990-2021		Change 1995-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	1995	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	NO	36	1 651	1 431	2.2%	1 431	∞	1 395	3920%	-220	-13%	T2	D
Belgium	NO	87	2 336	2 183	3.4%	2 183	∞	2 097	2419%	-152	-7%	T2	CS,D,PS
Bulgaria	NO	3	765	716	1.1%	716	∞	713	23570%	-49	-6%	T2	D
Croatia	NO	21	1 541	1 667	2.6%	1 667	∞	1 645	7666%	125	8%	T2	CS,D
Cyprus	NO	28	319	337	0.5%	337	∞	308	1084%	18	6%	T2	D
Czechia	NO	87	3 699	3 676	5.8%	3 676	∞	3 590	4133%	-23	-1%	T2	CS
Denmark	NO	45	306	264	0.4%	264	∞	219	483%	-42	-14%	T2	D
Estonia	NO	10	172	183	0.3%	183	∞	174	1797%	11	6%	T2	CS
Finland	0	146	876	811	1.3%	811	6902381%	665	455%	-65	-7%	T2	CS,D
France	NO	367	10 303	9 138	14.4%	9 138	∞	8 770	2387%	-1 165	-11%	T2	CS
Germany	NA	546	7 460	7 274	11.4%	7 274	∞	6 729	1233%	-186	-2%	T2	CS,D
Greece	NO	40	4 427	4 287	6.7%	4 287	∞	4 247	10629%	-141	-3%	IE,T2,T3	D,IE
Hungary	0	22	1 652	1 655	2.6%	1 655	76877077%	1 633	7369%	3	0%	T2	CS,D
Ireland	NO	5	521	573	0.9%	573	∞	568	12556%	51	10%	T2	CS
Italy	NO	368	13 704	13 105	20.6%	13 105	∞	12 738	3465%	-599	-4%	T2	CS,D
Latvia	NO	16	231	244	0.4%	244	∞	228	1429%	13	5%	T2	CS,D,OTH
Lithuania	NO	5	449	459	0.7%	459	∞	453	8450%	10	2%	T2	CS,D,PS
Luxembourg	0	3	41	39	0.1%	39	59700809%	36	1185%	-2	-6%	T2	CS,M,PS
Malta	NO	0	222	225	0.4%	225	∞	225	13156431%	4	2%	NA	NA
Netherlands	NO	44	823	798	1.3%	798	∞	754	1728%	-26	-3%	T2	CS
Poland	NO	151	4 844	4 771	7.5%	4 771	∞	4 621	3067%	-73	-1%	T2	D
Portugal	NO,NA	29	2 965	2 992	4.7%	2 992	∞	2 964	10284%	27	1%	NO,T2	D,NO
Romania	NO	2	1 799	1 866	2.9%	1 866	∞	1 864	102916%	67	4%	T2	CS,D
Slovakia	NO	10	615	643	1.0%	643	∞	632	6199%	28	4%	T2	CS
Slovenia	NO	3	271	261	0.4%	261	∞	258	9520%	-11	-4%	T1,T2	CS,D
Spain	NO	NO	3 088	3 204	5.0%	3 204	∞	3 204	∞	116	4%	T2	CS
Sweden	5	122	849	811	1.3%	806	17335%	689	566%	-38	-5%	T2	CS,D
EU-27	**5**	**2 195**	**65 931**	**63 612**	**100%**	**63 607**	**1364152%**	**61 418**	**2799%**	**-2 318**	**-3.5%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

In 2021, HFC emissions from 2.F.1 were about 29 times higher than in 1995 (Table **4.41** and ***Figure 4.16*** to Figure 4.19) but decreased by 5% compared to 2020 (EU-27) which is due to the measures of the EU F-gas Regulation, however, might also reflect impacts of the COVID-19 pandemic.

France, Germany and Italy were responsible for 46% of total EU-27 emissions from this source in 2021.

Figure 4.16: 2F1 Refrigeration and Air conditioning: EU-27 HFC emissions

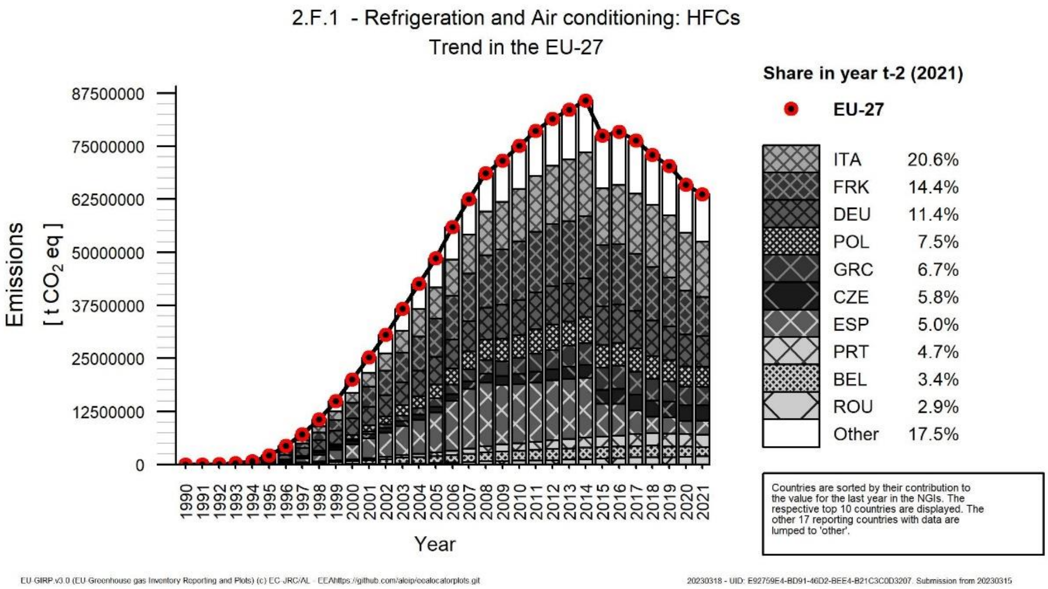


Figure 4.16 shows that emissions in sector 2.F.1 decreased again in 2021.

The main HFCs reported in this subcategory are HFC-32, HFC-125, HFC-134a and HFC-143a. They can be used as pure substances (such as HFC-32 and HFC-134a) and in mixtures (e.g. a refrigerant blend commonly used in stationary air conditioning is called “R410A” and is composed of 50% HFC-32 and 50% HFC-125).

Major developments in category 2.F.1 are driven by the subcategories 2.F.1.a Commercial refrigeration, 2.F.1.e Mobile air conditioning and 2.F.1.f Stationary air conditioning.

Emission plots for these prominent subcategories are provided in the following graphs. Please note that 2.F.1.a often includes emissions from all types of stationary equipment in Member States (i.e. also industrial refrigeration and partly also stationary air conditioning). After a peak in 2014, emissions from 2.F.1.a decreased in 2015 and 2017 onwards. This is in line with the policies and measures of the EU F-gas Regulation No. 517/2014.

Figure 4.17: 2F1a Commercial refrigeration: EU-27 HFC emissions

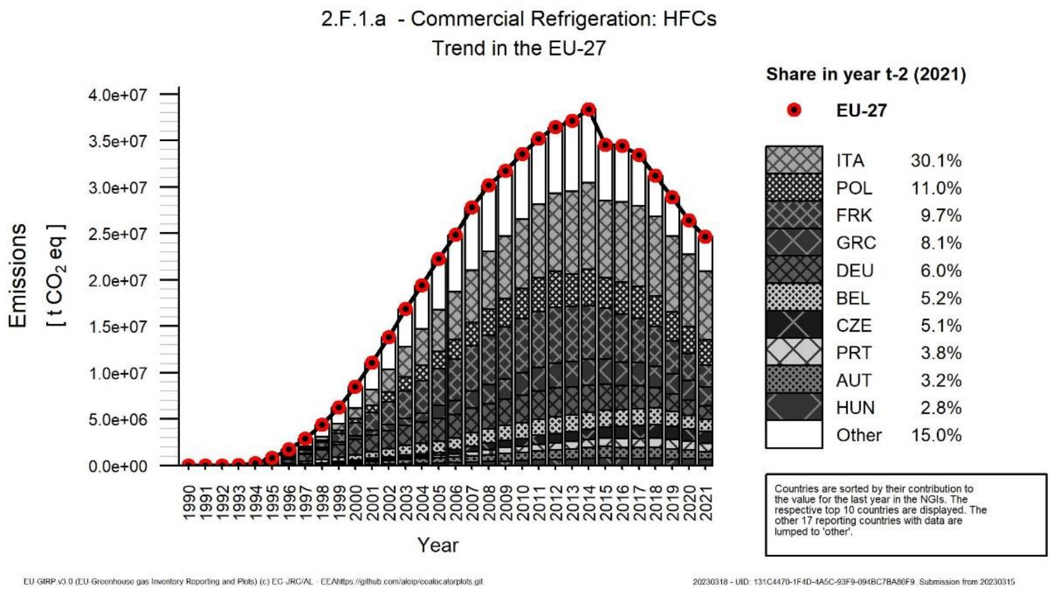


Figure 4.18: 2F1e Mobile air conditioning: EU-27 HFC emissions

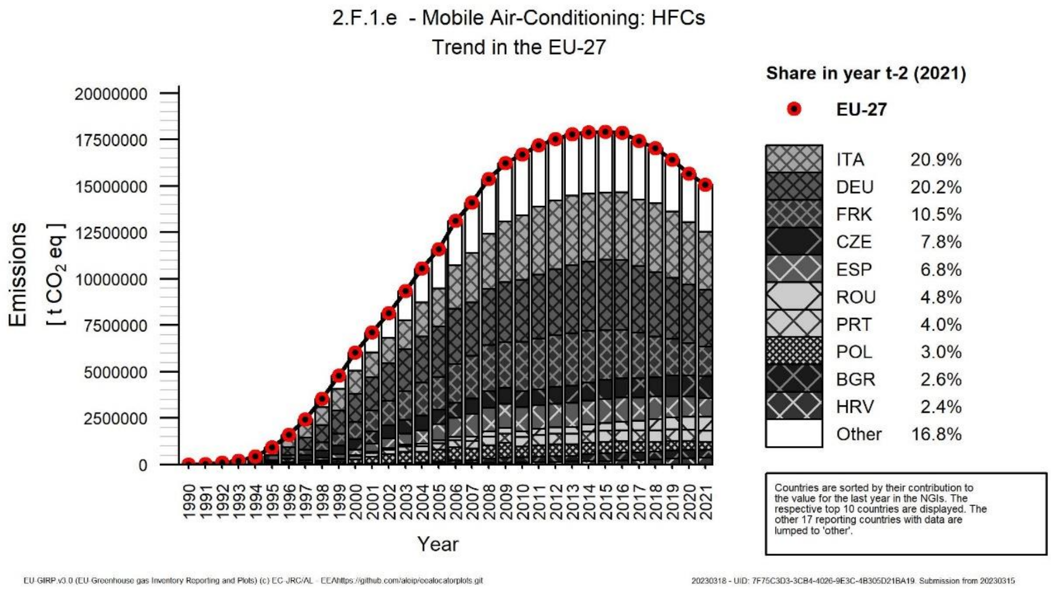


Figure 4.18 shows emission trends for mobile air-conditioning: The EU reported HFC-134a emissions from disposal in the subcategory mobile air conditioning (2.F.1.e) in CRF table 2(II)B-Hs2. The disposal loss factor related to HFC-134a emissions from disposal in mobile air conditioning (2.F.1.e) was 99.8% for the year 1995. HFC-134a was introduced in the early 1990s, and 1995 was the first year in which it was used on a large scale for mobile air conditioning in passenger cars. The very small amounts in 1995 relate to particularities of the inventories of France and Latvia, which run models of the vehicle stock that assume end of life of a certain share of vehicles each year, in line with a Gaussian normal distribution. Some cars reached their end of life in the first year of widespread use of HFC-134a in mobile air conditioning. The 2018 ERT considered the assumption that not every car reaches an average lifespan and that some are disposed of earlier (e.g. owing to damage in an accident) and that, in the first year of disposal, there was no (or only minor) recovery as realistic and acceptable. Emissions from 2.F.1.e decreased in all years from 2017 onwards. This relates to the introduction of the low-GWP refrigerant R1234yf in air-conditioning systems of new passenger cars. Italy accounts for 20.9% of emissions from 2.F.1.e followed by Germany (20.2%) and France (10.5%).

Figure 4.19: 2F1f Stationary air conditioning: EU-27 HFC emissions

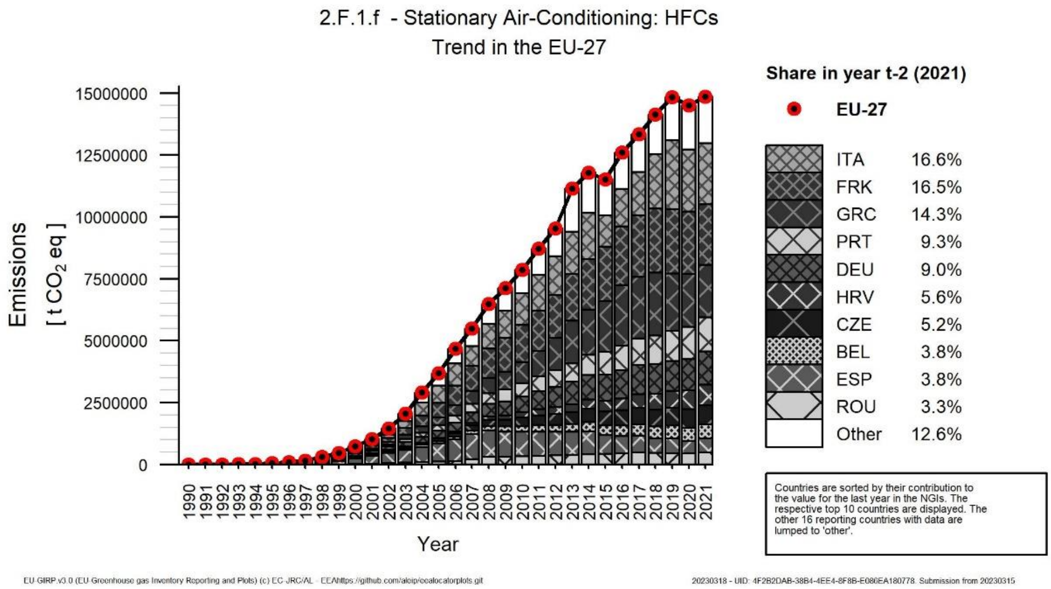


Figure 4.19 shows a consistent trend for sector 2.F.1.f with increasing emissions until 2019. This development reflects the growing use of air conditioning equipment, in particular in Southern Europe, and the delayed uptake of alternatives to HFCs in this sub-category. While emissions in 2020 decreased slightly, which might be a consequence of the COVID-19 pandemic, they increased again in 2021.

Table 4.42 2F2 Foam Blowing: Countries' contributions to HFC emissions and information on method applied, activity data and emission factor

Member State	HFCs Emissions in kt CO2 equiv.				Share in EU-27	Change 1990-2021		Change 1995-2021		Change 2020-2021		Method	Emission factor
	1990	1995	2020	2021	Emissions in 2021	kt CO2 equiv.	%	kt CO2 equiv.	%	kt CO2 equiv.	%		Informa-tion
Austria	NO	275	17	18	1.1%	18	∞	-257	-93%	1	5%	T2	D
Belgium	NO	324	44	46	2.8%	46	∞	-278	-86%	2	4%	T2	CS,D,PS
Bulgaria	NO	NO	NO	NO	-	-	-	-	-	-	-	NA	NA
Croatia	NO	NO	18	17	1.0%	17	∞	17	∞	-1	-5%	CS	D
Cyprus	NO,NE	NO,NE	1	1	0.1%	1	∞	1	∞	0	0%	CS	CS
Czechia	NO	0	3	1	0.1%	1	∞	1	7833%	-2	-67%	T1	D
Denmark	NO	192	1	1	0.0%	1	∞	-192	-100%	0	-9%	NA	NA
Estonia	NO	17	2	2	0.1%	2	∞	-15	-87%	0	1%	T2	CS
Finland	NO	0	4	4	0.3%	4	∞	4	816%	0	9%	T2	D
France	NO	NO	193	189	11.5%	189	∞	189	∞	-4	-2%	T2	CS,D
Germany	IE,NA	1 533	353	343	21.0%	343	∞	-1 190	-78%	-10	-3%	T2	CS
Greece	NO	NO	189	189	11.6%	189	∞	189	∞	0	0%	T2	D
Hungary	NO	NO	155	165	10.1%	165	∞	165	∞	10	6%	T2	CS
Ireland	NO	NO	NO	NO	-	-	-	-	-	-	-	NA	NA
Italy	NO	NO	453	429	26.2%	429	∞	429	∞	-24	-5%	T2	D
Latvia	NO	0	0	0	0.0%	0	∞	0	-20%	0	13%	T1a	D,OTH
Lithuania	NO	NO	40	41	2.5%	41	∞	41	∞	2	4%	T2	D
Luxembourg	NO	9	1	0	0.0%	0	∞	-9	-95%	0	-54%	T1	CS
Malta	NO,IE	NO,IE	1	1	0.1%	1	∞	1	∞	0	10%	NA	NA
Netherlands	NO	NO	NO	NO	-	-	-	-	-	-	-	T2	CS
Poland	NO	NO	72	75	4.6%	75	∞	75	∞	3	5%	T2	D
Portugal	NA	1	50	52	3.2%	52	∞	51	6102%	2	5%	T2	D
Romania	NO	NO	1	1	0.0%	1	∞	1	∞	0	0%	T2	D
Slovakia	NO	NO	2	2	0.1%	2	∞	2	∞	0	0%	T2	D
Slovenia	NO	27	1	1	0.1%	1	∞	-26	-95%	0	-4%	T2	CS,D
Spain	NO	NO	42	40	2.5%	40	∞	40	∞	-2	-5%	T2	D
Sweden	NO	NO	26	16	1.0%	16	∞	16	∞	-10	-39%	T2	PS
EU-27	**A,IE,NO**	**2 379**	**1 668**	**1 635**	**100%**	**1 635**	**∞**	**-745**	**-31%**	**-34**	**-2.0%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year. Note: NLD reports HFC emissions from 2.F.2, 2.F.3, 2.F.4 and 2.F.5 in 2.F.6.

In 2021, HFC emissions from 2.F.2 (Table **4.42** and ***Figure 4.20***) decreased by 2% compared to the previous year. The HFC foam blowing agents reported in 2.F.2 are HFC-152a, HFC-134a, HFC-227ea, HFC-245fa and HFC-365mfc. The biggest contributors to emissions from this sector are Italy (26.2%), Germany (21%), Greece (11.6%) and France (11.5%) and those four countries account for 70% of the share in EU-27 emissions in this sector.

Figure 4.20: 2F2 Foam Blowing Agents: EU-27 HFC emissions

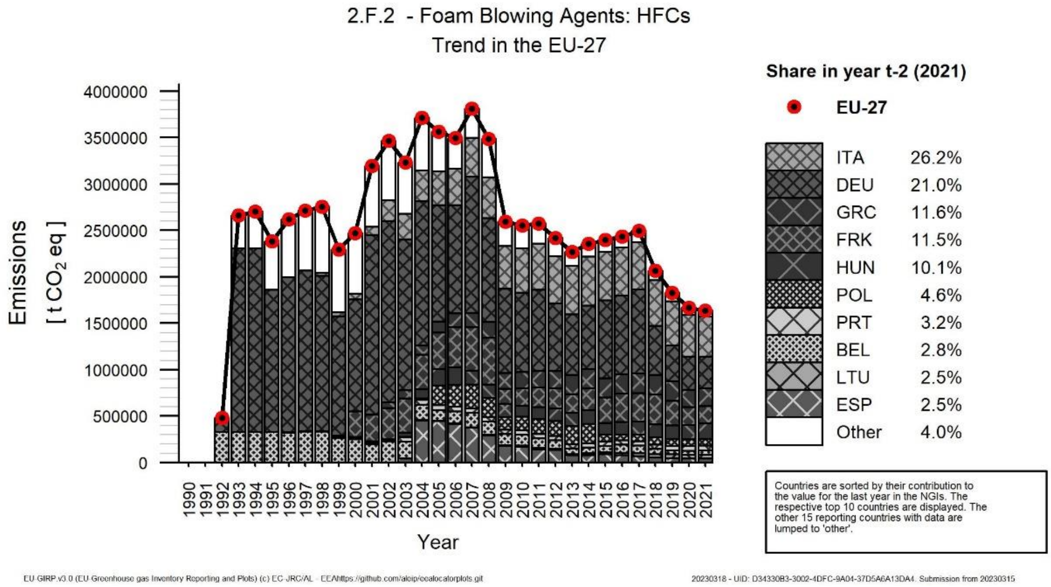


Figure 4.20 displays that emissions from sector 2.F.2 showed an overall increase until 2008 and then dropped to a lower level unti 2017 followed by another decrease in recent years as major foam manufacturers converted their production to non-HFC blowing agents (usually hydrocarbons). The F-gas Regulation further limits the use of F-gases for this subcategory as the placing on the market of foams containing HFCs with GWP of 150 or more has been banned from 2020 for extruded polystyrene (XPS) foams and for other foams from 2023, unless HFCs with higher GWPs are needed to meet national safety requirements (Annex III, point 16).

Table4.43 2F3 Fire protection: Countries' contributions to HFC emissions and information on method applied, activity data and emission factor

Member State	HFCs Emissions in kt CO2 equiv.				Share in EU-27	Change 1990-2021		Change 1995-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	1995	2020	2021	Emissions in 2021	kt CO2 equiv.	%	kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	NO	NO	11	11	0.5%	11	∞	11	∞	0	0%	T2	D
Belgium	NO	1	11	10	0.4%	10	∞	9	1481%	-1	-10%	T2	CS
Bulgaria	NO	NO	12	13	0.5%	13	∞	13	∞	1	6%	T2	D
Croatia	NO	0	6	6	0.2%	6	∞	5	2724%	0	-1%	T1,T2	D,PS
Cyprus	NO,NE	0	11	12	0.5%	12	∞	12	21116%	0	2%	CS	CS
Czechia	NO	NO	29	30	1.3%	30	∞	30	∞	1	3%	D	D
Denmark	NO	NO	NO	NO	-	-	-	-	-	-	-	NA	NA
Estonia	NO	NO	3	2	0.1%	2	∞	2	∞	0	-14%	T2	CS
Finland	NO	NO	NO,IE,NA	NO,IE,NA	-	-	-	-	-	-	-	NA	NA
France	NO	5	47	36	1.5%	36	∞	32	684%	-11	-23%	T1	CS
Germany	NA	NA	98	95	4.0%	95	∞	95	∞	-3	-3%	CS	CS,D
Greece	NO	NO	159	159	6.7%	159	∞	159	∞	0	0%	CS	D
Hungary	NO	NO	10	12	0.5%	12	∞	12	∞	2	18%	T1	D
Ireland	NO	NO	34	34	1.4%	34	∞	34	∞	0	0%	-	-
Italy	NO	16	1 659	1 656	69.8%	1 656	∞	1 640	10454%	-3	0%	T2	CS
Latvia	NO	NO	0	0	0.0%	0	∞	0	∞	0	0%	T2	D
Lithuania	NO	NO	4	4	0.2%	4	∞	4	∞	0	5%	T1b	D
Luxembourg	-	-	-	-	-	-	-	-	-	-	-	-	-
Malta	NO	NO	1	1	0.1%	1	∞	1	∞	0	5%	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-	T2	CS
Poland	NO	NO	95	91	3.8%	91	∞	91	∞	-4	-4%	T2	D
Portugal	NA	NO	56	99	4.2%	99	∞	99	∞	42	75%	T2	D
Romania	NO	NO	3	3	0.1%	3	∞	3	∞	0	-5%	T2	D
Slovakia	NO	2	22	19	0.8%	19	∞	17	778%	-2	-11%	T1a	CS
Slovenia	NO	NO	0	0	0.0%	0	∞	0	∞	0	-18%	-	-
Spain	NO	1	89	81	3.4%	81	∞	80	9537%	-8	-9%	T1a	CS,D
Sweden	NO	NO	1	0	0.0%	0	∞	0	∞	0	-69%	T1	CS
EU-27	**NE,NA,NO**	**24**	**2 360**	**2 373**	**100%**	**2 373**	**∞**	**2 349**	**9706%**	**13**	**0.5%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year. Note: NLD reports HFC emissions from 2.F.2, 2.F.3, 2.F.4 and 2.F.5 in 2.F.6.

HFC emissions from 2.F.3 (Table4.43) showed a strong increase from 1995 until peaking in 2016. This development was caused by the phase-out of ozone depleting substances, especially halons, as fire extinguishing agents under the Montreal Protocol and the subsequent introduction of HFCs and other ODS alternatives as replacements. Since 2016 emissions have been quite stable. Emissions from this category arise on the one hand from assembly, leakage and decommissioning but also from releases in the case of fires and false alarms. The HFCs reported in this subcategory are HFC-23 (banned in new equipment in the EU since 2015), HFC-227ea and HFC-236fa. In Denmark, Luxembourg and Iceland HFCs are not used as fire extinguishing agents. Instead, other chemicals or not-in-kind alternatives, e.g. water mist, fluorinated ketones etc., have been applied for many years. The Netherlands included estimated emissions from this subcategory in the 2.F.6 subcategory.

The biggest contributors to this sector are Italy (69.8%), Greece (6.7%) and Portugal (4.2%), those three countries account for over 80% of the share in EU-27 emissions in this sector. Relevant increases of emissions from this subcategory compared to 2020 were reported by Portugal (+75%), and Hungary (18%), while certain decreases were reported by Sweden (-69%), France (-23%) and Slovenia (-18%).

Figure 4.21: 2F3 Fire Protection, EU-27: HFC emissions

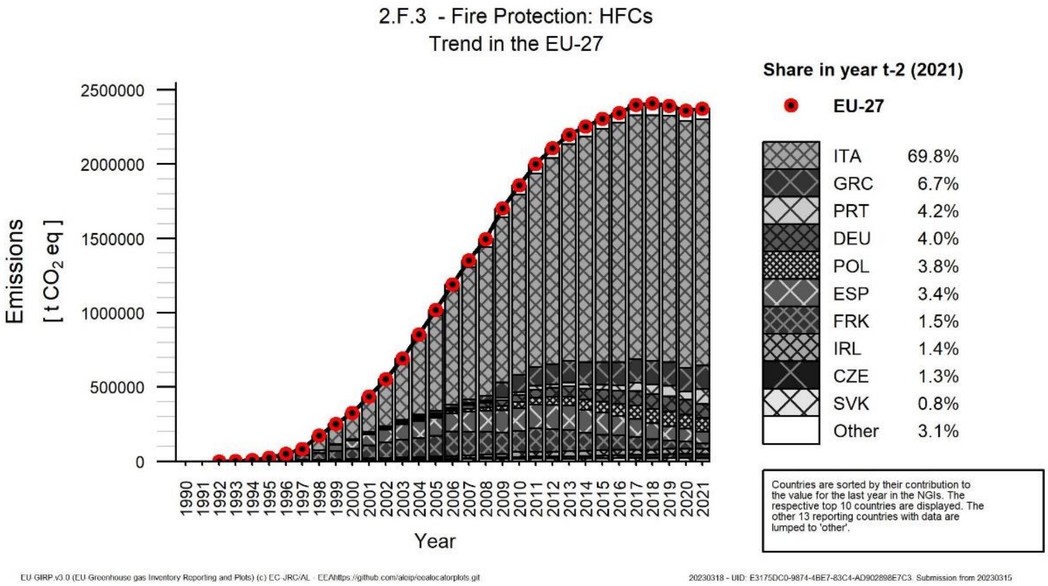


Figure 4.21 illustrates that emissions from fire protection were rather stable in recent years.

Table.4.44 2F4 Aerosols/ Metered Dose Inhalers: Countries' contributions to HFC emissions and information on method applied, activity data and emission factor

Member State	HFCs Emissions in kt CO2 equiv.				Share in EU-27 Emissions in 2021	Change 1990-2021		Change 1995-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	1995	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	NO	4	24	23	1.4%	23	∞	19	469%	0	-2%	T2	D
Belgium	NO	38	44	45	2.8%	45	∞	7	18%	0	0%	T2	CS,D,PS
Bulgaria	NO	NO	13	10	0.6%	10	∞	10	∞	-2	-19%	T2	D
Croatia	NO	NO	9	10	0.6%	10	∞	10	∞	0	2%	T1a	D
Cyprus	NO	0	4	4	0.2%	4	∞	4	640502%	0	-5%	CS	CS
Czechia	NO	0	2	2	0.1%	2	∞	2	21341506%	0	4%	T1	D
Denmark	NO	NO	10	10	0.6%	10	∞	10	∞	0	-3%	T2	D
Estonia	NO	0	3	3	0.2%	3	∞	2	5432%	0	-16%	T2	CS
Finland	NO	2	20	18	1.1%	18	∞	16	740%	-2	-11%	T2	D
France	NO	566	532	467	28.8%	467	∞	-99	-18%	-66	-12%	T2	CS,PS
Germany	NO,IE,NA	311	313	323	19.9%	323	∞	12	4%	10	3%	CS,T2	CS
Greece	NO	0	41	41	2.5%	41	∞	41	139503%	0	-1%	T2,T3	D
Hungary	NO	11	32	31	1.9%	31	∞	20	189%	-1	-4%	T2	CS,D
Ireland	NO	25	64	63	3.9%	63	∞	38	153%	-1	-2%	-	-
Italy	NO	NO	206	185	11.4%	185	∞	185	∞	-21	-10%	T2	CS
Latvia	NO	0	6	6	0.4%	6	∞	6	11384%	1	16%	T1a	D
Lithuania	NO	1	9	9	0.5%	9	∞	8	1036%	0	-2%	T1a	D
Luxembourg	NO	1	1	1	0.1%	1	∞	-1	-41%	0	2%	T1,T2	CS
Malta	NO,NE	NO,NE	1	1	0.0%	1	∞	1	∞	0	-12%	NA	NA
Netherlands	IE	IE	IE	IE	-	-	-	-	-	-	-	NA	NA
Poland	NO	16	104	0	0.0%	0	∞	-16	-99%	-104	-100%	T1a,T1b,T2	D
Portugal	NA	25	16	16	1.0%	16	∞	-8	-35%	0	3%	T2	D
Romania	0	1	45	39	2.4%	39	23790%	39	5908%	-6	-13%	T2	D
Slovakia	NO	NO	8	9	0.5%	9	∞	9	∞	1	6%	T1a	D
Slovenia	NO	NO	5	5	0.3%	5	∞	5	∞	0	-1%	NA	NA
Spain	NO	NO,NA	278	288	17.8%	288	∞	288	∞	10	3%	T2	CS
Sweden	1	7	13	14	0.8%	12	951%	7	105%	1	8%	T2	D
EU-27	**1**	**1 007**	**1 802**	**1 620**	**100%**	**1 618**	**110490%**	**613**	**61%**	**-183**	**-10.1%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year. Note: NLD reports HFC emissions from 2.F.2, 2.F.3, 2.F.4 and 2.F.5 in 2.F.6.

In 2021, HFC emissions from 2.F.4 peaked in 2006, the increase is due to increased use of medical aerosols throughout Europe, especially for asthma treatment (metered-dose inhalers). **Table.4.44**Figure ***4.21***). The HFCs reported in 2.F.4 are HFC-134a (medical and technical aerosols), HFC-227ea (medical aerosols only) and HFC-152a (technical and medical aerosols). Emissions from technical aerosols have been playing a minor role from 2018 onwards, as the EU F-gas Regulation bans the placing on the market of technical aerosols containing HFCs with GWP of 150 or more, except when required to meet national safety standards. This is reflected in a 10% decrease of EU-27 emissions in 2021 compared to 2020.

France (28.8%), Germany (19.9%) and Spain (17.8%) accounted for 66.9% of total EU-27 emissions from this source. A significant relative decrease between 2020 and 2021 was reported by Poland (-100%)[27], Bulgaria (-19%) and Estonia (-16%); the biggest relative increase was reported by Latvia (+16%).(Table.**4.44**). .

[27] Consultation with Poland on this issue is ongoing.

Figure 6 4 2F4 Aerosols/Metered Dose Inhalers: EU-27 HFC emissions

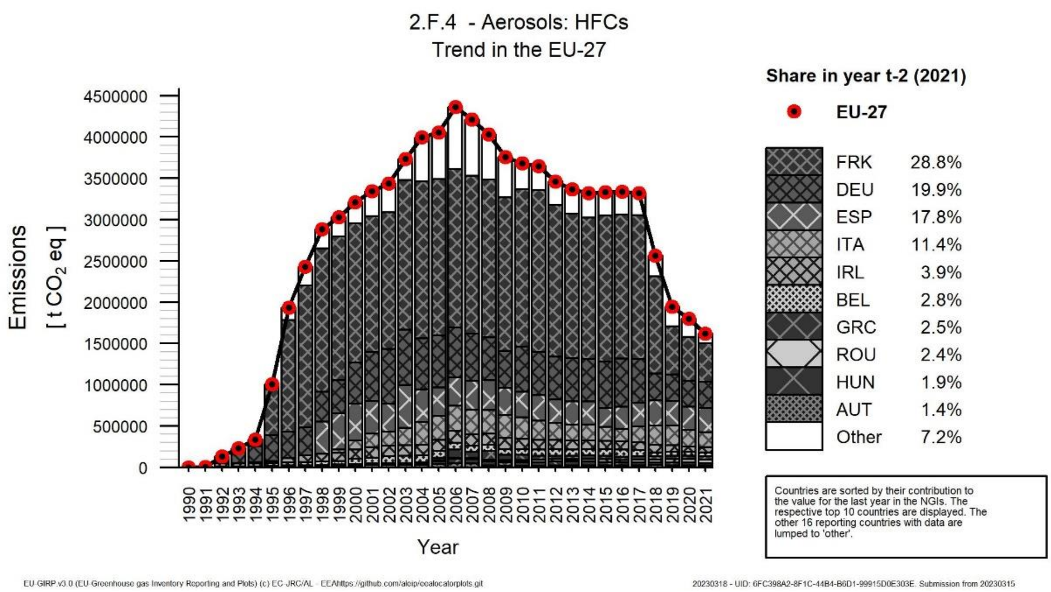


Figure 4.21 shows the emission reductions in 2021 compared to previous years.

Only few companies are relevant in terms of HFC emissions from subcategories 2.F.5 Solvents and 2.F.6 Other applications, thus, for confidentiality reasons, MS report emissions together with other subcategories and no futher details can be provided in this report.

4.2.7 Other product manufacture and use (CRF Source Category 2G)

PFCs and SF_6 have been used for certain applications within this category for many decades. SF_6 is a particularly potent greenhouse gas (GWP 23500) that is used predominantly in insulated switch gear for transportation and distribution of electric power (2.G.1). Emissions also occur from other product use (2.G.2), such as military applications (SF_6), particle accelerators (SF_6), applications of adiabatic properties - shoes and tyres (SF_6, PFCs), sound proof windows (SF_6), medical and cosmetic applications (SF_6, PFCs), other (SF_6, PFCs) etc.

Table 8 shows that all Member States report GHG emissions in 2.G Other product manufacture and use for the year 2021. SF_6 emissions from the subcategory electrical equipment (2.G.1) are reported by all Member States except the Netherlands where the share of non-F-gas alternatives is particularly high and SF_6 emission estimates are included elsewhere.

Table.4.45 2G Other: Overview of sources reported under this source category

Country	2.G Other product manufacture and use	HFC emissions [kt CO_2 equivalents]	PFC emissions [kt CO_2 equivalents]	SF_6 emissions [kt CO_2 equivalents]	NF_3 emissions [kt CO_2 equivalents]	Unspecified mix of HFCs and PFCs [kt CO_2 equivalents]	Total emissions [kt CO_2 equivalents]	Share in EU-KP Total
AUT	Electrical equipment (SF_6); Soundproof windows (SF_6); Other (SF_6)	NO	NO	351			351	7.3%
BEL	Electrical equipment (SF_6); Soundproof windows (SF_6); Other (C6F14)	NO	NO	79	NO	NO	79	1.7%
BGR	Electrical equipment (SF_6)		NO	23			23	0.5%
HRV	Electrical equipment (SF_6)	NO	NO	10	NO	NO	10	0.2%
CYP	Electrical equipment (SF_6)		NO	16			16.2	0.3%
CZE	Electrical equipment (SF_6); Accelerators (SF_6); Soundproof windows (SF_6); Other (SF_6)			63			63	1.3%
DNM	Electrical equipment (SF_6); Soundproof windows (SF_6); Other (SF_6)	NO,NA	NO,NA	15	NO,NA	NO,NA	15	0.3%
EST	Electrical equipment (SF_6); Accelerators (SF_6)	NO	NO	3	NO	NO	3	0.1%
FIN	Electrical equipment (SF_6)	0	NO,IE	17	0	0	17	0.4%
FRK	Electrical equipment (SF_6); Accelerators (SF_6); Other (SF_6, Unspecified mix of PFCs)	1	294	358			653	13.7%
DEU	Electrical equipment (SF_6); Military applications (SF_6 => Notation Key C); Accelerators (SF_6); Soundproof windows (SF_6); Adiabatic properties: shoes and tyres (SF_6, C3F8 => Notation Key C); Other (SF_6 => partly Notation Key C, C10F18 => Notation Key C); 4. Other (HFC-134a, HFC-245fa => Notation Key C, HFC-365mfc => Notation Key C)	14	IE,NA	2578	NA	NA	2592	54.2%
GRC	Electrical equipment (SF_6)		NO	5			5	0.1%
HUN	Electrical equipment (SF_6); Other (SF_6)	NO	NO	97	NO	NO	97	2.0%
IRL	Electrical equipment (SF_6); Soundproof windows (SF_6); Adiabatic properties: shoes and tyres (SF_6); Other (SF_6)	NO	NO	6	NO	NO	6	0.1%
ITA	Electrical equipment (SF_6); Accelerators (SF_6)	NO	NO	217	NO	NO	217	4.5%
LVA	Electrical equipment (SF_6)	NO	NO	12	NO	NO	12	0.3%

Country	2.G Other product manufacture and use	HFC emissions [kt CO_2 equivalents]	PFC emissions [kt CO_2 equivalents]	SF_6 emissions [kt CO_2 equivalents]	NF_3 emissions [kt CO_2 equivalents]	Unspecified mix of HFCs and PFCs [kt CO_2 equivalents]	Total emissions [kt CO_2 equivalents]	Share in EU-KP Total
LTU	Electrical equipment (SF_6); Accelerators (SF_6)	NO	NO	1	NO	NO	1	0.0%
LUX	Electrical equipment (SF_6); Soundproof windows (SF_6), Other (HFC-43-10mee)	4		10			13	0.3%
MLT	Electrical equipment (SF_6), Other (SF_6, C3F8)		0	0			0.41	0.0%
NLD	Other (SF_6)	NO	NO	124			124	2.6%
POL	Electrical equipment (SF_6)	NA	NA	93	NA	NA	93	1.9%
PRT	Electrical equipment (SF_6)	NO	NO	24	NO	NO	24	0.5%
ROU	Electrical equipment (SF_6)	NO	NO	50	NO	NO	50	1.0%
SVK	Electrical equipment (SF_6)	NO	NO	17	NO	NO	17	0.4%
SVN	Electrical equipment (SF_6)	NO	NO	17	NO	NO	17	0.3%
ESP	Electrical equipment (SF_6); Accelerators (SF_6), Other (SF_6)	NO	NO	240	NO	NO	240	5.0%
SWE	Electrical equipment (SF_6); Soundproof windows (SF_6)		NO	40			40	0.8%
EU-27	**TOTAL**	**19**	**294**	**4466**	**0**	**0**	**4779**	

Abbreviations explained in the Chapter 'Units and abbreviations'.

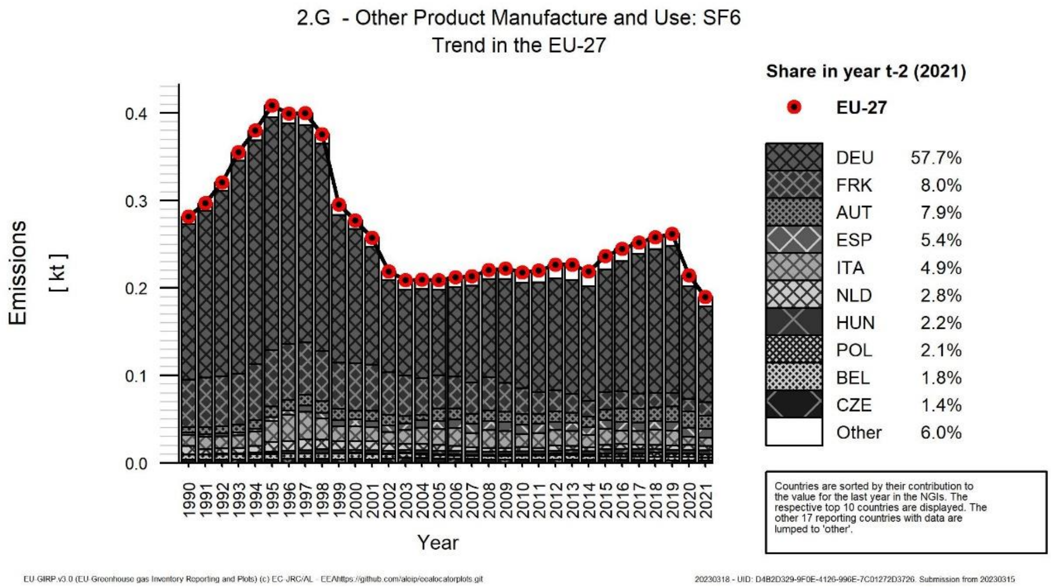
Figure 4.22 and Table 4.46 summarize information by Member State on SF_6 emissions for the key source 2.G. Emissions peaked in the mid 1990ties and have been relatively stable after that until 2002 and showing a small but rather steady increase in the period from 2014 to 2019. However, in 2020 and 2021 emissions decreased considerably compared to 2019. The development of emissions from this category is dominated by the emission trend in Germany (57.7% of SF_6 emissions from EU-27 in 2021), where the disposal of sound-proof windows containing SF_6 represents a particularly high emission source, which however is decreasing.

Table 4.46: 2G - Member States' contributions to SF_6 emissions

Member State	SF6 Emissions in kt CO2 equiv.				Share in EU-27	Change 1990-2021		Change 1995-2021		Change 2020-2021		Method	Emission factor
	1990	1995	2020	2021	Emissions in 2021	kt CO2 equiv.	%	kt CO2 equiv.	%	kt CO2 equiv.	%		Informa-tion
Austria	136	277	436	351	7.9%	215	159%	74	27%	-86	-20%	T2	D
Belgium	133	139	85	79	1.8%	-54	-40%	-59	-43%	-6	-7%	T1,T2	D
Bulgaria	4	5	20	23	0.5%	19	511%	18	361%	3	14%	NO,T2	D,NO
Croatia	11	12	9	10	0.2%	-1	-13%	-3	-23%	0	3%	T2	CS
Cyprus	3	6	19	16	0.4%	14	495%	10	174%	-2	-13%	T1	D
Czechia	87	91	65	63	1.4%	-24	-28%	-29	-31%	-2	-3%	D,T1	D
Denmark	13	72	47	15	0.3%	2	14%	-57	-79%	-32	-68%	T2,T3	D
Estonia	NO	3	3	3	0.1%	3	∞	0	-3%	0	1%	T3	CS
Finland	46	27	16	17	0.4%	-30	-64%	-11	-38%	0	2%	T2	CS
France	1 287	1 524	345	358	8.0%	-929	-72%	-1 166	-76%	13	4%	T1,T2	CS,D
Germany	4 174	6 259	3 018	2 578	57.7%	-1 596	-38%	-3 681	-59%	-440	-15%	CS,D,T3	CS,D
Greece	3	4	5	5	0.1%	2	67%	2	43%	0	-1%	CS	CS
Hungary	13	53	111	97	2.2%	84	660%	44	84%	-14	-13%	T1,T2	D
Ireland	34	39	7	6	0.1%	-28	-82%	-33	-84%	0	-4%	T1,T2	CS
Italy	303	568	220	217	4.9%	-87	-29%	-351	-62%	-4	-2%	CS,T3	CS,PS
Latvia	NO	0	12	12	0.3%	12	∞	12	6674%	0	-2%	T1	D
Lithuania	NO	0	0	1	0.0%	1	∞	0	973%	0	136%	T3	CS
Luxembourg	1	1	10	10	0.2%	9	998%	8	593%	0	0%	D,T1,T3	CS,D,M,PS
Malta	0	1	0	0	0.0%	0	3684%	-1	-72%	0	0%	-	-
Netherlands	213	264	128	124	2.8%	-89	-42%	-140	-53%	-5	-4%	NA	NA
Poland	NA,NO	13	92	93	2.1%	93	∞	80	616%	0	0%	T1	D
Portugal	NO,NA	14	24	24	0.5%	24	∞	10	69%	1	3%	T1	NO
Romania	0	1	62	50	1.1%	50	10422%	49	5374%	-12	-20%	T2	D
Slovakia	0	10	18	17	0.4%	17	28886%	7	67%	0	-2%	T3	CS
Slovenia	10	13	17	17	0.4%	7	65%	4	34%	0	0%	T2	CS
Spain	66	103	238	240	5.4%	174	264%	137	133%	2	1%	T2,T3	CS,D
Sweden	81	111	38	40	0.9%	-42	-51%	-71	-64%	1	4%	T2,T3	CS,PS
EU-27	**6 619**	**9 610**	**5 048**	**4 466**	**100%**	**-2 153**	**-33%**	**-5 144**	**-54%**	**-582**	**-11.5%**	**-**	**-**

Abbreviations explained in the Chapter 'Units and abbreviations'. Presented methods and emission factor information refer to the last inventory year.

Figure 4.22: 2G - Other Product Manufacture and Use: SF_6 Trend in the EU-27



4.2.8 IPPU – non-key categories

Table 4.47 provides an overview on the role of non-key categories in the IPPU sector.

Table 4.47 Aggregated GHG emission from non-key categories in the IPPU sector

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 2. IPPU in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
2.A.3 Glass production: no classification (CO_2)	3 845.2	3 772.0	4 064.7	1.28%	219.5	6%	292.7	8%
2.B.1 Ammonia Production: no classification (CH_4)	2.1	2.4	1.8	0.00%	-0.2	-11%	-0.6	-24%
2.B.1 Ammonia Production: no classification (N_2O)	0.3	0.4	0.4	0.00%	0.2	54%	0.0	5%
2.B.10 Other chemical industry: no classification (CH_4)	181.6	132.0	129.2	0.04%	-52.4	-29%	-2.8	-2%
2.B.10 Other chemical industry: no classification (HFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.10 Other chemical industry: no classification (N_2O)	735.1	483.4	465.5	0.15%	-269.6	-37%	-17.9	-4%
2.B.10 Other chemical industry: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.10 Other chemical industry: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.10 Other chemical industry: no classification (SF_6)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.10 Other chemical industry: no classification (Unspecified mix of HFCs and PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 2. IPPU in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
2.B.3 Adipic Acid Production: no classification (CO_2)	26.5	14.2	23.6	0.01%	-2.9	-11%	9.4	66%
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production: no classification (CO_2)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production: no classification (N_2O)	3 673.7	1 267.7	1 035.4	0.33%	-2 638.3	-72%	-232.3	-18%
2.B.5 Carbide Production: no classification (CH_4)	6.2	9.5	15.6	0.00%	9.3	150%	6.0	63%
2.B.5 Carbide Production: no classification (CO_2)	1 798.9	211.0	246.5	0.08%	-1 552.4	-86%	35.5	17%
2.B.6 Titanium Dioxide Production: no classification (CO_2)	21.5	116.6	123.5	0.04%	102.0	474%	6.9	6%
2.B.7 Soda Ash Production: no classification (CO_2)	1 966.0	1 672.1	1 832.2	0.58%	-133.8	-7%	160.0	10%
2.B.8 Petrochemical and Carbon Black Production: no classification (CH_4)	1 090.5	1 268.8	1 262.2	0.40%	171.7	16%	-6.6	-1%
2.B.9 Fluorochemical Production: no classification (NF_3)	0.0	7.1	4.3	0.00%	4.3	100%	-2.8	-39%
2.B.9 Fluorochemical Production: no classification (PFCs)	3 955.4	541.3	440.4	0.14%	-3 515.0	-89%	-100.8	-19%
2.B.9 Fluorochemical Production: no classification (SF_6)	1 902.2	163.0	168.5	0.05%	-1 733.7	-91%	5.5	3%
2.C.1 Iron and Steel Production: no classification (CH_4)	406.0	119.7	137.4	0.04%	-268.6	-66%	17.7	15%
2.C.2 Ferroalloys Production: no classification (CH_4)	28.7	15.3	19.7	0.01%	-9.0	-31%	4.3	28%
2.C.2 Ferroalloys Production: no classification (CO_2)	4 659.7	1 725.1	2 169.5	0.68%	-2 490.2	-53%	444.4	26%
2.C.3 Aluminium Production: no classification (CO_2)	4 316.6	2 959.7	2 932.1	0.92%	-1 384.5	-32%	-27.6	-1%
2.C.3 Aluminium Production: no classification (SF_6)	14.1	0.0	0.0	0.00%	-14.1	-100%	0.0	0%
2.C.4 Magnesium Production: no classification (CO_2)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.C.4 Magnesium Production: no classification (HFCs)	0.0	12.9	12.4	0.00%	12.4	100%	-0.5	-4%
2.C.4 Magnesium Production: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.C.4 Magnesium Production: no classification (SF_6)	474.7	57.8	56.3	0.02%	-418.4	-88%	-1.5	-3%
2.C.5 Lead Production: no classification (CO_2)	391.5	201.5	204.4	0.06%	-187.1	-48%	3.0	1%
2.C.6 Zinc Production: no classification (CO_2)	1 610.3	999.5	1 017.5	0.32%	-592.8	-37%	18.0	2%
2.C.7 Other Metal Industry: no classification (CH_4)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.C.7 Other Metal Industry: no classification (CO_2)	464.8	219.1	526.6	0.17%	61.8	13%	307.5	140%
2.C.7 Other Metal Industry: no classification (HFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.C.7 Other Metal Industry: no classification (N_2O)	23.6	10.6	11.9	0.00%	-11.7	-49%	1.3	12%
2.C.7 Other Metal Industry: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 2. IPPU in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
2.C.7 Other Metal Industry: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.C.7 Other Metal Industry: no classification (SF_6)	742.7	7.9	7.9	0.00%	-734.8	-99%	0.0	0%
2.C.7 Other Metal Industry: no classification (Unspecified mix of HFCs and PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.D.1 Lubricant Use: no classification (CH_4)	1.9	0.4	0.5	0.00%	-1.5	-76%	0.1	15%
2.D.1 Lubricant Use: no classification (CO_2)	3 039.3	1 826.2	1 962.7	0.62%	-1 076.6	-35%	136.5	7%
2.D.1 Lubricant Use: no classification (N_2O)	2.7	2.5	2.7	0.00%	0.0	0%	0.3	10%
2.D.2 Paraffin Wax Use: no classification (CH_4)	0.2	0.4	0.4	0.00%	0.2	120%	0.0	3%
2.D.2 Paraffin Wax Use: no classification (CO_2)	631.4	1 025.9	1 114.2	0.35%	482.8	76%	88.3	9%
2.D.2 Paraffin Wax Use: no classification (N_2O)	0.7	1.3	1.4	0.00%	0.8	114%	0.1	11%
2.D.3 Other non energy products: no classification (CH_4)	0.3	0.5	0.4	0.00%	0.1	42%	0.0	-6%
2.D.3 Other non energy products: no classification (CO_2)	5 824.0	3 901.0	4 452.0	1.40%	-1 372.0	-24%	551.0	14%
2.D.3 Other non energy products: no classification (N_2O)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.1 Integrated Circuit or Semiconductor: no classification (HFCs)	68.6	35.2	35.2	0.01%	-33.4	-49%	0.0	0%
2.E.1 Integrated Circuit or Semiconductor: no classification (NF_3)	21.9	61.3	67.0	0.02%	45.1	206%	5.7	9%
2.E.1 Integrated Circuit or Semiconductor: no classification (PFCs)	392.9	460.9	507.3	0.16%	114.4	29%	46.5	10%
2.E.1 Integrated Circuit or Semiconductor: no classification (SF_6)	245.0	126.1	132.6	0.04%	-112.4	-46%	6.6	5%
2.E.2 TFT Flat Panel Display: no classification (HFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.2 TFT Flat Panel Display: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.3 Photovoltaics: no classification (HFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.3 Photovoltaics: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.4 Heat Transfer Fluid: no classification (HFCs)	0.0	0.1	0.1	0.00%	0.1	100%	0.0	0%
2.E.4 Heat Transfer Fluid: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.5 Other electronics industry: no classification (HFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.5 Other electronics industry: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.5 Other electronics industry: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.5 Other electronics industry: no classification (SF_6)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.E.5 Other electronics industry: no classification (Unspecified mix of HFCs and PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.1 Refrigeration and Air conditioning: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 2. IPPU in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
2.F.1 Refrigeration and Air conditioning: no classification (PFCs)	0.0	64.6	81.2	0.03%	81.2	100%	16.6	26%
2.F.1 Refrigeration and Air conditioning: no classification (SF_6)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.1 Refrigeration and Air conditioning: no classification (Unspecified mix of HFCs and PFCs)	0.0	1 355.9	1 350.6	0.42%	1 350.6	100%	-5.3	0%
2.F.2 Foam Blowing Agents: no classification (HFCs)	0.0	1 668.3	1 634.5	0.51%	1 634.5	100%	-33.8	-2%
2.F.2 Foam Blowing Agents: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.2 Foam Blowing Agents: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.2 Foam Blowing Agents: no classification (SF_6)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.2 Foam Blowing Agents: no classification (Unspecified mix of HFCs and PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.3 Fire Protection: no classification (HFCs)	0.0	2 360.2	2 373.2	0.75%	2 373.2	100%	13.0	1%
2.F.3 Fire Protection: no classification (PFCs)	0.0	10.7	10.1	0.00%	10.1	100%	-0.5	-5%
2.F.4 Aerosols: no classification (HFCs)	1.5	1 802.4	1 619.8	0.51%	1 618.4	110490%	-182.6	-10%
2.F.4 Aerosols: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.4 Aerosols: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.4 Aerosols: no classification (SF_6)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.4 Aerosols: no classification (Unspecified mix of HFCs and PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.5 Solvents: no classification (HFCs)	0.0	34.6	30.5	0.01%	30.5	100%	-4.1	-12%
2.F.5 Solvents: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.6 Other Applications: no classification (HFCs)	0.0	131.8	130.2	0.04%	130.2	100%	-1.6	-1%
2.F.6 Other Applications: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.6 Other Applications: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.6 Other Applications: no classification (SF_6)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.F.6 Other Applications: no classification (Unspecified mix of HFCs and PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.G.1 Electrical Equipment: no classification (HFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.G.1 Electrical Equipment: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.G.1 Electrical Equipment: no classification (SF_6)	2 344.5	1 467.3	1 427.1	0.45%	-917.4	-39%	-40.2	-3%
2.G.2 SF_6 and PFCs from Other Product Use: no classification (PFCs)	205.9	346.5	293.8	0.09%	87.8	43%	-52.7	-15%
2.G.2 SF_6 and PFCs from Other Product Use: no classification (SF_6)	4 274.6	3 580.9	3 039.3	0.96%	-1 235.3	-29%	-541.7	-15%
2.G.3 N_2O from Product Uses: no classification (N_2O)	4 462.2	2 515.1	2 485.4	0.78%	-1 976.8	-44%	-29.7	-1%
2.G.4 Other unspecifed product manufacture and use: no classification (CH_4)	65.2	79.7	79.9	0.03%	14.6	22%	0.2	0%

EU-27	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 2. IPPU in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
2.G.4 Other unspecifed product manufacture and use: no classification (CO_2)	158.6	124.8	122.8	0.04%	-35.8	-23%	-2.1	-2%
2.G.4 Other unspecifed product manufacture and use: no classification (HFCs)	0.0	15.2	18.7	0.01%	18.7	100%	3.6	24%
2.G.4 Other unspecifed product manufacture and use: no classification (N_2O)	4.4	14.5	6.1	0.00%	1.7	38%	-8.4	-58%
2.G.4 Other unspecifed product manufacture and use: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.G.4 Other unspecifed product manufacture and use: no classification (PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.G.4 Other unspecifed product manufacture and use: no classification (SF_6)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.G.4 Other unspecifed product manufacture and use: no classification (Unspecified mix of HFCs and PFCs)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.H Other Industrial Process and Product Use: no classification (CH_4)	6.8	9.8	9.7	0.00%	2.9	43%	-0.1	-1%
2.H Other Industrial Process and Product Use: no classification (CO_2)	112.9	106.3	110.0	0.03%	-2.9	-3%	3.7	4%
2.H Other Industrial Process and Product Use: no classification (HFCs)	0.0	4.6	4.6	0.00%	4.6	53288%	0.1	2%
2.H Other Industrial Process and Product Use: no classification (N_2O)	56.7	80.7	80.3	0.03%	23.6	42%	-0.4	-1%
2.H Other Industrial Process and Product Use: no classification (NF_3)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
2.H Other Industrial Process and Product Use: no classification (PFCs)	0.2	0.8	0.9	0.00%	0.7	385%	0.1	17%
2.H Other Industrial Process and Product Use: no classification (SF_6)	7.7	5.3	6.0	0.00%	-2	-22%	0.7	13%
2.H Other Industrial Process and Product Use: no classification (Unspecified mix of HFCs and PFCs)	289.9	96.0	121.1	0.04%	-169	-58%	25.1	26%

4.3 Methodological issues and uncertainties

The previous section presented for each EU key source in CRF Sector 2 an overview of the Member States' contributions to the key source in terms of level and trend, information on methodologies, emission factors, completeness and qualitative uncertainty estimates. Detailed information on national methods and circumstances is available in the Member States' national inventory reports.

4.3.1 Gap filling of Activity data

It is important to explain the reasons why the EU is not always able to provide EU-level AD or IEFs but has instead opted to transparently document what the MS have reported.

Because of the differences in methodological approaches used by countries the EU NIR provides overview tables for the activity data used by countries and the corresponding IEFs. Some of these tables do include a calculation of EU-level implied emission factors based on a number of countries. In those cases where (a) more than 75% of the emissions are calculated on basis of consistent activity data, and (b) the IEF has a reasonable degree of consistency (i.e. standard deviation divided by mean < 50%) we gap-filled activity data in the CRF. In these cases we are confident that the IEF included in the CRF provides reliable information to reviewers and adds to the transparency of the EU inventory. In all other cases we believe that an IEF in the CRF would be misleading because it would be based on a limited number of countries or based on very different methodological approaches which cannot be meaningfully aggregated. Due to the significant amount of time required, the CRF only includes gap filled activity data for 2021 and only for the EU key categories where the criteria above apply. In 2023 the following categories have been gap-filled:

- Lime production in 2.A.2
- Ammonia Production in 2.B.1

The method for gap filling includes four steps:

1. Emissions have been aggregated for those MS that are using the same activity data and that are reporting activity data and emissions (i.e. not using notation keys for either activity data or emissions. Usually the geographical coverage of these MS is smaller than EU.
2. These emissions have been divided by the aggregated activity data of those MS in order to derive an IEF for those MS.
3. The total emissions of the EU have been divided by this IEF in order to derive a gap-filled estimate for activity data for EU.

Table **4.48** shows the results for the gap filling of activity data for the two categories.

Table 4.48 Documentation of gap filling of activity data

Category	2021			
	Activity data Description	(kt)	IEF (t/t)	Emissions (kt)
2.A.2	Lime Production	23 024	0.73	24249
2.B.1	Ammonia Production	16 077	1.41	13691

4.3.2 Uncertainty estimates

Table 4.49 shows the total EU uncertainty estimates for the sector 'Industrial processes' and the uncertainty estimates for the relevant gases of each source category. The highest level uncertainty was estimated for PFCs from 2.F (158 %) and the lowest for CO_2 from 2.A (3 %). With regard to trend HFC from 2.F shows the highest uncertainty estimates, CO_2 from 2.A the lowest. For a description of the Tier 1 uncertainty analysis carried out for the EU-27 see Chapter 1.6.

Table 4.49 Sector 2 Industrial processes: Uncertainty estimates for the EU-27

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
2.A Mineral Industry	CO_2	134 061	104 086	-22.4%	3.0%	0.8%
2.A Mineral Industry	CH_4	0	0	0.0%	0.0%	0.0%
2.A Mineral Industry	N_2O	0	0	0.0%	0.0%	0.0%
2.B Chemical Industry	CO_2	51 281	45 566	-11.1%	7.8%	1.4%
2.B Chemical Industry	CH_4	1 118	1 296	15.9%	24.5%	7.0%
2.B Chemical Industry	N_2O	76 042	3 698	-95.1%	10.5%	3.6%
2.B Chemical Industry	HFC	10 262	392	-96.2%	10.5%	9.9%
2.B Chemical Industry	PFC	3 955	440	-88.9%	30.4%	9.3%
2.B Chemical Industry	Unspecified mix of HFCs and PFCs	0	0	0.0%	0.0%	0.0%
2.B Chemical Industry	SF_6	1 902	169	-91.1%	42.0%	21.2%
2.B Chemical Industry	NF_3	0	4	Inf	26.0%	Inf
2.C Metal Industry	CO_2	114 918	74 135	-35.5%	5.6%	1.1%
2.C Metal Industry	CH_4	402	134	-66.7%	10.6%	4.9%
2.C Metal Industry	N_2O	24	12	-49.5%	70.9%	35.1%
2.C Metal Industry	HFC	0	12	Inf	26.3%	Inf
2.C Metal Industry	PFC	16 129	255	-98.4%	5.0%	11.4%
2.C Metal Industry	Unspecified mix of HFCs and PFCs	0	0	0.0%	0.0%	0.0%
2.C Metal Industry	SF_6	1 046	13	-98.8%	20.5%	21.5%
2.C Metal Industry	NF_3	0	0	0.0%	0.0%	0.0%

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
2.D Non-energy products from fuels and solvent use	CO_2	9 302	7 321	-21.3%	45.8%	5.4%
2.D Non-energy products from fuels and solvent use	CH_4	2	1	-45.0%	52.6%	55.8%
2.D Non-energy products from fuels and solvent use	N_2O	3	4	22.6%	60.7%	28.3%
2.E Electronics industry	CO_2	0	0	0.0%	0.0%	0.0%
2.E Electronics industry	CH_4	0	0	0.0%	0.0%	0.0%
2.E Electronics industry	N_2O	0	0	0.0%	0.0%	0.0%
2.E Electronics industry	HFC	68	31	-54.9%	21.1%	28.3%
2.E Electronics industry	PFC	393	412	4.8%	9.9%	13.2%
2.E Electronics industry	Unspecified mix of HFCs and PFCs	0	0	0.0%	0.0%	0.0%
2.E Electronics industry	SF_6	245	121	-50.6%	19.0%	65.1%
2.E Electronics industry	NF_3	22	53	144.4%	17.3%	21.1%
2.F Product uses as substitutes for ODS	CO_2	0	0	0.0%	0.0%	0.0%
2.F Product uses as substitutes for ODS	CH_4	0	0	0.0%	0.0%	0.0%
2.F Product uses as substitutes for ODS	N_2O	0	0	0.0%	0.0%	0.0%
2.F Product uses as substitutes for ODS	HFC	6	56 401	920351.0 %	37.5%	191645.5%
2.F Product uses as substitutes for ODS	PFC	0	30	Inf	157.7%	Inf
2.F Product uses as substitutes for ODS	Unspecified mix of HFCs and PFCs	0	0	0.0%	0.0%	0.0%
2.F Product uses as substitutes for ODS	SF_6	0	0	0.0%	0.0%	0.0%
2.F Product uses as substitutes for ODS	NF_3	0	0	0.0%	0.0%	0.0%
2.G Other product manufacture and use	CO_2	159	123	-22.6%	11.4%	1.4%
2.G Other product manufacture and use	CH_4	65	80	22.4%	35.2%	8.9%
2.G Other product manufacture and use	N_2O	2 302	1 698	-26.3%	9.9%	2.7%
2.G Other product manufacture and use	HFC	0	15	Inf	18.5%	Inf
2.G Other product manufacture and use	PFC	206	294	42.7%	22.4%	9.5%
2.G Other product manufacture and use	Unspecified mix of HFCs and PFCs	0	0	0.0%	0.0%	0.0%
2.G Other product manufacture and use	SF_6	2 378	1 546	-35.0%	40.9%	16.0%

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
2.G Other product manufacture and use	NF_3	0	0	0.0%	0.0%	0.0%
2.H Other	CO_2	92	44	-51.9%	9.5%	5.5%
2.H Other	CH_4	7	10	42.7%	21.2%	9.0%
2.H Other	N_2O	57	80	41.6%	21.0%	8.7%
2.H Other	HFC	0	5	53288.4%	59.4%	31588.6%
2.H Other	PFC	0	1	385.1%	60.0%	230.9%
2.H Other	Unspecified mix of HFCs and PFCs	0	0	0.0%	0.0%	0.0%
2.H Other	SF_6	8	6	-22.1%	60.3%	13.3%
2.H Other	NF_3	0	0	0.0%	0.0%	0.0%
2 (where no subsector data were submitted)	*all*	18 221	19 448	6.7%	11.6%	9.8%
Total - 2	**all**	**444 676**	**317 934**	-28.5%	**8.0%**	**2.8%**

N*ote:* *Emissions are in Gg CO_2 equivalents; trend uncertainty is presented as percentage points; the sum of the source category emissions may not be the total sector emissions because uncertainty estimates are not available for all source categories*

4.4 Sector-specific quality assurance and quality control

There are several arrangements for improving the quality of GHG emissions from industrial processes: (1) Before and during the compilation of the EU GHG inventory, a number of assessments are made of the Member States data in particular for time series consistency of emissions and implied emission factors, comparisons of implied emission factors across countries and checks of internal consistency. Table 3.127 (in the Energy chapter), summarizes the main checks carried out on Member States' submissions. Internal reviews are carried out for selected source categories. In 2006 the following source categories were reviewed by countries experts: 2A Mineral Products, 2B Chemical Industry, 2C Iron and Steel Production and Fluorinated Gases, 2E Production of Halocarbons and SF_6 and 2F Consumption of Halocarbons and SF_6. In 2008, completeness and allocation issues were reviewed by countries experts for all source categories in Industrial Processes. In 2012 a comprehensive review was carried out for all sectors and all EU countries in order to fix the base year emissions under the EU Effort Sharing Decision. (ESD review 2012). For the inventory 2005 plant-specific data was available from the EU ETS for the first time. This information was used by EU Member States for quality checks and as an input for calculating total CO_2 emissions for the sectors Energy and Industrial Processes in the 2005 report (see Section 1.4.2). During the ESD review 2012 consistency checks were carried out between EU ETS data and the inventory estimates.

In 2013 two workshops were organized in the context of the MS assistance project with the aim of supporting Member States in improving their inventories related to the use of EU ETS data and related to F-gases.

In 2014, the initial checks for F-gases were extended: (1) the time series of HFC emissions of the EU Member States was checked at 3-digit level (2.F.1, 2.F.2,…) and at 4-digit level for 2.F.1 (i.e. 2.F.1.1, 2.F.1.2,…); (2) time series and comparability across EU Member States was checked for per capita HFC emissions of category 2-F.1 and its subcategories (2.F.1.1, 2.F.1.2, …). As a result of the checks, 74 issues were clarified with EU Member States. Furthermore, in 2014 additional quality checks of the

EU NIR chapter were carried out in order to improve the consistency between the CRF tables and the EU NIR and consistency of tables and figures with text in the EU NIR.

In recent years, comprehensive ESD reviews were performed in 2016 and 2020, and annual ESD reviews were conducted in 2017, 2018, 2019, 2021 and 2022.

Since 2016, additional focus is put on the introduction of alternatives to F-gases in the quality checks of Member States' submissions. This is relevant in the context of the HFC phase-down under the EU F-gas Regulation.

5 AGRICULTURE (CRF SECTOR 3)

Half the European Union's land is farmed. This fact alone highlights the importance of farming for the EU's natural environment. Farming and nature exercise a profound influence over each other. Farming has contributed over the centuries to creating and maintaining a variety of valuable semi-natural habitats. Today these shape the majority of the EU's landscapes and are home to many of the EU's richest wildlife. Farming also supports a diverse rural community that is not only a fundamental asset of European culture, but also plays an essential role in maintaining the environment in a healthy state[28].

The links between the richness of the natural environment and farming practices are complex. While many valuable habitats in Europe are maintained by extensive farming, and a wide range of wild species rely on this for their survival, agricultural practices can also have an adverse impact on natural resources. Pollution of soil, water and air, fragmentation of habitats and loss of wildlife can be the result of inappropriate agricultural practices and land use.

Agriculture in Europe is determined by the Common Agricultural Policy (CAP) of the European Union. The CAP dates from 1957, and its foundations are entrenched in the Treaty of Rome. Initially, the emphasis of the CAP was to increase agricultural productivity, partly for food security reasons, but also to ensure that the EU had a viable agricultural sector and that consumers had a stable supply of affordable food (Gay et al., 2005). With the MacSharry reform of 1992 several steps were taken by the EU to shift CAP subsidies away from price and market support towards direct support for farmers. This was further pursued with the Agenda 2000 reform, as signified by the shift in focus towards the maintenance and enhancement of the rural environment and the growing recognition of agriculture as a multifunctional activity. In environmental terms, the focus is on less-favoured areas and areas with environmental restrictions, and on agricultural production methods designed to protect the environment and to maintain the countryside.

However, price support and income payments, together with milk quotas, remained the dominant support measures. The 2003 CAP reform made further progress in the direction initiated by the Agenda 2000 reform, by aiming to make European agriculture more market oriented and giving a stronger focus to environmental protection. With the CAP reform, cross-compliance became an obligatory element of the CAP. Cross compliance links direct payments to respecting a number of statutory management requirements and to maintain all agricultural land in good agricultural and environmental conditions (EC 2003)[29].

- "Statutory management requirements" (SMR, Annex III of Regulation (EC) No 1782/2003) which are set in 19 community legislative acts on environment, food safety, animal health and welfare.
- The obligation to maintaining land in good agricultural and environmental conditions (GAECs) and maintaining permanent pasture at level at 1.5.2004. Definitions of GAEC are specified at national or regional level and should warrant appropriate soil protection, ensure a minimum level of maintenance of soil organic matter and soil structure and avoid the deterioration of habitats.

In 2013, the Council of the EU Agriculture Ministers adopted four Basic Regulations for a reformed CAP following a CAP Health Check[30] in 2008 and a Commission Communication on the CAP towards 2020[31] in 2011. The four legislative texts that regulate the post-2013 CAP are (i) Rural Development: Regulation

28 http://ec.europa.eu/agriculture/envir/index_en.htm

29 http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32003R1782

30 http://ec.europa.eu/agriculture/healthcheck/index_en.htm

31 https://ec.europa.eu/agriculture/cap-post-2013_en

1305/2013[32]; (ii) "Horizontal" issues such as funding and controls: Regulation 1306/2013[33]; (iii) Direct payments for farmers: Regulation 1307/2013[34]; (iv) Market measures: Regulation 1308/2013[35].

With the adoption of the 2013 CAP reform, the environment concerns received an enhanced focus being materialised by explicitly linking the agricultural support to "agricultural practices beneficial to the climate and environment" (so called 'CAP greening'). Agro-environmental indicators have been identified as useful tools to perform this task, especially since they allow for the assessment of territorial impacts. The monitoring and evaluation of CAP performance is carried out through indicators (EC 2006[36], 2001[37], 2000[38]). Green direct payments account for 30 % of EU countries' direct payment budgets. Farmers receiving an area-based payment have to make use of various straightforward, non-contractual practices that benefit the environment and the climate. These require action each year. They include:

- diversifying crops;
- maintaining permanent grassland; and
- dedicating 5 % of arable land to ecologically beneficial elements ('ecological focus areas').

Currently, the next reform of the CAP is under discussion enabling agriculture in Europe by its modernisation and simplification to face new challenges, such related to economic prospects and care for the environment including action over climate change and maximise its contribution to the Commission's priorities and to the Sustainable Development Goals[39].

The **Nitrates Directive** (Council Directive 91/676/EEC) is the SMR with the largest impact on greenhouse gas emissions from agriculture. The directive aims at reducing and preventing water pollution caused by nitrates from agricultural sources with the goal that nitrate concentrations in groundwater will not exceed 50 mg NO_3^- l^{-1} and listing codes of good practice (Annex II A) to be implemented by the farmers on a voluntary basis. Nitrate vulnerable zones (NVZ) must be designated on the basis of monitoring results which indicate that the groundwater and surface waters in these zones are or could be affected by nitrate pollution from agriculture. The action program must contain mandatory measures relating to: (i) periods when application of animal manure and fertilizers are prohibited; (ii) capacity of and facilities for storage of animal manure; and (iii) limits to the amounts of animal manure and fertilizers applied to land.

The action programmes need to be implemented by farmers within NVZs on a compulsory basis. These programmes must include measures already included in Codes of Good Agricultural Practice, which become mandatory, and other measures, such as limitation of fertilizer application (mineral and organic), taking into account crop needs and all nitrogen inputs and soil nitrogen supply, with maximum amount of livestock manure to be applied. Every four years countries are required to report on nitrates concentrations in groundwaters and surface waters; eutrophication of surface waters; assessment of the impact of action programme(s) on water quality and agricultural practices; revision of NVZs and action programme(s); estimation of future trends in water quality.

32 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0487:0548:en:PDF

33 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0549:0607:en:PDF

34 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0608:0670:en:PDF

35 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0671:0854:en:PDF

36 EC (2006). Development of agri-environmental indicators for monitoring the integration of environmental concerns into the common agricultural policy. Communication from the Commission to the Council and the European Parliament. COM(2006) 508 final. Commission of the European Communities, Brussels.

37 EC (2001). Statistical Information needed for Indicators to monitor the Integration of Environmental concerns into the Common Agricultural Policy. Communication from the Commission to the Council and the European Parliament. COM(2001) 144 final. Commission of the European Communities.

38 EC (2000). Indicators for the Integration of Environmental Concerns into the Common Agricultural Policy. Commission of the European Communities.

39 https://ec.europa.eu/agriculture/consultations/cap-modernising/2017_en

This has affected emissions in most countries:

- In Belgium, Manure Action Plans (MAP, based on the Nitrate Directive) in Flanders affected NH_3 volatilization from manure application. The first action plan in 1991 regulated the reduced period in which manure can be spread and foresaw low-emission techniques for the application of manure on land. The MAP2bis in 2000 focused on the reduction of the manure surplus and manure processing in order to reduce the NH_3 emissions from manure application on land. Other MAP's followed, which have had a positive effect on the NH_3 and N_2O emissions.
- In Denmark, the environmental policy has introduced a series of measures to prevent loss of nitrogen from agricultural soils to the aquatic environment. The measures include improvements to the utilization of nitrogen in manure, a ban on manure application during autumn and winter, increasing area with winter-green fields to catch nitrogen, a maximum number of animals per hectare and maximum nitrogen application rates for agricultural crops. All farmers are obliged to do N-mineral accounting at farm and field level with the N-excretion data from FAS (Faculty of Agricultural Sciences). The N figures also include the quantities of mineral fertilizers bought and sold. Suppliers of mineral fertilizers are required to report all N sales to commercial farmers to the Plant Directorate. An active environmental policy has brought about a decrease in the N-excretion and a decrease of emission per produced animal, because of more efficient feeding. As a result of increasing requirements to reduce the nitrogen loss to the environment, the consumption of nitrogen in synthetic fertilizer has more than halved since 1990.
- In the Netherlands, manure and fertilizer policy influences livestock numbers. Especially young cattle, pigs and poultry numbers decreased by the introduction of measures like buying up part of the so-called pig and poultry production rights (ceilings for total animal numbers) by the government and lowering the maximum nutrient application standards for manure and fertilizer. However, greater compliance to standards and requirements for animal welfare and the housing of animals may contribute to increasing emissions (so-called pollution swapping).

Beside the environmentally-targeted directives, also the first pillar of the CAP (dealing with market support in contrast to pillar two covering rural development measures) had a strong impact on the greenhouse gas emissions from agriculture in Europe, namely through the milk quota system, which lead to a strong reduction of animal numbers in the dairy sector to compensate for the increasing animal performance during the last decades. The milk quota system ended in 2015.

Other important policies affecting greenhouse gas emissions from agriculture, particularly by addressing the abatement of air pollution through the control of NO_X and NH_3 emissions include, amongst others:

- The 1999 Gothenburg Protocol under the Convention on Long Range Transboundary Air Pollution (CLRTAP[40]) to 'Abate Acidification, Eutrophication and Ground-level Ozone', revised in 2012 setting national emission reduction commitments to be achieved by 2020 and beyond;
- The National Emission Ceilings Directive (NEC - Directive 2016/2284/EC[41]) sets upper limits for each country for the total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution. It has been updated in 2016[42] setting new objectives for EU air policy for 2020 and 2030;
- The Industrial Emission Directive (IED[43][44]), which was established in 1996, and aims at minimizing pollution from point sources, i. e., intensive animal production facilities (pig and poultry farms, with more than 2000 fattening pigs (over 30 kg); more than 750 sows or more

40 http://www.unece.org/env/lrtap/multi_h1.html

41 https://eur-lex.europa.eu/legal-content/EN/X/?qid=1554903780611&uri=CELEX:32016L2284

42 http://eur-lex.europa.eu/legal-content/EN/X/PDF/?uri=CELEX:32016L2284&from=EN

43 http://eur-lex.europa.eu/legal-content/EN/X/?uri=CELEX:32010L0075

44 http://ec.europa.eu/environment/industry/stationary/index.htm

than 40,000 head of poultry). These are required under the directive to apply control techniques for preventing NH_3 emissions according to Best Available Technology (BAT).

Legislation related with animal health may also affect emissions through changes in specific parameters. That is the case of Spain, where the methane conversion factor (Ym), and therefore the implied emission factor for CH_4 emissions from enteric fermentation from swine decreased in 2006, partly due to the ban of the use of growth-promoting antibiotics in animal feeding. This resulted in a radical change in feeding conditions: raw materials with lowest digestibility were removed and replaced by carbohydrates (mainly cereals). To increase higher digestibility and quality protein supply, the soybean flour 44 was systematically replaced by soybean 47 which has higher protein content. Also, affordable synthetic amino acids and digestive enzymes were systematically introduced. In addition, during the same year, the regulation on additives used in animal feeding was published, thus forcing the withdrawal of products that were being used to date, in order to make the digestion of other diet components easier.

Structural changes are caused also by the general development of countries. For example, in Finland, the membership in the EU resulted in changes in the economic structure followed by an increase in the average farm size and a decrease in the number of small farms (Pipatti, 2001), causing also a decrease in the livestock numbers for most animal types. Swedish agriculture has undergone radical structural changes and rationalizations over the past 50 years. One fifth of the Swedish arable land cultivated in the 1950s is no longer farmed. Closures have mainly affected small holdings and those remaining are growing larger. In 1999, some 31,000 agricultural holdings were livestock farms, 14,000 were purely crop husbandry farms, and only 5,000 were a combination of the two. Livestock farmers predominately engage in milk production and the main crops grown in Sweden are grain and fodder crops. The decrease of agricultural land area has continued since Sweden joined the European Union in 1995 and the acreages of land for hay and silage has increased. Organic farming increased from 3 % of the arable land area in 1995 to 17 % in 2007.

In the case of Croatia, we can observe livestock population drops in 1992 due to the beginning of the Croatian War of Independence in 1991/1992, which significantly influenced animal production for most animal categories. The countries which formed part of the communist block suffered structural changes when they changed regime, mainly due to privatizations. Lithuania shows an important decrease of non-dairy cattle population in 1993-1994, after the collapse of the Soviet Union and the restoration of independence in 1990, when changes in economy and significant reforms occurred. The reform included the re-establishment of private ownership and management in agriculture sector. Legislation defined dismemberment of collective farms, but they did not definitively ensure their replacement by at least equally productive private farms and corporations. The decrease in cattle population occurred also due to high costs in production, product differences in prices and lack of market for meat and milk. Similarly, Bulgaria shows a decline in cattle numbers in 1992-1995, after the communist period, due to the reforms in agricultural holdings, together with a decrease in the quantities of inorganic fertilizers. Poland, in turn, had a significant drop in cattle population since mid-1990s up to 2002 due to intentional limitations of cattle breeding related to weakening demand for beef meat. Further increase in population could be connected with the prospect of inclusion of Poland into the EU planned for 2004 and joining the common agricultural policy, with expectations for stable agricultural production. An increase in population in 2012 was probably triggered by the improved economic situation for the agricultural markets. The economic situation seems to highly influence the use of fertilizers in the EU countries, especially for liming and urea fertilization. In Poland, limestone/dolomite fertilizer use dramatically decreased after 2004 as a result of a cut in their subsidies for farmers. In 2006, limestone use was lower by 40 % than in previous year, despite remaining high need of soils. In Lithuania, a sharp increase of N input from application of other organic fertilizers took place in 2013, caused by changes in national circumstances when using financial resources of 2004-2006 EU ISPA/Cohesion funds Lithuania started to improve municipal solid waste management system. Also in Italy, fertilizer use was affected by the economic crisis (2009-2011), which led to a reduction in the application of all synthetic fertilizers, in particular urea. In 2012, a recovery from the sharp decline was recorded. In the same line, Slovenia reports a strong decrease in urea fertilizers in 1991 and 2008 due to the economic crisis and high prices of fertilizers.

Similarly, the area used for rice cultivation suffers large changes for both continuous flooded and intermittently flooded rice as consequences of economic and environmental pressures. For emissions at EU-level, the combination of emissions from rice from different countries and cultivation systems contributes additionally to fluctuations. Emissions from burning of agricultural residues also have fluctuating trends due to the heterogeneity of the emission source: it is a composite emission category over countries and crops with different shares of residues burned and different shares of agricultural area and, consequently, large fluctuations are to be expected.

5.1 Overview of sector

In the year 2021, CO_2, CH_4 and N_2O emissions from CRF sector 3 Agriculture were 55.9 %, 73.6 %, and 0.37 % of total CH_4, N_2O and CO_2 EU emissions, respectively. Total emissions from agriculture were 378 Mt CO_2-eq with contributions from CH_4, N_2O, and CO_2 of 232 Mt CO_2-eq, 137 Mt CO_2-eq and 9.8 Mt CO_2-eq, respectively. Thus, CH_4, N_2O, and CO_2 contributed with 7.0 %, 4.1 % and 0.30 % to total EU GHG emissions.

Figure 5.1 shows the development of total GHG emissions from agriculture from 485 Mt CO_2-eq in 1990 to 378 Mt CO_2-eq in 2021. The reduction of emissions was most pronounced for CO_2 with a decrease of 30.8 %, followed by N_2O and CH_4 with respectively a decrease of 21.7 % and 21.6 %. The cut was most pronounced in the first decade with a total reduction of 15.5 % between 1990 and 2000, a further decrease by between 2000 and 2005, while remaining constant since 2005 (change -2.8 %).

Figure 5.2 shows that largest reductions occurred in the largest key sources CH_4 from *3.A.1: Cattle* and N_2O from *3.D.1: Direct emissions from managed soils*. The main reasons for this are decreasing use of fertilizer and manure and declining cattle numbers in most countries. Figure 5.3 shows the distribution of agricultural GHG emissions among the different source categories for the year 2021.

Figure 5.1: EU GHG emissions for 1990-2021 from CRF Sector 3: 'Agriculture' in CO_2 equivalents (Mt)

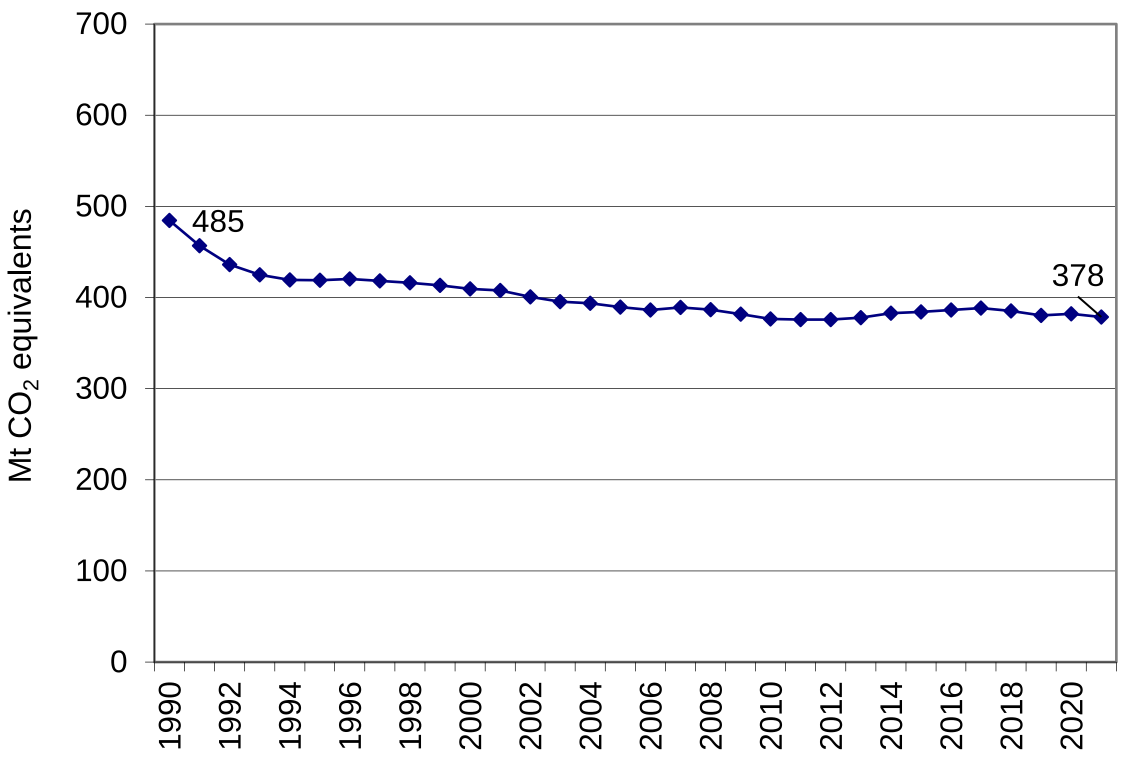


Figure 5.2: **Absolute change of GHG emissions by large key source categories 1990-2021 in CO_2 equivalents (Mt) in CRF Sector 3: 'Agriculture'**

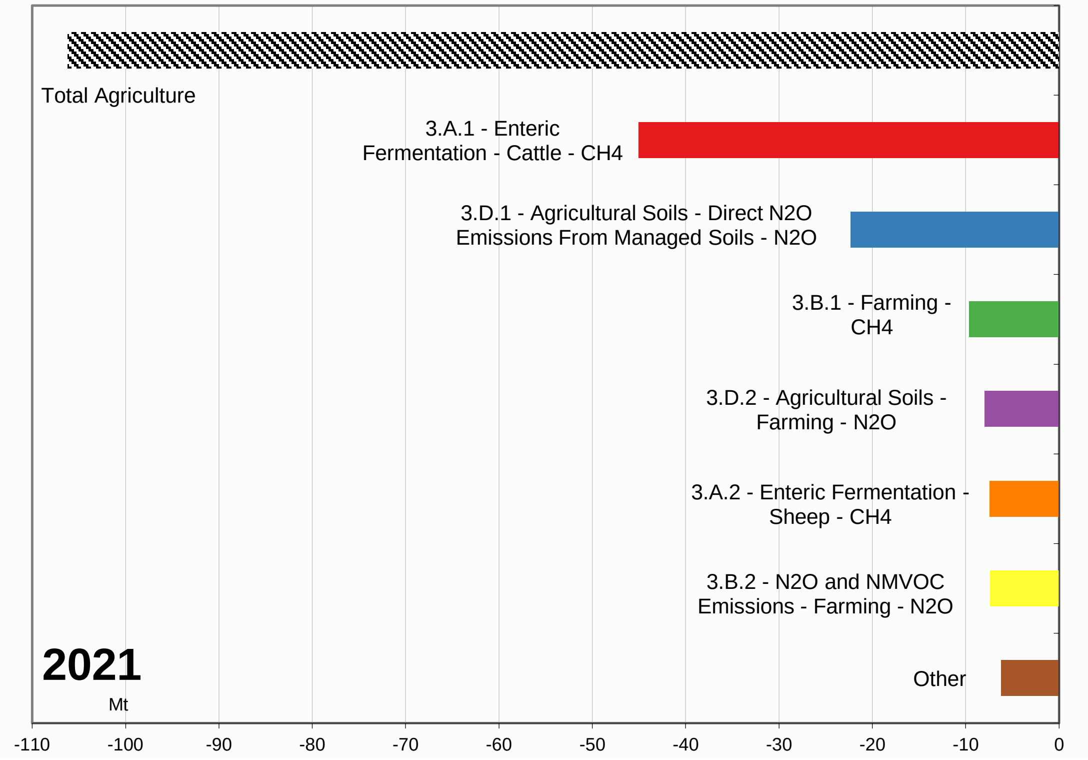
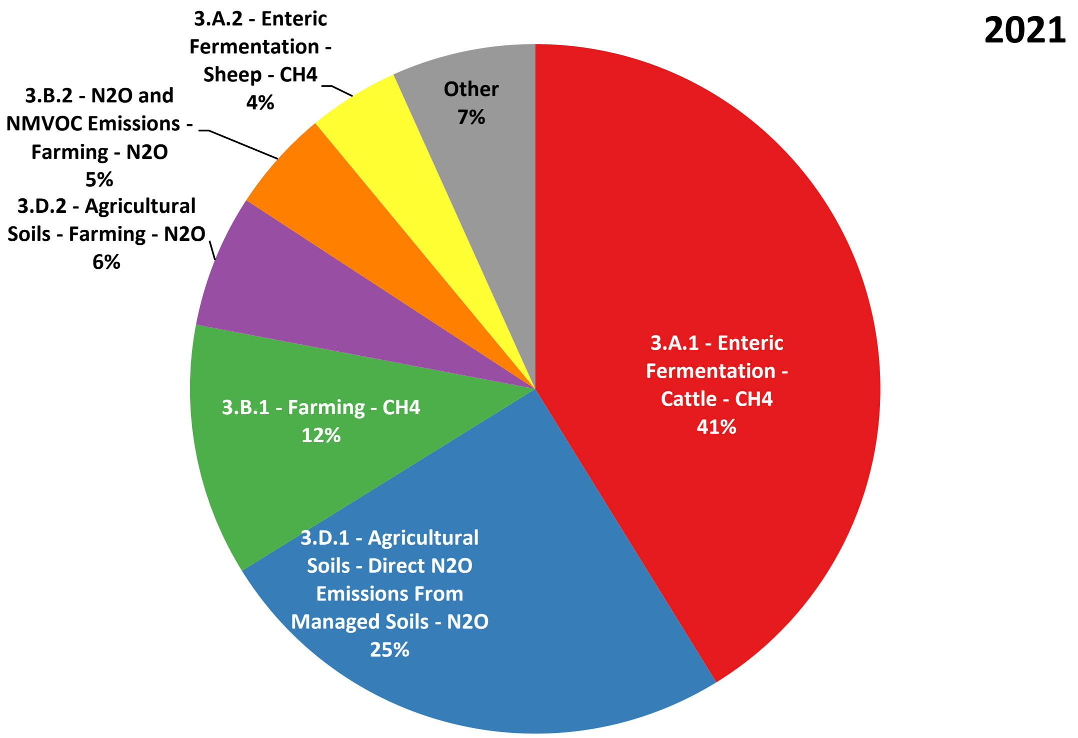


Figure 5.3: **Distribution of agricultural GHG emissions among the different source categories for the year 2021**



5.2 Emission trends

In this section we analyze the contribution of the different emission categories and the individual countries to the overall trend of emissions from the EU agricultural sector. Table 5.1 shows the different emission categories, their contribution to total emissions in the EU sector and their contribution to the trend 1990-2021 and 2020-2021. A negative share of the trend means that the emissions in that category are evolving in the opposite direction to those of the EU.

Total emissions from agriculture have decreased by 21.9 % compared to 1990, and 51 % of this reduction is due to sector 3.A. Another important sector in determining long-term emission trends is 3.D.1 which accounts for 21 % of the total decrease in agricultural emissions, followed by 3.B.1 (9 %), 3.D.2 (7.5 %) and 3.B.2 (7 %), while all the other categories contribute less. The decrease in emissions is due to the decrease in the cattle population (29.6 % between 1990 and 2021) and the decrease in the quantities applied of fertilizers, both synthetic and organic (25.2 % and 14.3 % decrease, respectively).

Table 5.1 Contribution of the different emission categories to the total trend in emissions from the agricultural sector, compared to the share of emissions of those categories from the total of the sector

Emission category	Gas	Contribution to total agricultural emissions (2021)	Share of trend 1990-2021	Share of trend 2020-2021
3.A	CH_4	48%	51%	34%
3.B.1	CH_4	12%	9%	25%
3.B.2	N_2O	5%	7%	9%
3.C	CH_4	1%	0%	0%
3.D.1	N_2O	25%	21%	13%
3.D.2	N_2O	6%	7%	5%
3.F	CH_4	0%	1%	6%
3.F	N_2O	0%	0%	2%
3.G	CO_2	1%	4%	-8%
3.H	CO_2	1%	0%	12%
3.I	CO_2	0%	0%	2%

The data presented in Table 5.2 shows the contribution of the different emission categories in the individual countries to the overall emission trend of EU agriculture (2020-2021). The impacts on trends (both positive or negative) are mostly proportional to the importance of the MS to the overall agricultural emissions. Different figures are observed for the short-term trends, where the contribution of the emission categories is not linked to their weight in total emissions, and some of them have different sign from changes in the overall emissions of the sector. For the whole sector, there was a very slight decrease of emissions between 2020 and 2021 (1 % of total emissions). The main contributor to the total decrease in agricultural emissions from last year is category 3.A (34 % of the total trend), followed by 3.B.1, 3.D.1, and 3.H (25 %, 13 %, and 12 %, respectively). The contribution of the other categories is approximately 15 % of total change.

Table 5.2 Contribution to EU emission trends (2020-2021) per country and emission (%)

Country	3.A	3.B.1	3.B.2	3.D.1	3.D.2	3.G	3.H	Share of total EU emissions from agriculture in 2021
FRK	23.96	4.94	2.17	-1.68	-0.36	0.87	2.36	17.58
DEU	16.10	9.61	2.23	3.91	1.59	0.10	0.96	14.50
ESP	-4.19	1.19	0.04	3.15	1.55	0.00	6.50	9.12
POL	-4.60	0.87	1.49	1.07	0.35	-0.99	0.91	9.04
ITA	2.83	2.65	1.00	8.90	2.64	-0.44	1.66	8.69

Country	3.A	3.B.1	3.B.2	3.D.1	3.D.2	3.G	3.H	Share of total EU emissions from agriculture in 2021
IRL	-10.88	-0.59	-0.43	-5.50	-0.46	-5.62	0.21	6.09
ROU	8.81	0.56	0.28	-16.64	-4.33	-0.38	-0.35	5.09
NLD	2.59	4.36	0.79	3.43	0.11	0.21	-0.26	4.77
DNM	-0.73	2.10	0.75	7.13	0.28	-0.61	-0.01	3.21
BEL	1.49	0.37	0.20	0.58	0.17	0.00	0.07	2.50
GRC	-0.25	0.06	0.01	2.31	0.73	NA	0.11	2.14
CZE	0.08	0.00	-0.02	-2.73	-0.90	0.53	-0.56	2.08
PRT	-0.26	-0.04	-0.10	1.31	0.36	0.07	0.17	1.93
AUT	-0.28	-0.07	-0.08	-0.22	-0.02	0.00	0.04	1.92
HUN	-0.50	-0.85	-0.04	0.26	0.06	0.04	0.24	1.91
SWE	-0.36	0.01	0.11	3.67	0.08	0.00	-0.01	1.77
FIN	1.17	0.42	0.14	1.08	0.24	0.03	0.01	1.67
BGR	-1.18	-0.49	-0.11	-1.50	-0.19	0.00	-0.01	1.62
LTU	-0.26	-0.21	-0.06	4.68	1.27	-0.54	0.23	1.15
HRV	0.34	0.05	0.09	-0.20	-0.07	-0.34	0.12	0.72
SVK	0.57	0.33	0.24	0.23	1.43	0.07	0.00	0.65
LVA	0.12	-0.16	-0.01	0.25	0.08	-0.34	-0.01	0.60
SVN	0.09	0.00	0.00	-0.12	-0.03	-0.03	0.07	0.48
EST	-0.05	0.07	-0.01	0.01	-0.06	-0.36	0.00	0.42
LUX	0.17	0.00	0.01	-0.05	0.00	0.03	0.00	0.19
CYP	-0.64	-0.12	-0.03	0.13	0.01	NA	0.00	0.17
MLT	0.02	0.00	0.00	0.02	0.01	NA	NA	0.02
Total	34.10	25.00	8.70	13.50	4.60	-7.70	12.40	100.00

5.3 Source categories and methodological issues

In this section, we present the information relevant for EU key source categories in the sector 3 Agriculture.

Key source categories identified are:

- CH_4 emissions from source category 3.A.1 - Cattle.
- CH_4 emissions from source category 3.A.2 - Sheep.
- CH_4 emissions from source category 3.A.4 - Other livestock.
- CH_4 emissions from source category 3.B.1 - Manure management.
- N_2O emissions from source category 3.B.2 - Manure management.
- N_2O emissions from source category 3.D.1 - Direct N_2O emissions from managed soils.
- N_2O emissions from source category 3.D.2 - Indirect emissions from managed soils

The data presented in Table 5.3 shows emissions from key categories in the base year and in the last reported year, whether they are identified as key due to the level or to the trend in emissions and the share of emissions in the category which are calculated using a Tier 2 or Tier 3 method. CH_4 emissions from enteric fermentation from dairy and non-dairy cattle are calculated with sophisticated methods in all countries, with only Cyprus using partially T1 for non-dairy cattle. For enteric fermentation of sheep, the situation is more divided with 14 countries use Tier 1 methods and 13 using higher tiers or country specific values (including those with higher emissions). For sector 3.A.4, only one country (France) is using higher tiers, with all the others combining different methods. In 3.B.1 it is also more mixed, with Germany, Denmark, Finland, France, Croatia and Austria using exclusively higher tiers. For 3.B.2, most of the countries use combined approaches, except Cyprus and Greece. For the calculation of emissions from soils, the share of high tiers is very low; only Denmark, Sweden and Finland use solely higher tiers in 3.D.2, while there are no countries using only high tiers in 3.D.1, but only some combining high with low tier methods. For category 3.G.1, all the countries use tier 1 methods.

Table 5.3 Key categories for the EU (Agriculture - sector excerpt). Emissions in kt CO_2 eq.

Source category gas	kt CO_2 equ.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
3.A.1 Enteric Fermentation: Cattle (CH_4)	200 979	155 937	T	L	L	99.9 %
3.A.2 Enteric Fermentation: Other Sheep (CH_4)	23 561	16 111	0	L	L	82.8 %
3.A.4 Enteric Fermentation: Other livestock (CH_4)	6 545	6 070	0	0	L	63.8 %
3.B.1 CH_4 Emissions: Farming (CH_4)	54 426	44 772	T	L	L	99.8 %
3.B.2 N_2O and NMVOC Emissions: Farming (N_2O)	25 555	18 131	0	L	L	98.2 %
3.D.1 Agricultural Soils: Direct N_2O Emissions From Managed Soils (N_2O)	116 774	94 410	T	L	L	48.6 %
3.D.2 Agricultural Soils: Farming (N_2O)	31 590	23 584	0	L	L	43.2 %
3.G.1 Limestone CaCO3: Farming (CO_2)	6 701	4 744	0	0	L	0%

Other source categories are not identified as key source in the analysis at EU level and are therefore not further discussed here. Emissions from source category J - other agriculture emissions are reported only from Germany (digestion of energy crops).

For each of the above-mentioned source categories, data on the countries contributing most to EU emissions and to EU emission trends are provided, as well as information on relevant activity data and IEFs and other parameters, if relevant.

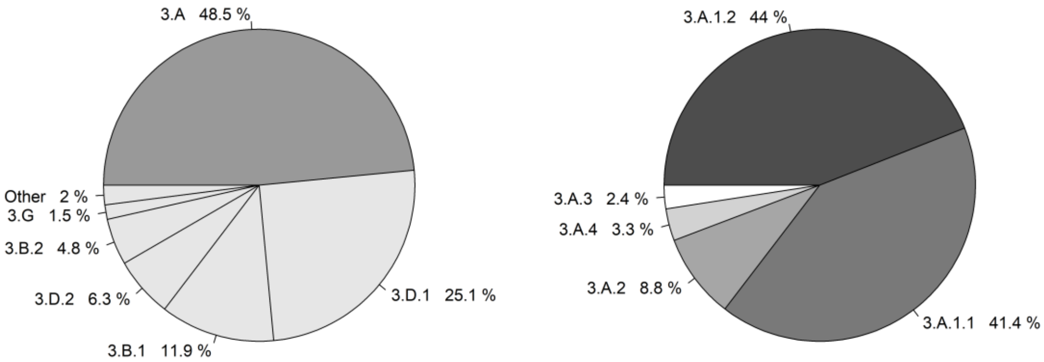
Many countries recognize that in the agriculture sector the emissions from the different categories are inherently linked and are best estimated in a comprehensive model that covers not only greenhouse gases (CH_4 and N_2O) in a consistent manner, but also ammonia. Estimations of ammonia emissions are required for reporting under the Convention on Long-Range Transboundary Air Pollution and are needed to estimate indirect N_2O emissions. Hence, several countries have developed comprehensive models covering consistently different source categories and different gases.

5.3.1 Enteric fermentation (CRF Source Category 3.A)

In 2021 CH_4 emissions in source category *3.A - Enteric Fermentation* in EU were 182545.5 kt CO_2 equivalent. This corresponds to 5.5 % of total EU GHG emissions and 44 % of total EU CH_4 emissions. They make 48.2 % of total agricultural emissions and 79 % of total agricultural CH_4 emissions. It is thus the largest GHG source in agriculture and the largest source of CH_4 emissions. The main sub-categories are 3.A.1.2 (Non-Dairy Cattle), 3.A.1.1 (Dairy Cattle) and 3.A.2 (Sheep) as shown in Figure 5.4. Emissions are also reported for 3.A.4 (Other Livestock) and 3.A.3 (Swine). CH_4 emissions from Enteric Fermentation for 'Other Livestock' are reported for the categories Buffalo, Deer, Goats, Horses, Mules and Asses, Poultry, and Other Other Livestock.

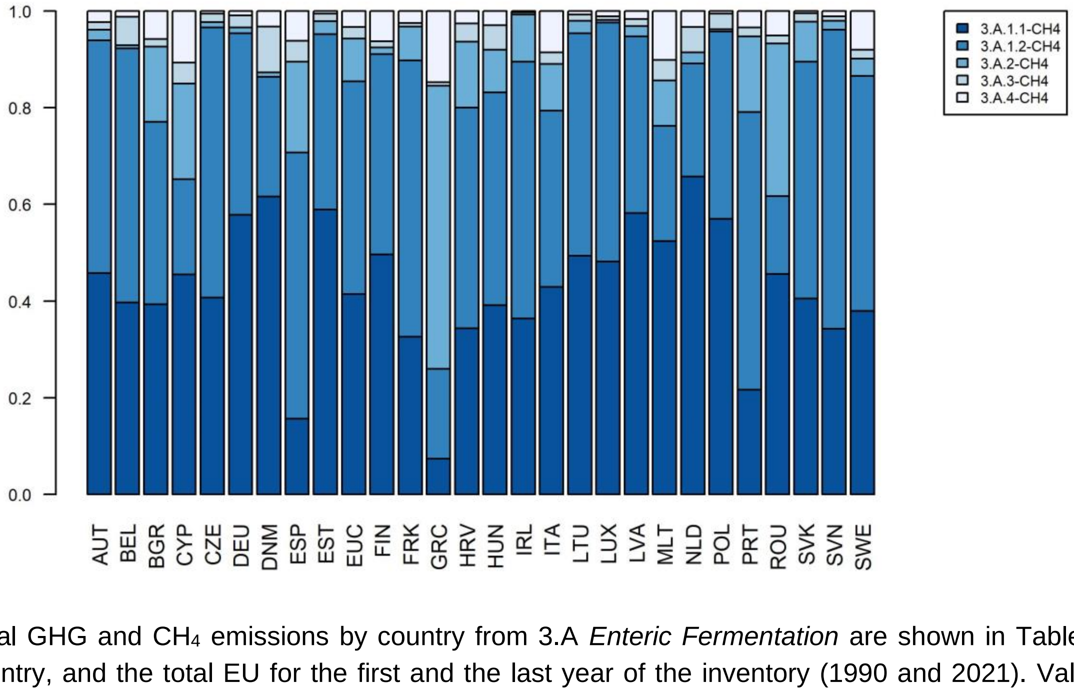
Regarding the origin of emissions in the different countries, Figure 5.5 shows the distribution of CH_4 emissions from enteric fermentation by livestock category in all countries and in the EU. Each bar represents the total emissions of a country in the current emission category, where different shades of blue correspond to the emitting animal types.

Figure 5.4: Share of source category 3.A on total EU agricultural emissions (left panel) and decomposition into its sub-categories (right panel). The percentages refer to the emissions in the year 2021.



In the left panel, some minor differences in the numbers might be present due to automatic rounding of numbers.

Figure 5.5: Decomposition of emissions in source category 3.A - Enteric Fermentation into its sub-categories by country in the year 2021.



Total GHG and CH_4 emissions by country from 3.A *Enteric Fermentation* are shown in Table 5.4 by country, and the total EU for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. In this category GHG and CH_4 columns have the same values, as no other greenhouse gases are produced in the enteric fermentation process. Between 1990 and 2021, CH_4 emission in this source category decreased by 23 % or 54.5 Mt CO_2-eq. The decrease was largest in Bulgaria in relative terms (68 %) and in Germany in absolute terms (11 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 0.7 %.

Table 5.4 3.A - Enteric Fermentation: Countries' contributions to total EU-GHG and CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	5 055	4 182	4 192	2.3%	-863	-17%	10	0%	T1,T2	CS,D
Belgium	5 327	4 517	4 464	2.4%	-863	-16%	-53	-1%	T1,T2	CS,D
Bulgaria	5 381	1 672	1 714	0.9%	-3 668	-68%	42	2%	T1,T2	CS,D
Croatia	2 336	1 091	1 079	0.6%	-1 257	-54%	-12	-1%	T1,T2,T3	CS,D
Cyprus	221	330	352	0.2%	132	60%	23	7%	T1,T2	CS,D
Czechia	6 612	3 631	3 628	2.0%	-2 983	-45%	-3	0%	T1,T2	CS,D
Denmark	4 489	4 117	4 142	2.3%	-346	-8%	26	1%	T1,T2	CS,D,OTH
Estonia	1 421	622	623	0.3%	-797	-56%	2	0%	T1,T2	CS,D,OTH
Finland	2 712	2 331	2 290	1.3%	-422	-16%	-41	-2%	,OTH,T1,T2	CS,D,OTH
France	43 268	37 149	36 305	19.9%	-6 963	-16%	-844	-2%	T2,T3	CS
Germany	37 141	26 709	26 141	14.3%	-11 000	-30%	-567	-2%	T1,T2,T3	CS,D
Greece	4 603	4 043	4 052	2.2%	-551	-12%	9	0%	T1,T2	CS,D
Hungary	4 108	2 346	2 364	1.3%	-1 743	-42%	18	1%	T1,T2	CS,D
Ireland	12 319	14 105	14 488	7.9%	2 169	18%	383	3%	CS,T1,T2	CS,D
Italy	17 093	14 771	14 671	8.0%	-2 422	-14%	-100	-1%	T1,T2	CS,D
Latvia	2 488	959	955	0.5%	-1 534	-62%	-4	0%	T1,T2	CS,D,OTH
Lithuania	4 834	1 711	1 720	0.9%	-3 114	-64%	9	1%	T1,T2	CS,D,OTH
Luxembourg	436	449	443	0.2%	7	2%	-6	-1%	T1,T2	CS,D
Malta	59	41	40	0.0%	-19	-32%	-1	-1%	T1,T2	CS,D
Netherlands	10 339	9 163	9 072	5.0%	-1 268	-12%	-91	-1%	T1,T2,T3	CS,D
Poland	22 008	14 424	14 587	8.0%	-7 421	-34%	162	1%	T1,T2	CS,D
Portugal	3 943	4 055	4 064	2.2%	121	3%	9	0%	T1,T2	CS,D
Romania	17 195	8 832	8 521	4.7%	-8 674	-50%	-310	-4%	T1,T2	CS,D
Slovakia	3 132	1 082	1 062	0.6%	-2 070	-66%	-20	-2%	T1,T2	CS,D
Slovenia	1 047	1 055	1 051	0.6%	4	0%	-3	0%	T1,T2	CS,D
Spain	15 787	17 075	17 222	9.4%	1 436	9%	148	1%	CS,T1,T2,T3	CS,D
Sweden	3 668	3 290	3 303	1.8%	-366	-10%	13	0%	CS,T1	CS,D
EU-27	**237 020**	**183 748**	**182 545**	**100%**	**-54 475**	**-23%**	**-1 203**	**-1%**	**-**	**-**

Total GHG and CH_4 emissions by country from *3.A.1 - Cattle Enteric Fermentation* are shown in Table 5.5 and total EU for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, CH_4 emission in this source category decreased by 22 % or 45 Mt CO_2-eq. The decrease was largest in Slovakia in relative terms (66 %) and in Germany in absolute terms (10.6 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 0.6 %.

Table 5.5 3.A.1 - Cattle: Countries' contributions to total EU-GHG and CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	4 854	3 931	3 938	2.5%	-915	-19%	7	0%	T2	CS
Belgium	4 991	4 173	4 119	2.6%	-872	-17%	-55	-1%	T2	CS
Bulgaria	3 313	1 276	1 321	0.8%	-1 991	-60%	45	4%	T2	CS
Croatia	2 052	873	864	0.6%	-1 188	-58%	-9	-1%	T2,T3	CS
Cyprus	113	204	230	0.1%	116	102%	25	12%	T1,T2	CS,D
Czechia	6 295	3 499	3 503	2.2%	-2 792	-44%	4	0%	T2	CS
Denmark	4 064	3 536	3 579	2.3%	-485	-12%	44	1%	T2	CS,D
Estonia	1 355	591	593	0.4%	-762	-56%	2	0%	T2	CS,D
Finland	2 487	2 115	2 085	1.3%	-402	-16%	-30	-1%	T2	CS
France	38 227	33 433	32 599	20.9%	-5 628	-15%	-834	-2%	T2,T3	CS
Germany	35 543	25 447	24 929	16.0%	-10 614	-30%	-518	-2%	T2,T3	CS,D
Greece	1 423	1 058	1 052	0.7%	-371	-26%	-6	-1%	T2	CS,D
Hungary	3 221	1 935	1 966	1.3%	-1 256	-39%	30	2%	T2	CS
Ireland	10 185	12 609	12 972	8.3%	2 787	27%	363	3%	CS,T2	CS
Italy	14 405	11 686	11 637	7.5%	-2 767	-19%	-49	0%	T2	CS
Latvia	2 372	909	905	0.6%	-1 468	-62%	-5	-1%	T2	CS
Lithuania	4 672	1 630	1 641	1.1%	-3 030	-65%	11	1%	T2	CS
Luxembourg	429	438	432	0.3%	3	1%	-6	-1%	T2	CS
Malta	49	31	31	0.0%	-18	-37%	-1	-3%	T2	CS
Netherlands	9 179	8 155	8 088	5.2%	-1 090	-12%	-67	-1%	T2,T3	CS
Poland	19 759	13 793	13 972	9.0%	-5 787	-29%	179	1%	T2	CS
Portugal	2 755	3 213	3 216	2.1%	461	17%	3	0%	T2	CS
Romania	12 595	5 492	5 258	3.4%	-7 337	-58%	-233	-4%	T2	CS
Slovakia	2 819	967	951	0.6%	-1 868	-66%	-16	-2%	T2	CS
Slovenia	1 013	1 015	1 011	0.6%	-2	0%	-4	0%	T2	CS
Spain	9 579	11 983	12 186	7.8%	2 607	27%	203	2%	CS,T2	CS,D
Sweden	3 230	2 852	2 859	1.8%	-370	-11%	7	0%	CS	CS
EU-27	**200 979**	**156 846**	**155 937**	**100%**	**-45 042**	**-22%**	**-909**	**-1%**	**-**	**-**

Total GHG and CH_4 emissions by country from *3.A.2 - Sheep Enteric Fermentation* are shown in Table 5.6 and the total EU for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, CH_4 emission in this source category decreased by 32 % or 7.5 Mt CO_2-eq. The decrease was largest in Poland in relative terms (93 %) and in France in absolute terms (1.4 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 1.1 %.

Table 5.6 3.A.2 - Sheep: Countries' contributions to total EU-GHG and CH_4 emissions

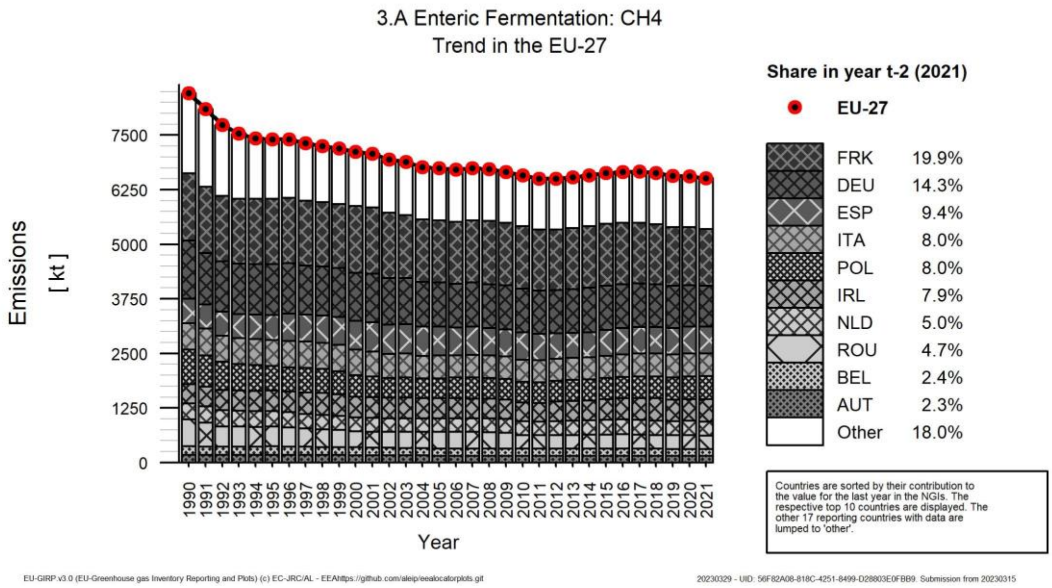
Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	69	88	90	0.6%	21	30%	2	2%	T1	D
Belgium	43	28	30	0.2%	-13	-30%	3	10%	T1	D
Bulgaria	1 628	272	265	1.6%	-1 363	-84%	-6	-2%	T2	CS
Croatia	168	148	147	0.9%	-22	-13%	-2	-1%	T1	D
Cyprus	65	73	70	0.4%	5	7%	-4	-5%	T1	D
Czechia	96	46	41	0.3%	-55	-57%	-5	-10%	T1	D
Denmark	44	38	38	0.2%	-7	-15%	-1	-2%	T2	D
Estonia	36	17	17	0.1%	-19	-53%	0	-1%	T1	D
Finland	24	34	32	0.2%	8	32%	-3	-8%	CS	CS
France	3 957	2 536	2 527	15.7%	-1 430	-36%	-10	0%	T2,T3	CS
Germany	580	317	320	2.0%	-261	-45%	3	1%	T1	CS,D
Greece	2 300	2 369	2 373	14.7%	73	3%	4	0%	T2	CS,D
Hungary	439	224	210	1.3%	-229	-52%	-14	-6%	T1	D
Ireland	2 048	1 391	1 413	8.8%	-635	-31%	21	2%	T1	D
Italy	1 761	1 475	1 424	8.8%	-337	-19%	-51	-3%	T2	CS
Latvia	37	21	20	0.1%	-17	-45%	0	-2%	T1	D
Lithuania	21	46	43	0.3%	23	110%	-2	-5%	T2	CS
Luxembourg	2	3	3	0.0%	1	44%	0	3%	T2	CS
Malta	4	4	4	0.0%	0	-7%	0	-3%	T2	CS
Netherlands	381	214	205	1.3%	-176	-46%	-8	-4%	T1	D
Poland	932	64	65	0.4%	-867	-93%	0	0%	T1	D
Portugal	889	628	636	3.9%	-253	-28%	8	1%	T2	CS
Romania	3 498	2 728	2 691	16.7%	-807	-23%	-38	-1%	T2	CS
Slovakia	199	88	88	0.5%	-111	-56%	-1	-1%	T2	CS
Slovenia	3	18	20	0.1%	16	515%	1	7%	T1	D
Spain	4 246	3 302	3 224	20.0%	-1 022	-24%	-77	-2%	CS,T2	CS
Sweden	91	112	117	0.7%	26	29%	5	4%	T1	D
EU-27	**23 561**	**16 285**	**16 111**	**100%**	**-7 451**	**-32%**	**-174**	**-1%**	**-**	**-**

5.3.1.1 Trends in Emissions and Activity Data

3.A - Enteric Fermentation - Emissions

Emissions in source category *3.A - Enteric Fermentation* decreased considerably in EU by 23 % or 54.5 Mt CO_2-eq in the period 1990 to 2021. Figure 5.6 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in CH_4 emissions from enteric fermentation for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 82 % of the total in 2021. Emissions decreased in 21 countries and increased in six countries. The four countries with the largest decreases were Germany, Romania, Poland and France with a total absolute decrease of 34.1 Mt CO_2-eq. The largest increases occurred in Spain and Ireland, with a total absolute increase of 3.6 Mt CO_2-eq.

Figure 5.6: 3.A: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.A.1 - Cattle - Emissions

Emissions in source category *3.A.1 - Cattle* decreased considerably in EU by 22 % or 45 Mt CO_2-eq in the period 1990 to 2021. The ten countries with the highest emissions accounted together for 83.2 % of the total in 2021. Emissions decreased in 22 countries and increased in five countries. The four countries with the largest decreases were Germany, Romania, Poland and France with a total absolute decrease of 29.4 Mt CO_2-eq. The largest increases occurred in Spain and Ireland, with a total absolute increase of 5.4 Mt CO_2-eq.

Emissions in source category *3.A.1.1 - Dairy Cattle* decreased strongly in EU by 28 % or 29.4 Mt CO_2-eq in the period 1990 to 2021. Figure 5.7 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in CH_4 emissions from enteric fermentation for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 84.5 % of the total in 2021. Emissions decreased in 23 countries and increased in four countries. The three countries with the largest decreases were Poland, Germany and Romania with a total absolute decrease of 14.1 Mt CO_2-eq. The largest increases occurred in Ireland, with a total absolute increase of 1.5 Mt CO_2-eq.

Emissions in source category *3.A.1.2 - Non-Dairy Cattle* decreased considerably in EU by 16 % or 15.6 Mt CO_2-eq in the period 1990 to 2021. Figure 5.8 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in CH_4 emissions from enteric fermentation for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 84 % of the total in 2021. Emissions decreased in 21 countries and increased in six countries. The three countries with the largest decreases were Germany, Romania and France with a total absolute decrease of 11.4 Mt CO_2-eq. The three countries with the largest increases were Portugal, Ireland and Spain, with a total absolute increase of 5.6 Mt CO_2-eq.

3.A.1 - Cattle - Population

The main driver for the decrease of CH_4 emissions from enteric fermentation was the decrease in animal numbers that we can see in Figure 5.9 and Figure 5.10.

Cattle population decreased strongly in EU by 30 % or 33.7 million heads in the period 1990 to 2021. The ten countries with the highest population accounted together for 84.5 % of the total in 2021. Population decreased in 23 countries and increased in four countries. The four countries with the largest decreases were Germany, France, Poland and Romania with a total absolute decrease of 19.8 million heads. The three countries with the largest increases were Portugal, Ireland and Spain, with a total absolute increase of 2.4 million heads.

Figure 5.7: 3.A.1.1 Dairy Cattle: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

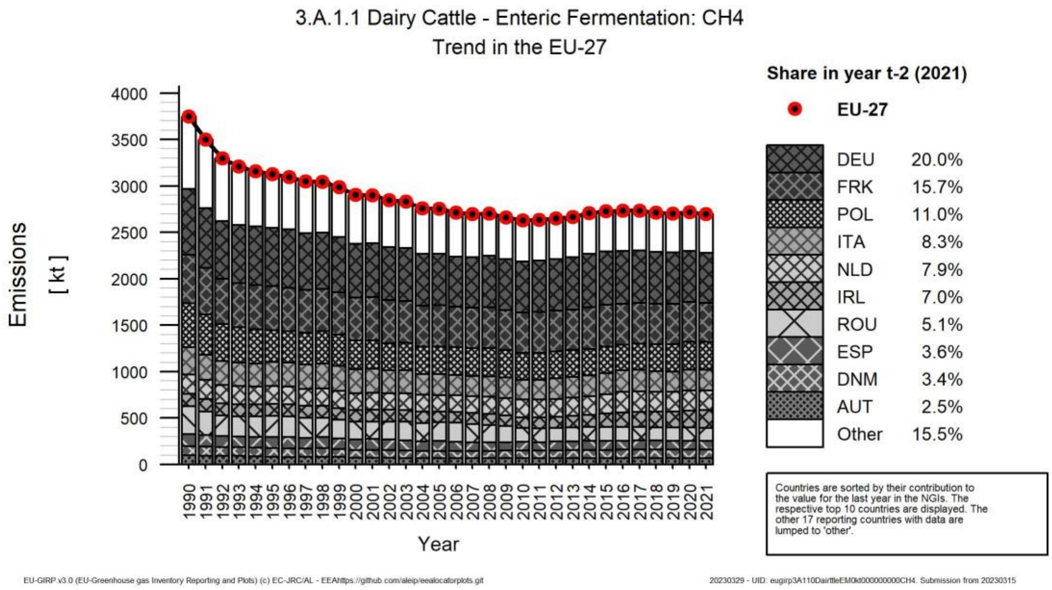


Figure 5.8: 3.A.1.2 Non-Dairy Cattle: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

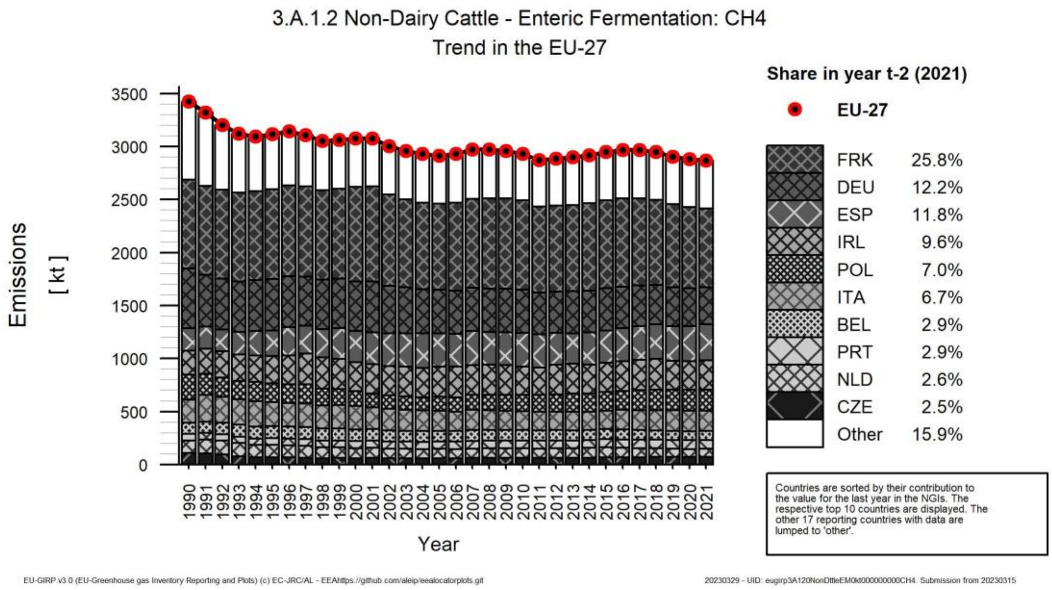


Figure 5.9: 3.A.1 Dairy Cattle: Trend in cattle population in the EU and the countries contributing most to EU values including their share to EU population in 2021

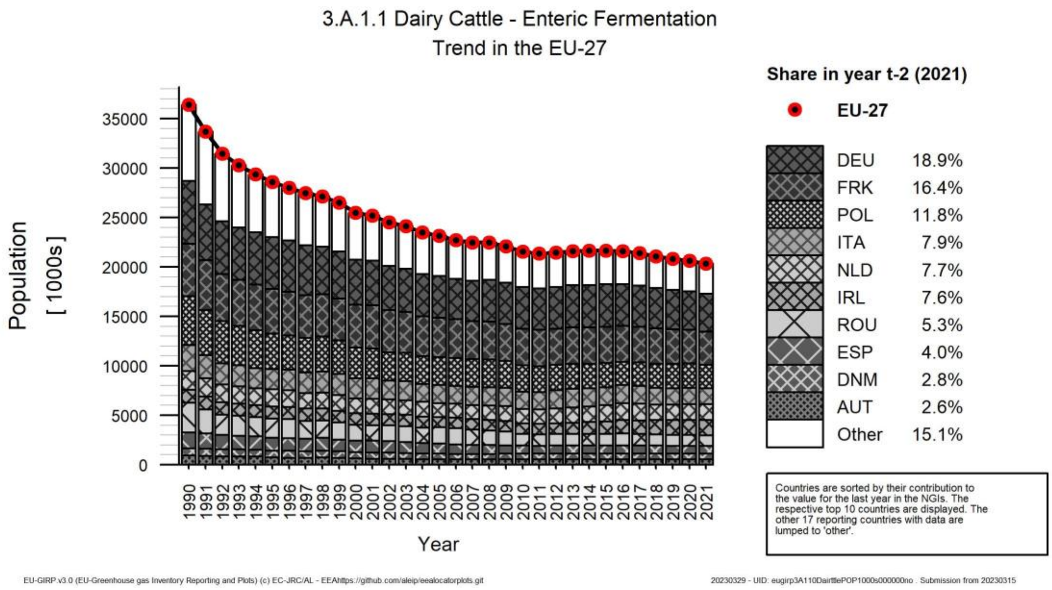
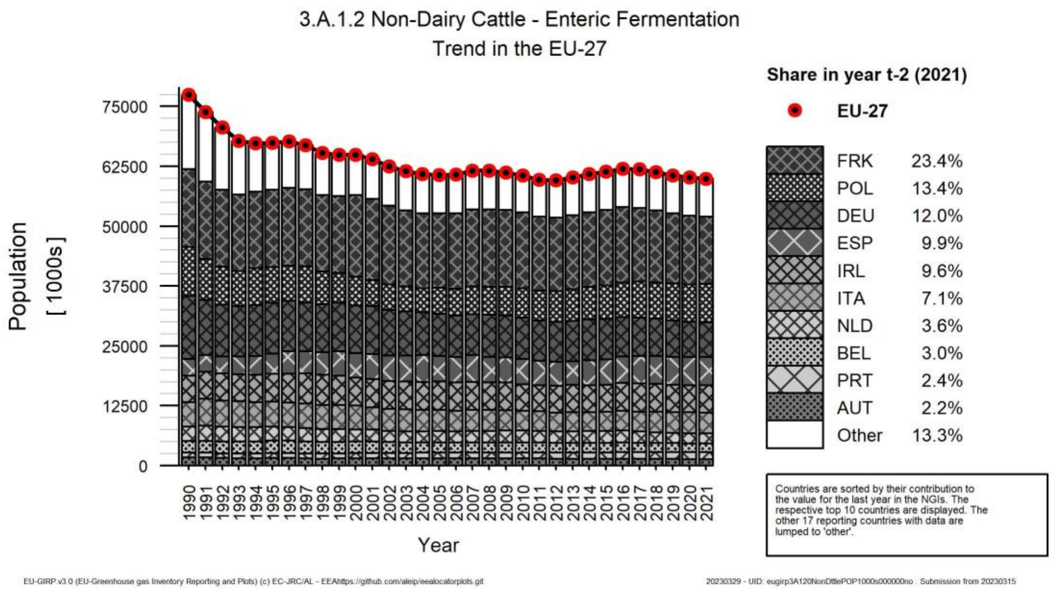


Figure 5.10: 3.A.1 Non-Dairy Cattle: Trend in cattle population in the EU and the countries contributing most to EU values including their share to EU population in 2021



3.A.2 - Sheep - Emissions

Emissions in source category *3.A.2 - Sheep* decreased strongly in EU by 32 % or 7.5 Mt CO_2-eq in the period 1990 to 2021. Figure 5.11 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in CH_4 emissions from enteric fermentation for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 93.6 % of the total in 2021. Emissions decreased in nineteen countries and increased in eight countries. The five countries with the largest decreases were France, Bulgaria, Spain, Poland and Romania with a total absolute decrease of 5.5 Mt CO_2-eq. The four countries with the largest increases were Austria, Lithuania, Sweden and Greece, with a total absolute increase of 142 kt CO_2-eq.

3.A.2 - Sheep - Population

The main driver for the decrease of CH_4 emissions from enteric fermentation for sheep was the decrease in animal numbers shown in Figure 5.12.

Sheep population decreased strongly in EU by 37 % or 37.6 million heads in the period 1990 to 2021. Figure 5.12 shows the trend of sheep population indicating the countries contributing most to EU total. The figure represents the trend in sheep population for the different countries along the inventory period. The ten countries with the highest population accounted together for 93 % of the total in 2021. Population decreased in nineteen countries and increased in eight countries. The five countries with the largest decreases were Spain, Bulgaria, France, Romania and Poland with a total absolute decrease of 28.4 million heads. The five countries with the largest increases were Slovenia, Lithuania, Austria, Sweden and Greece, with a total absolute increase of 648 thousand heads.

Figure 5.11: 3.A.2: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

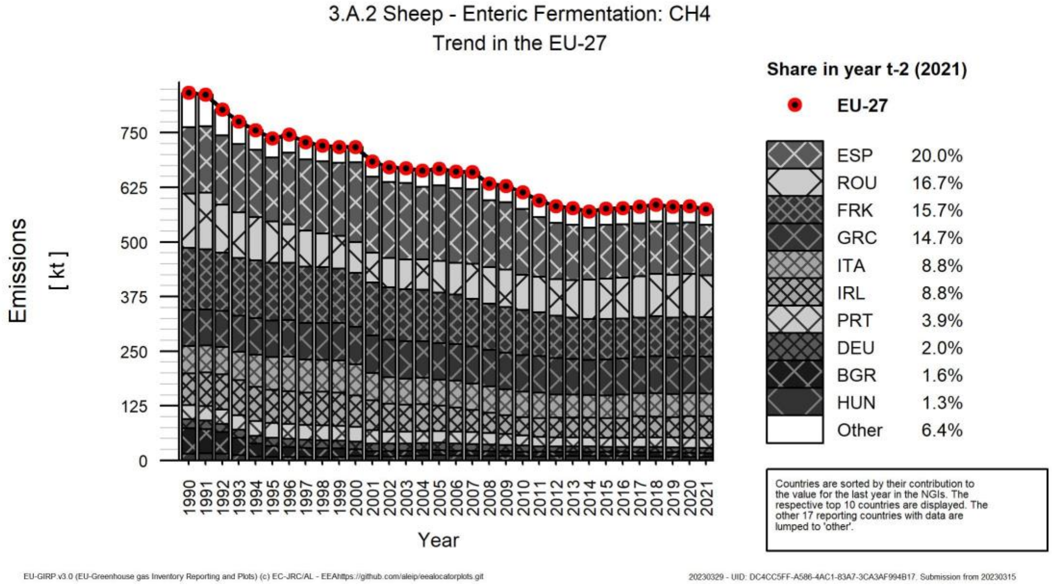
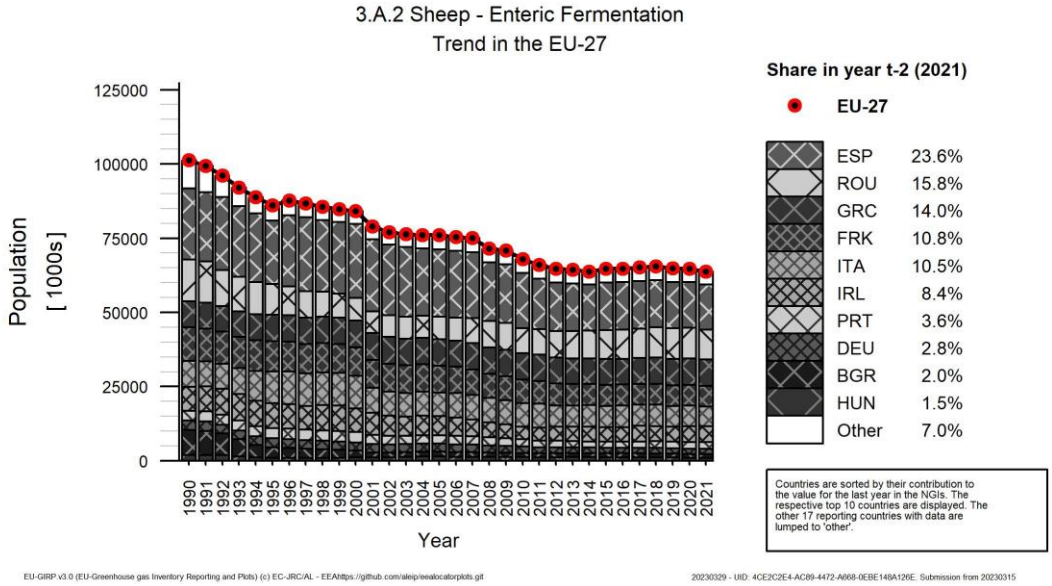


Figure 5.12: 3.A.2: Trend in sheep population in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



5.3.1.2 Implied EFs and Methodological Issues

Information for cattle, sheep and swine are reported using national classification of the animals. For example, it is possible to report cattle numbers using one of three options:

- Option A distinguishes 'Dairy Cattle' and 'Non-Dairy Cattle'.
- Option B distinguishes 'Mature Dairy Cattle', 'Other Mature Cattle' and 'Growing Cattle'.

- Option C allows for any national classification.

To obtain values that can be aggregated to EU level, data reported under Option B and Option C were converted to Option A categories. ‘Mature Dairy Cattle’ is taken for ‘Dairy Cattle’ and the other two categories under Option B are used for ‘Non-Dairy Cattle’. Also in Option C, dairy cattle can be identified (e.g. ‘Dairy Cows’, ‘Other Dairy Cattle’ etc.) and all other cattle categories have been grouped to the animal type ‘Non-Dairy Cattle’.

In case data were aggregated, this was done on the basis of a weighted average using population data as weighting factors.

In the cases for ‘Sheep’ and ‘Swine’, all animal types reported by countries are aggregated to one single parent category using the same approach.

In this section we discuss the Implied Emission Factor for the main animal types. Furthermore, we present data on the average gross energy intake and - for dairy cattle - also the milk yield.

3.A.1 - Cattle - Implied emission factor

The implied emission factor for CH_4 emissions in source category *3.A.1 - Cattle* increased in EU clearly between 1990 and 2021 by 10.1 % or 6.4 kg/head/year. Table 5.7 shows the implied emission factor for CH_4 emissions in source category *3.A.1 - Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in five countries and increased in 22 countries. The three countries with the largest decreases were Croatia, Malta and Portugal with a mean absolute value of 8 kg/head/year. The four countries with the largest increases were the Czech Republic, Latvia, Finland and Lithuania with a mean absolute value of 23 kg/head/year.

Table 5.7 3.A.1 - Cattle: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	67	75	|	Ireland	53	64
Belgium	55	63	|	Italy	66	71
Bulgaria	74	81	|	Lithuania	70	92
Cyprus	74	93	|	Luxembourg	71	82
Czech Republic	64	89	|	Latvia	59	82
Germany	65	81	|	Malta	83	78
Denmark	65	86	|	Netherlands	67	77
Spain	67	64	|	Poland	70	78
Estonia	64	84	|	Portugal	72	69
Finland	65	88	|	Romania	85	104
France	63	67	|	Slovakia	64	78
Greece	73	73	|	Slovenia	68	75
Croatia	89	72	|	Sweden	67	70
Hungary	71	76	|	EU	63	69

3.A.1.1 - Dairy Cattle - Implied emission factor

The implied emission factor for CH_4 emissions in source category *3.A.1.1 - Dairy Cattle* increased in EU strongly between 1990 and 2021 by 29 % or 30 kg/head/year. Figure 5.13 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.8 shows the implied emission factor for CH_4 emissions in source category *3.A.1.1 - Dairy Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in one country and increased in 26 countries. A decrease occurred in Malta with an absolute value of 4 kg/head/year. The four countries with the largest increases were Estonia, the Czech Republic, Latvia and Finland with a mean absolute value of 50 kg/head/year.

Figure 5.13: 3.A.1.1 - Dairy Cattle: Trend in implied emission factor in the EU and range of values reported by countries

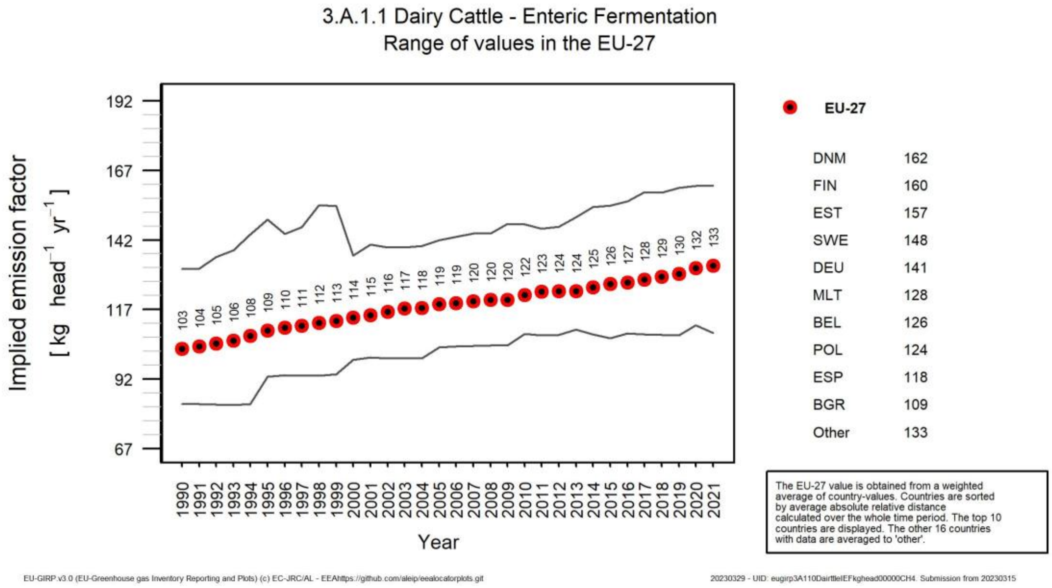


Table 5.8 3.A.1.1 - Dairy Cattle: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	108	130	|	Ireland	101	121
Belgium	88	126	|	Italy	111	140
Bulgaria	105	109	|	Lithuania	101	132
Cyprus	99	128	|	Luxembourg	115	153
Czech Republic	98	147	|	Latvia	103	151
Germany	112	141	|	Malta	132	128
Denmark	128	162	|	Netherlands	110	136
Spain	83	118	|	Poland	96	124
Estonia	104	157	|	Portugal	97	136
Finland	112	160	|	Romania	100	130
France	99	127	|	Slovakia	85	128
Greece	109	129	|	Slovenia	92	127
Croatia	110	129	|	Sweden	112	148
Hungary	105	134	|	EU	103	133

3.A.1.1 - Dairy Cattle - Gross energy

The gross energy, a parameter used for calculating CH_4 emissions in source category *3.A.1.1 - Dairy Cattle*, increased in EU strongly between 1990 and 2021 by 35.3 % or 84 MJ/day. Figure 5.14 shows the trend of the gross energy in EU indicating also the range of values used by the countries. Table 5.9 shows the gross energy in source category *3.A.1.1 - Dairy Cattle* for the years 1990 and 2021 for all countries and EU. Gross energy decreased in one country and increased in 24 countries. No data were available for two countries (Bulgaria and the Netherlands). A decrease occurred in Malta with an absolute value of 9 MJ/day. The four countries with the largest increases were the Czech Republic, Estonia, Denmark and Latvia with a mean absolute value of 123 MJ/day.

Figure 5.14: 3.A.1.1 - Dairy Cattle: Trend in gross energy in the EU and range of values reported by countries

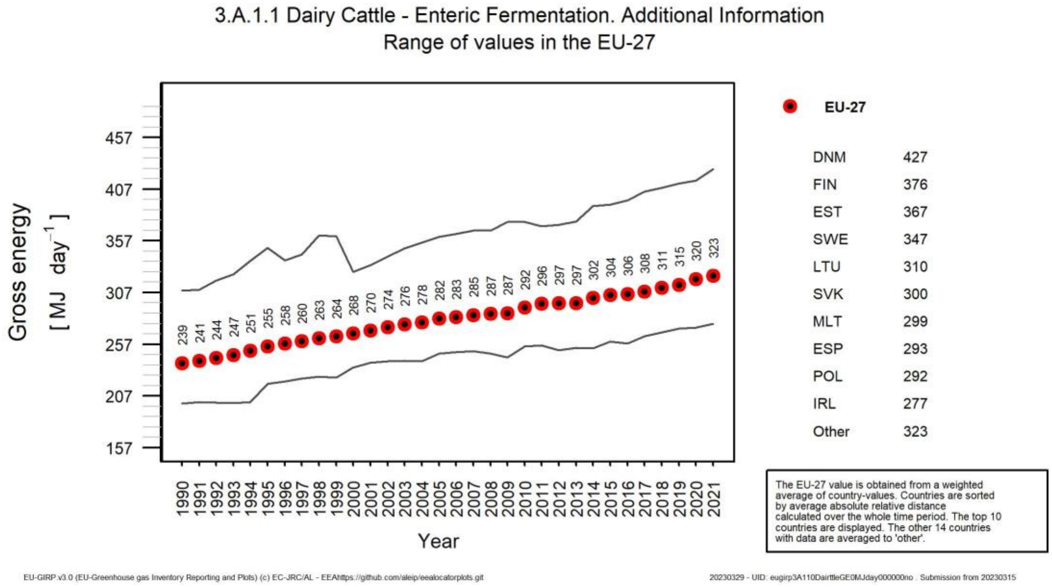


Table 5.9 3.A.1.1 - Dairy Cattle: countries' gross energy (MJ/day)

Country	1990	2021		Country	1990	2021
Austria	254	315	|	Ireland	226	277
Belgium	220	315	|	Italy	261	355
Cyprus	232	301	|	Lithuania	236	310
Czech Republic	229	365	|	Luxembourg	270	359
Germany	241	343	|	Latvia	242	355
Denmark	305	427	|	Malta	309	299
Spain	201	293	|	Poland	225	292
Estonia	245	367	|	Portugal	227	318
Finland	263	376	|	Romania	234	305
France	242	317	|	Slovakia	200	300
Greece	255	302	|	Slovenia	215	299
Croatia	258	304	|	Sweden	271	347
Hungary	255	331	|	EU	239	323

3.A.1.1 - Dairy Cattle - Milk yield

The milk yield, a parameter used for calculating CH_4 emissions in source category *3.A.1.1 - Dairy Cattle*, increased in EU very strongly between 1990 and 2021 by 88 % or 9.9 kg/head/day. Figure 5.15 shows the trend of the milk yield in EU indicating also the range of values used by the countries. Table 5.10 shows the milk yield in source category *3.A.1.1 - Dairy Cattle* for the years 1990 and 2021 for all countries and EU. The reported milk yield increased in all reporting countries. The four countries with the largest increases were Estonia, Spain, Slovakia and the Czech Republic with a mean absolute value of 15 kg/head/day.

Figure 5.15: 3.A.1.1 - Dairy Cattle: Trend in milk yield in the EU and range of values reported by countries

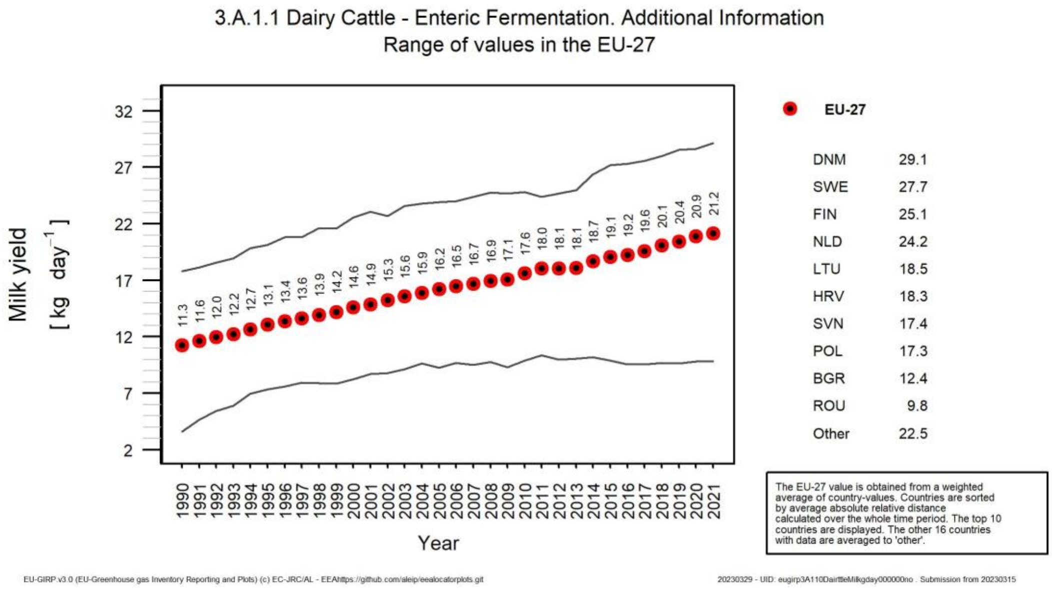


Table 5.10 3.A.1.1 - Dairy Cattle: countries' milk yield (kg/head/day) [45]

Country	1990	2021	Country	1990	2021
Austria	10.4	19.9	Ireland	11.5	16.4
Belgium	11.2	23.5	Italy	11.5	25.0
Bulgaria	11.1	12.4	Lithuania	10.0	18.5
Cyprus	12.2	21.0	Latvia	11.3	24.1
Czech Republic	11.0	25.1	Malta	10.1	18.4
Germany	12.9	23.3	Netherlands	16.4	24.2
Denmark	17.7	29.1	Poland	8.9	17.3
Spain	10.1	25.8	Portugal	12.2	23.7
Estonia	11.4	27.3	Romania	3.6	9.8
Finland	15.7	25.1	Slovakia	7.0	22.0
France	13.1	20.4	Slovenia	7.6	17.4
Greece	7.6	20.2	Sweden	17.8	27.7
Croatia	7.8	18.3	EU	11.3	21.2
Hungary	13.8	23.2			

3.A.1.2 - Non-Dairy Cattle - Implied emission factor

The implied emission factor for CH_4 emissions in source category *3.A.1.2 - Non-Dairy Cattle* increased in EU moderately between 1990 and 2021 by 8.4 % or 4 kg/head/year. Figure 5.16 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.11 shows the implied emission factor for CH_4 emissions in source category *3.A.1.2 - Non-Dairy Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in five countries and increased in 22 countries. The three countries with the largest decreases were Croatia, the Netherlands and Malta with a mean absolute value of 5 kg/head/year. The four countries with the largest increases were the Czech Republic, Finland, Lithuania and Latvia with a mean absolute value of 18 kg/head/year.

[45] Note that data from Luxembourg are not included in the plot as they are reported in a different unit.

Figure 5.16: **3.A.1.2 - Non-Dairy Cattle: Trend in implied emission factor in the EU and range of values reported by countries**

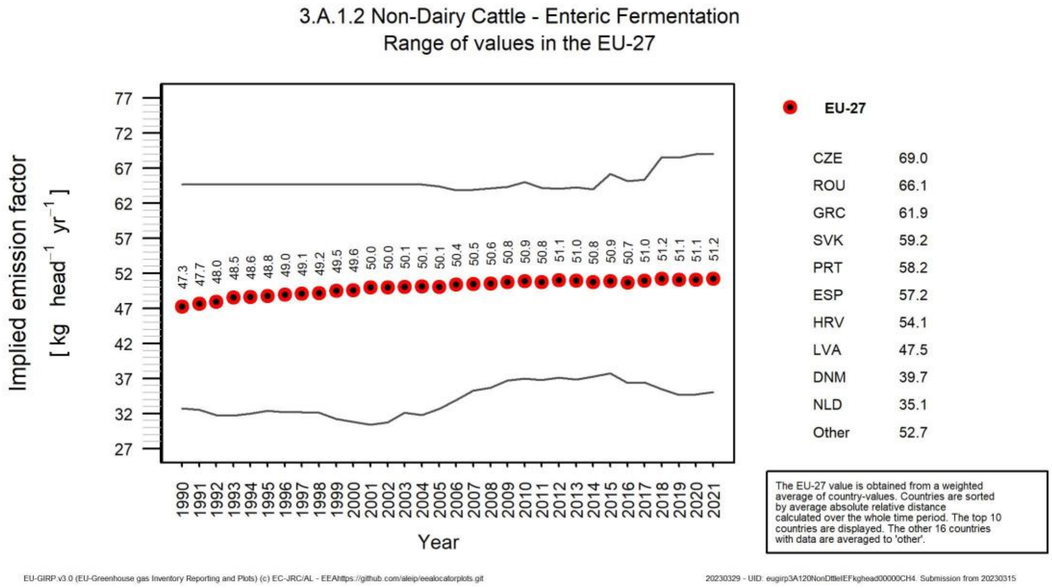


Table 5.11 3.A.1.2 - Non-Dairy Cattle: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	45	54	|	Ireland	42	48
Belgium	43	46	|	Italy	43	45
Bulgaria	55	65	|	Lithuania	53	69
Cyprus	57	57	|	Luxembourg	54	56
Czech Republic	47	69	|	Latvia	33	48
Germany	43	49	|	Malta	45	42
Denmark	33	40	|	Netherlands	40	35
Spain	59	57	|	Poland	46	50
Estonia	40	48	|	Portugal	62	58
Finland	39	57	|	Romania	65	66
France	52	53	|	Slovakia	57	59
Greece	57	62	|	Slovenia	50	56
Croatia	62	54	|	Sweden	44	50
Hungary	53	55	|	EU	44	48

3.A.1.2 - Non-Dairy Cattle - Average gross energy intake

The average gross energy intake, a parameter used for calculating CH_4 emissions in source category *3.A.1.2 - Non-Dairy Cattle*, increased in EU moderately between 1990 and 2021 by 8.3 % or 9.9 MJ/head/day. Figure 5.17 shows the trend of the average gross energy intake in EU indicating also the range of values used by the countries. Table 5.12 shows the average gross energy intake in source category *3.A.1.2 - Non-Dairy Cattle* for the years 1990 and 2021 for all countries and EU. Average gross energy intake decreased in five countries and increased in 21 countries. No data were available for Cyprus. The three countries with the largest decreases were Croatia, the Netherlands and Malta with a mean absolute value of 13 MJ/head/day. The four countries with the largest increases were the Czech Republic, Finland, Lithuania and Latvia with a mean absolute value of 41 MJ/head/day.

Figure 5.17: 3.A.1.2 - Non-Dairy Cattle: Trend in average gross energy intake in the EU and range of values reported by countries

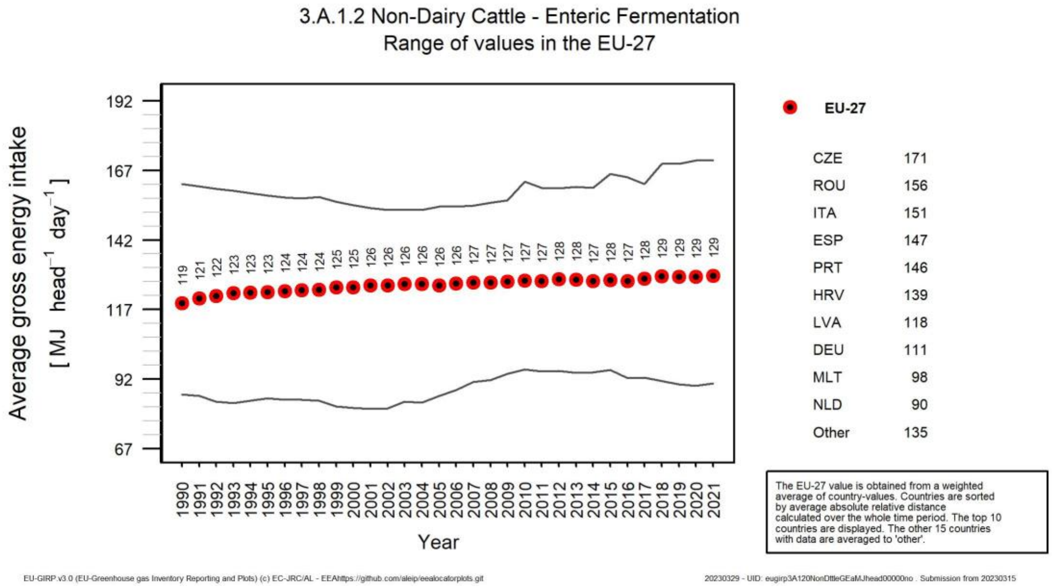


Table 5.12 3.A.1.2 - Non-Dairy Cattle: countries' average gross energy intake (MJ/head/day)

Country	1990	2021	Country	1990	2021
Austria	122	143	Italy	147	151
Belgium	112	121	Lithuania	125	163
Bulgaria	129	152	Luxembourg	127	132
Czech Republic	118	171	Latvia	86	118
Germany	100	111	Malta	106	98
Denmark	107	129	Netherlands	99	90
Spain	148	147	Poland	107	118
Estonia	113	127	Portugal	151	146
Finland	92	134	Romania	153	156
France	122	125	Slovakia	136	142
Greece	135	145	Slovenia	111	122
Croatia	162	139	Sweden	129	139
Hungary	134	137	EU	119	129
Ireland	128	132			

The factors driving the average methane implied emission factor for dairy cattle are the share of dairy cattle population in each country and the relative change of their implied emissions factor. The increase in the EU-IEF from 1990 to 2021 is 29 % is globally in line with the increase in the IEF of the four countries with the highest population (Germany, France, Poland and Italy) covering together 53 % of the EU dairy cattle population. In thirteen countries IEF of dairy cattle increased between 30 % and 50 % from 1990 to 2021 but they cover only the 20 % of dairy cattle population in 2021. The seven countries with the lowest increase of the IEF (less than 23 %) represented 14 % of the dairy cattle population in 2021.

Table 5.13: Change in dairy cattle population and dairy cattle implied emission factor from 1990 to 2021. Countries are ordered by the share of EU dairy cattle population in 2021

Party	1990 1000s	1990 POP %	1990 IEF kg/head	2021 1000s	2021 POP %	2021 IEF kg/head	1990-2021 Change POP %	1990-2021 Change IEF %
Germany	6354.6	17.4	111.5	3832.7	18.9	140.8	-39.7	26.3
France	5309.9	14.6	99.1	3327.7	16.4	127.0	-37.3	28.2
Poland	4919.0	13.5	95.8	2388.5	11.8	124.3	-51.4	29.8
Italy	2641.8	7.3	111.1	1609.9	7.9	139.5	-39.1	25.6
Netherlands	1877.7	5.2	110.4	1571.3	7.7	135.6	-16.3	22.8
Ireland	1341.0	3.7	101.3	1554.9	7.6	121.1	16.0	19.6
Romania	3002.1	8.2	100.0	1067.8	5.3	127.8	-64.4	27.9
Spain	1587.8	4.4	82.9	818.4	4.0	117.6	-48.5	41.7
Denmark	753.1	2.1	127.7	564.2	2.8	161.6	-25.1	26.5
Austria	904.6	2.5	108.2	526.5	2.6	130.1	-41.8	20.3
Belgium	838.7	2.3	88.1	502.9	2.5	125.9	-40.0	42.9
Czech Republic	1206.2	3.3	97.6	358.7	1.8	147.1	-70.3	50.7
Sweden	576.4	1.6	112.2	301.9	1.5	148.3	-47.6	32.2
Finland	489.9	1.3	112.0	253.5	1.2	160.2	-48.2	43.0
Hungary	563.6	1.5	105.3	245.4	1.2	134.5	-56.5	27.7
Portugal	394.3	1.1	96.8	232.0	1.1	135.6	-41.2	40.0
Lithuania	844.9	2.3	100.7	229.0	1.1	132.3	-72.9	31.3
Bulgary	619.1	1.7	104.7	221.4	1.1	108.7	-64.2	3.8
Latvia	535.1	1.5	103.0	131.2	0.6	151.2	-75.5	46.8
Slovakia	401.1	1.1	85.2	120.1	0.6	128.1	-70.1	50.4
Croatia	462.7	1.3	110.2	102.3	0.5	129.5	-77.9	17.6
Slovenia	225.3	0.6	91.7	100.9	0.5	127.4	-55.2	38.9
Estonia	280.7	0.8	104.5	83.7	0.4	156.6	-70.2	49.9
Greece	210.0	0.6	108.9	82.2	0.4	128.9	-60.8	18.3
Luxemburg	58.8	0.2	115.1	49.7	0.2	153.0	-15.5	32.9
Cyprus	22.4	0.1	98.8	44.5	0.2	128.5	98.6	30.1
Malta	9.2	0.0	131.6	5.9	0.0	127.6	-36.0	-3.0
EU	36430.0	100.0	103.0	20327.3	100.0	132.8	-42.6	28.9

3.A.2 - Sheep - Implied emission factor

The implied emission factor for CH_4 emissions in source category *3.A.2 - Sheep* increased in EU moderately between 1990 and 2021 by 8.7 % or 0.72 kg/head/year. Figure 5.18 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.14 shows the implied emission factor for CH_4 emissions in source category *3.A.2 - Sheep* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in six countries and increased in twelve countries. It was in 2021 at the level of 1990 in nine countries. The three countries with the largest decreases were Slovakia, Lithuania and Luxembourg with a mean absolute value of 0.4 kg/head/year. The three countries with the largest increases were Malta, Spain and France with a mean absolute value of 1 kg/head/year.

Figure 5.18: 3.A.2 - Sheep: Trend in implied emission factor in the EU and range of values reported by countries

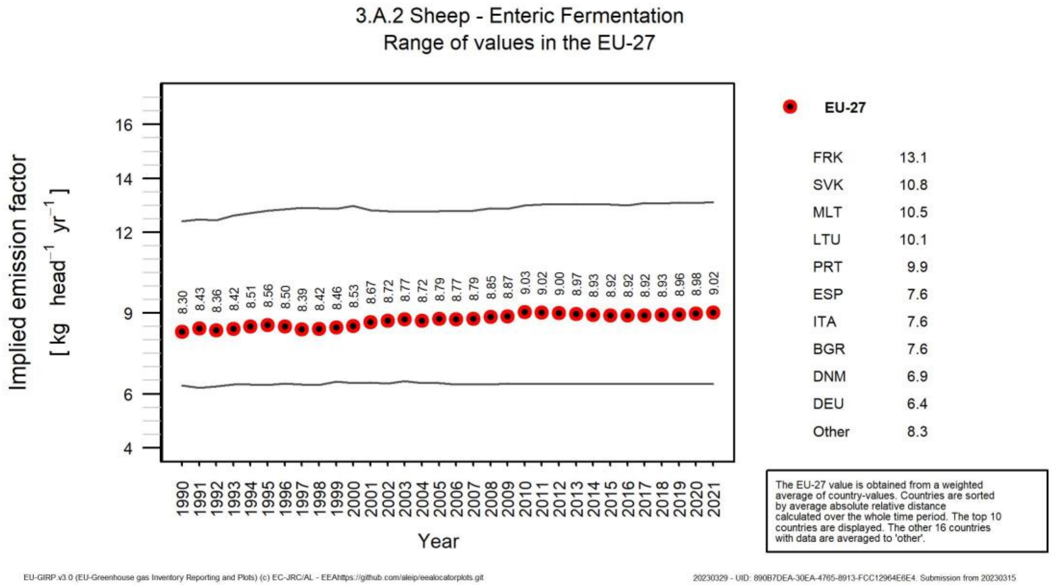


Table 5.14 3.A.2 - Sheep: countries' implied emission factor (kg/head/year)

Country	1990	2021	Country	1990	2021
Austria	8.0	8.0	Ireland	9.1	9.5
Belgium	8.0	8.0	Italy	7.2	7.6
Bulgaria	6.9	7.6	Lithuania	10.2	10.1
Cyprus	8.0	8.0	Luxembourg	7.3	7.3
Czech Republic	8.0	8.0	Latvia	8.0	8.0
Germany	6.3	6.4	Malta	9.0	10.5
Denmark	6.9	6.9	Netherlands	8.0	8.0
Spain	6.3	7.6	Poland	8.0	8.0
Estonia	8.0	8.0	Portugal	9.7	9.9
Finland	8.3	8.6	Romania	8.9	9.5
France	12.4	13.1	Slovakia	11.8	10.8
Greece	9.5	9.5	Slovenia	8.0	8.0
Croatia	8.0	8.0	Sweden	8.0	8.0
Hungary	8.0	8.0	EU	8.3	9.0

3.A.2 - Sheep - Average gross energy intake

The average gross energy intake, a parameter used for calculating CH_4 emissions in source category *3.A.2 - Sheep*, increased in EU moderately between 1990 and 2021 by 9 % or 1.7 MJ/head/day. Figure 5.19 shows the trend of the average gross energy intake in EU indicating also the range of values used by the countries. Table 5.15 shows the average gross energy intake in source category *3.A.2 - Sheep* for the years 1990 and 2021 for all countries and EU. Average gross energy intake decreased in four countries and increased in seven countries. It was in 2021 at the level of 1990 in two countries. No data were available for fourteen countries (Poland, Austria, Belgium, Cyprus, the Czech Republic, Germany, Estonia, Finland, France, Croatia, Hungary, Latvia, the Netherlands and Slovenia). The three countries with the largest decreases were Slovakia, Lithuania and Luxembourg with a mean absolute value of 1

MJ/head/day. The three countries with the largest increases were Malta, Spain and Bulgaria with a mean absolute value of 3 MJ/head/day.

Figure 5.19: 3.A.2 - Sheep: Trend in average gross energy intake in the EU and range of values reported by countries

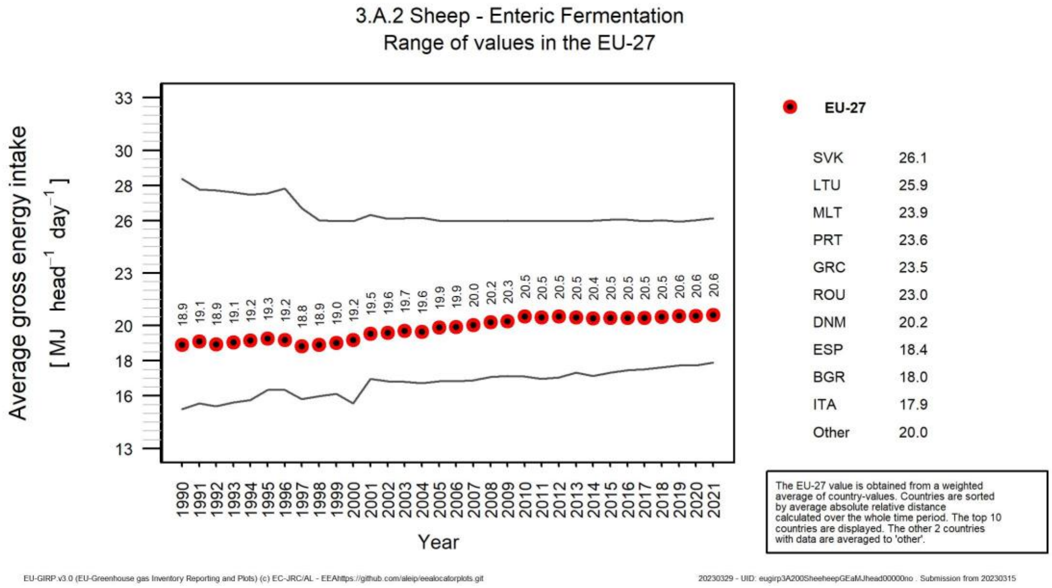


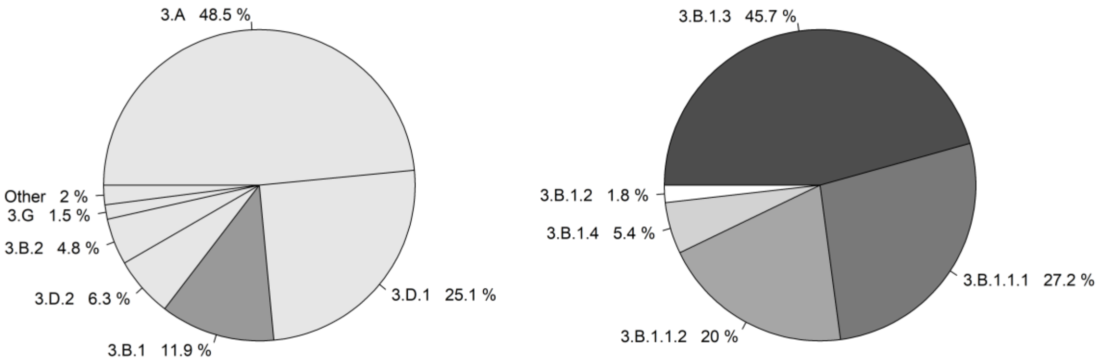
Table 5.15 3.A.2 - Sheep: countries' average gross energy intake (MJ/head/day)

Country	1990	2021		Country	1990	2021
Bulgaria	17	18	|	Luxembourg	19	19
Denmark	20	20	|	Malta	20	24
Spain	15	18	|	Portugal	23	24
Greece	23	23	|	Romania	23	23
Ireland	20	20	|	Slovakia	28	26
Italy	17	18	|	Sweden	20	20
Lithuania	26	26	|	EU	19	21

5.3.2 Manure Management - CH_4 (CRF Source Category 3B1)

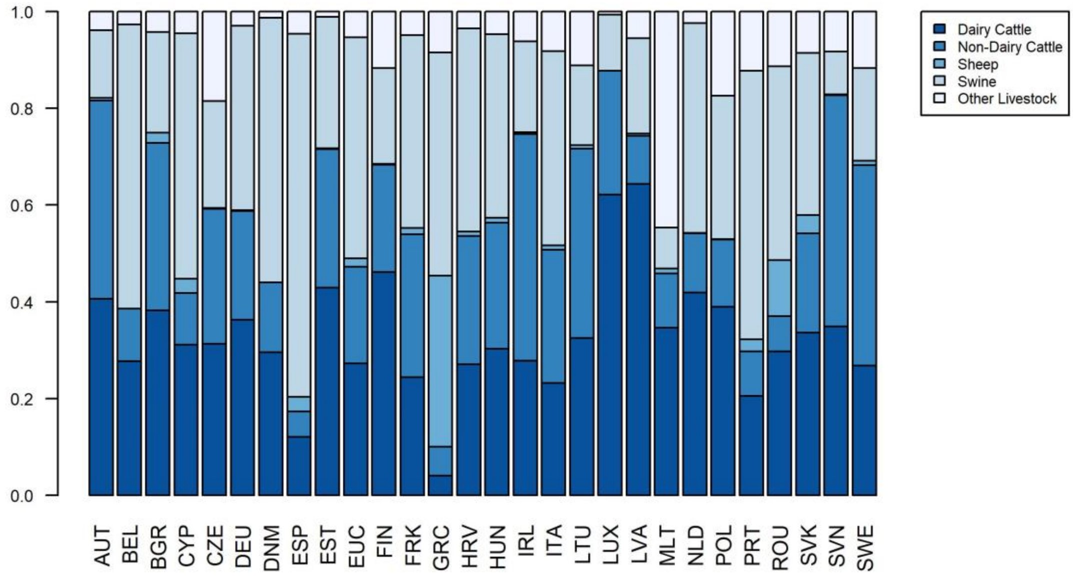
In 2021 CH_4 emissions in source category *3.B.1 - Manure Management* in EU were 44772 kt CO_2 equivalent. This corresponds to 1.4 % of total EU GHG emissions and 11 % of total EU CH_4 emissions. They make 11.8 % of total agricultural emissions and 19.3 % of total agricultural CH_4 emissions. The main sub-categories are 3.B.1.3 (Swine), 3.B.1.1.1 (Dairy Cattle) and 3.B.1.1.2 (Non-Dairy Cattle) as shown in Figure 5.20. Emissions are also reported for 3.B.1.4 (Other Livestock) and 3.B.1.2 (Sheep). CH_4 emissions from Manure Management for 'Other Livestock' are reported for the categories Buffalo, Deer, Goats, Horses, Mules and Asses, Poultry, and Other Other Livestock. Regarding the origin of emissions in the different countries, Figure 5.21 shows the distribution of CH_4 emissions from manure management by livestock category in all countries and in the EU. Each bar represents the total emissions of a country in the current emission category, where different shades of blue correspond to the emitting animal types.

Figure 5.20: **Share of source category 3.B.1 on total EU agricultural emissions (left panel) and decomposition into its sub-categories (right panel). The percentages refer to the emissions in the year 2021.**



In the left panel, some minor differences in the numbers might be present due to automatic rounding of numbers.

Figure 5.21: **Decomposition of emissions in source category 3.B.1 - Manure Management into its sub-categories by country in the year 2021.**



Total GHG and CH_4 emissions by country and for the total EU from 3.B.1 *Manure Management* are shown in Table 5.16 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, CH_4 emission in this source category decreased by 18 % or 9.7 Mt CO_2-eq. The decrease was largest in Slovakia in relative terms (82%) and in the Netherlands in absolute terms (2.1 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 1.9 %.

Table 5.16 3.B.1 - Manure Management: Countries' contributions to total EU-GHG and CH_4 emissions

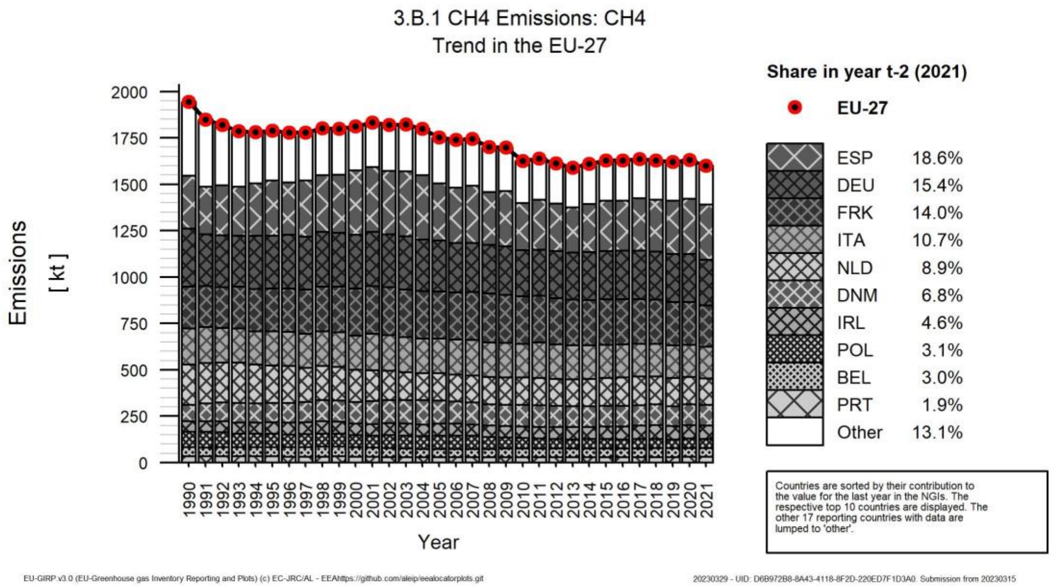
Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	632	620	623	1.4%	-10	-2%	2	0%	T2	CS,D
Belgium	1 376	1 335	1 322	3.0%	-54	-4%	-13	-1%	T1,T2	CS,D
Bulgaria	1 213	350	367	0.8%	-846	-70%	17	5%	T1,T2	CS,D
Croatia	492	424	422	0.9%	-70	-14%	-2	0%	T2	CS,D
Cyprus	114	80	84	0.2%	-30	-26%	4	5%	T1,T2	D
Czechia	1 575	386	386	0.9%	-1 189	-75%	0	0%	T1,T2	CS,D
Denmark	2 522	3 138	3 064	6.8%	542	21%	-74	-2%	CS,T2	CS,D
Estonia	186	190	188	0.4%	2	1%	-2	-1%	T1,T2	CS,D
Finland	413	507	492	1.1%	79	19%	-15	-3%	T2	CS
France	6 280	6 441	6 266	14.0%	-14	0%	-174	-3%	T2	CS
Germany	8 748	7 222	6 884	15.4%	-1 864	-21%	-339	-5%	T2	CS,D
Greece	939	730	728	1.6%	-210	-22%	-2	0%	T1,T2	CS,D
Hungary	1 334	728	758	1.7%	-577	-43%	30	4%	T1,T2	CS,D
Ireland	1 580	2 045	2 066	4.6%	486	31%	21	1%	T1,T2	CS,D
Italy	5 424	4 875	4 782	10.7%	-642	-12%	-93	-2%	T1,T2	CS,D
Latvia	213	99	105	0.2%	-107	-51%	6	6%	T1,T2	CS,D
Lithuania	747	253	260	0.6%	-488	-65%	7	3%	T1,T2	CS,D
Luxembourg	76	83	83	0.2%	7	10%	0	0%	T1,T2	CS,D
Malta	10	7	7	0.0%	-3	-34%	0	2%	T1,T2	CS,D
Netherlands	6 093	4 132	3 978	8.9%	-2 115	-35%	-154	-4%	T1,T2	CS,D
Poland	2 338	1 417	1 386	3.1%	-952	-41%	-31	-2%	T1,T2	CS,D
Portugal	907	837	838	1.9%	-69	-8%	2	0%	T1,T2	CS,D
Romania	2 087	731	711	1.6%	-1 376	-66%	-20	-3%	T1,T2	CS,D
Slovakia	485	97	86	0.2%	-400	-82%	-12	-12%	T1,T2	CS,D
Slovenia	364	265	265	0.6%	-99	-27%	0	0%	T1,T2	CS,D
Spain	8 001	8 366	8 324	18.6%	323	4%	-42	-1%	T1,T2	CS,D
Sweden	275	297	297	0.7%	22	8%	0	0%	T1,T2	CS,D
EU-27	**54 426**	**45 655**	**44 772**	**100%**	**-9 654**	**-18%**	**-883**	**-2%**	**-**	**-**

5.3.2.1 Trends in Emissions and Activity Data

3.B.1 - Manure Management - Emissions

Emissions in source category *3.B.1 - Manure Management* decreased considerably in EU by 18 % or 9.7 Mt CO_2-eq in the period 1990 to 2021. Figure 5.22 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in CH_4 emissions from manure management for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 86.9 % of the total in 2021. Emissions decreased in twenty countries and increased in seven countries. The four countries with the largest decreases were the Netherlands, Germany, Romania and the Czech Republic with a total absolute decrease of 6.5 Mt CO_2-eq. The three countries with the largest increases were Spain, Ireland and Denmark, with a total absolute increase of 1.4 Mt CO_2-eq.

Figure 5.22: 3.B.1: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.B.1.1 - Cattle - Emissions

In 2021 CH_4 emissions in source category *3.B.1.1 - Cattle* in EU were 21135.2 kt CO_2 equivalent. This corresponds to 0.6% of total EU GHG emissions and 5.1 % of total EU CH_4 emissions. They make 5.6 % of total agricultural emissions and 9.1 % of total agricultural CH_4 emissions. Figure 5.23 and Figure 5.24 show the trend of emissions for Dairy and Non-Dairy Cattle indicating the countries contributing most to EU.

Total GHG and CH_4 emissions by country and for the total EU from 3.B.1.1 *Manure Management* are shown in Table 5.17 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, CH_4 emission in this source category decreased by 15 % or 3.7 Mt CO_2-eq. The decrease was largest in the Czech Republic in relative terms (72%) and in Germany in absolute terms (1.1 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 1%. The ten countries with the highest emissions accounted together for 85.6% of the total in 2021. Emissions decreased in fifteen countries and increased in twelve countries. The three countries with the largest decreases were Germany, Italy and the Czech Republic with a total absolute decrease of 2.5 Mt CO_2-eq. The three countries with the largest increases were Denmark, Ireland and the Netherlands, with a total absolute increase of 874 kt CO_2-eq.

Table 5.17 3.B.1.1 - Cattle: Countries' contributions to total EU-GHG and CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	467	505	508	2.4%	41	9%	3	1%	T2	CS,D
Belgium	468	513	510	2.4%	42	9%	-3	-1%	T2	CS
Bulgaria	510	259	267	1.3%	-243	-48%	9	3%	T2	CS
Croatia	250	220	226	1.1%	-25	-10%	6	3%	T2	CS,D
Cyprus	19	31	35	0.2%	16	82%	4	13%	T2	D
Czechia	825	228	228	1.1%	-597	-72%	0	0%	T1,T2	CS
Denmark	1 164	1 343	1 348	6.4%	184	16%	5	0%	CS,T2	CS,D
Estonia	60	134	134	0.6%	74	124%	1	0%	T2	CS,D
Finland	260	343	337	1.6%	77	29%	-7	-2%	T2	CS
France	3 805	3 504	3 384	16.0%	-422	-11%	-120	-3%	T2	CS
Germany	5 153	4 133	4 043	19.1%	-1 110	-22%	-91	-2%	T2	CS
Greece	137	73	73	0.3%	-64	-47%	0	0%	T2	CS,D
Hungary	666	406	427	2.0%	-239	-36%	21	5%	T2	CS
Ireland	1 204	1 539	1 542	7.3%	338	28%	3	0%	T2	CS
Italy	3 176	2 473	2 426	11.5%	-750	-24%	-47	-2%	T2	CS
Latvia	124	74	78	0.4%	-46	-37%	4	5%	T2	CS
Lithuania	283	181	186	0.9%	-97	-34%	5	3%	T2	CS
Luxembourg	67	72	73	0.3%	6	8%	0	0%	T2	CS
Malta	6	3	3	0.0%	-3	-51%	0	-3%	T2	CS
Netherlands	1 801	2 141	2 153	10.2%	352	20%	12	1%	T2	CS
Poland	1 074	727	733	3.5%	-341	-32%	6	1%	T2	CS
Portugal	222	249	249	1.2%	27	12%	0	0%	T2	CS,D
Romania	732	277	263	1.2%	-468	-64%	-13	-5%	T2	CS
Slovakia	142	48	46	0.2%	-96	-67%	-1	-3%	T2	CS
Slovenia	183	220	219	1.0%	36	20%	0	0%	T2	CS
Spain	1 842	1 461	1 441	6.8%	-401	-22%	-20	-1%	T2	CS,D
Sweden	174	202	202	1.0%	28	16%	1	0%	T2	CS
EU-27	**24 818**	**21 359**	**21 135**	**100%**	**-3 683**	**-15%**	**-224**	**-1%**	**-**	**-**

Figure 5.23: 3.B.1.1: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

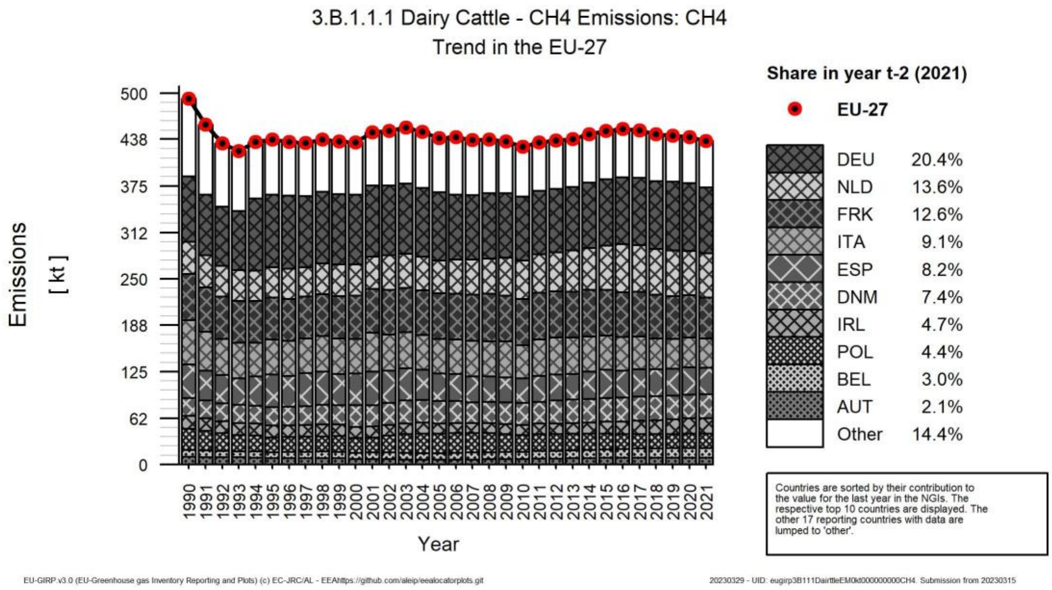
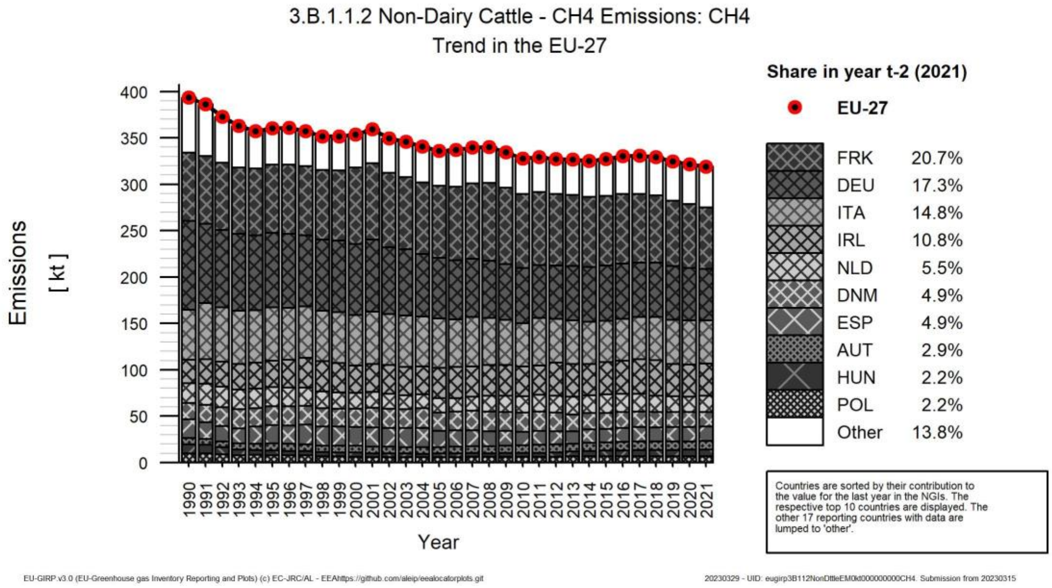


Figure 5.24: 3.B.1.2: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.B.1.1 - Cattle - Activity Data

The main activity data for CH_4 emissions from manure management - cattle are the animal numbers. Cattle numbers are already discussed under source category 3.A Enteric Fermentation and therefore not further discussed here.

Other relevant activity data are the allocation by climate region and the allocation by manure management system (MMS).

3.B.1.3 - Swine - Emissions

In 2021 CH_4 emissions in source category *3.B.1.3 - Swine* in EU were 20440.8 kt CO_2 equivalent. This corresponds to 0.62 % of total EU GHG emissions and 5 % of total EU CH_4 emissions. They make 5.4 % of total agricultural emissions and 8.8 % of total agricultural CH_4 emissions.

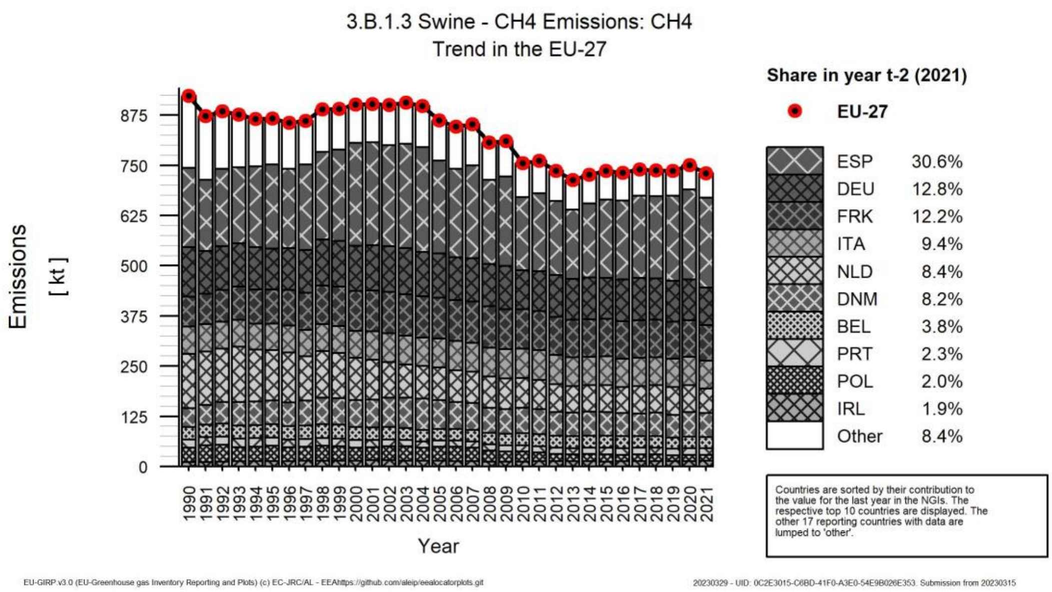
Total GHG and CH_4 emissions by country and for the total EU from 3.B.1.3 *Manure Management* are shown in Table 5.18 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, CH_4 emission in this source category decreased by 21 % or 5.4 Mt CO_2-eq. The decrease was largest in Slovakia in relative terms (91%) and in the Netherlands in absolute terms (2 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 2.8%. Figure 5.25 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in CH_4 emissions from manure management for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 91.6% of the total in 2021. Emissions decreased in twenty countries and increased in seven countries. The three countries with the largest decreases were the Netherlands, Romania and Germany with a total absolute decrease of 3.7 Mt CO_2-eq. The three countries with the largest increases were Denmark, France and Spain, with a total absolute increase of 1.5 Mt CO_2-eq.

Table 5.18 3.B.1.3 - Swine: Countries' contributions to total EU-GHG and CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	148	88	87	0.4%	-61	-41%	0	-1%	T2	CS,D
Belgium	888	786	776	3.8%	-112	-13%	-10	-1%	T2	CS
Bulgaria	609	67	77	0.4%	-532	-87%	9	14%	T2	CS
Croatia	201	184	177	0.9%	-24	-12%	-7	-4%	T2	CS,D
Cyprus	89	43	43	0.2%	-46	-52%	0	0%	T2	D
Czechia	632	84	85	0.4%	-546	-86%	1	1%	T2	CS
Denmark	1 301	1 723	1 674	8.2%	373	29%	-48	-3%	CS,T2	CS,D
Estonia	116	54	51	0.2%	-65	-56%	-3	-5%	T2	CS,D
Finland	76	103	97	0.5%	22	29%	-5	-5%	T2	CS
France	2 103	2 553	2 499	12.2%	396	19%	-54	-2%	T2	CS
Germany	3 427	2 871	2 622	12.8%	-805	-23%	-249	-9%	T2	CS
Greece	484	339	336	1.6%	-148	-31%	-3	-1%	T2	D
Hungary	562	280	288	1.4%	-274	-49%	8	3%	T2	CS
Ireland	286	371	387	1.9%	101	35%	16	4%	T2	CS,D
Italy	1 908	1 962	1 920	9.4%	13	1%	-42	-2%	T2	CS
Latvia	73	19	21	0.1%	-53	-72%	2	10%	T2	CS
Lithuania	369	42	43	0.2%	-326	-88%	2	4%	T2	CS
Luxembourg	8	10	10	0.0%	1	17%	0	-1%	T2	CS
Malta	1	1	1	0.0%	-1	-60%	0	0%	T2	CS
Netherlands	3 773	1 880	1 726	8.4%	-2 047	-54%	-154	-8%	T2	CS
Poland	1 022	441	410	2.0%	-612	-60%	-31	-7%	T1	CS
Portugal	567	467	466	2.3%	-101	-18%	-2	0%	T2	CS,D
Romania	1 143	293	285	1.4%	-858	-75%	-7	-3%	T2	CS
Slovakia	323	39	29	0.1%	-294	-91%	-10	-26%	T2	CS
Slovenia	143	25	23	0.1%	-120	-84%	-2	-6%	T1	D
Spain	5 536	6 248	6 251	30.6%	715	13%	3	0%	T2	CS,D
Sweden	67	55	57	0.3%	-10	-15%	1	3%	T2	CS
EU-27	**25 852**	**21 027**	**20 441**	**100%**	**-5 412**	**-21%**	**-586**	**-3%**	**-**	**-**

Note that some countries are using Tier 1 and default emission factors for 3.B.1.3 category. Although this is a key category for the EU, it is not a key category for all countries. For those countries using Tier 1, source category 3.B.1.3 is not a key category.

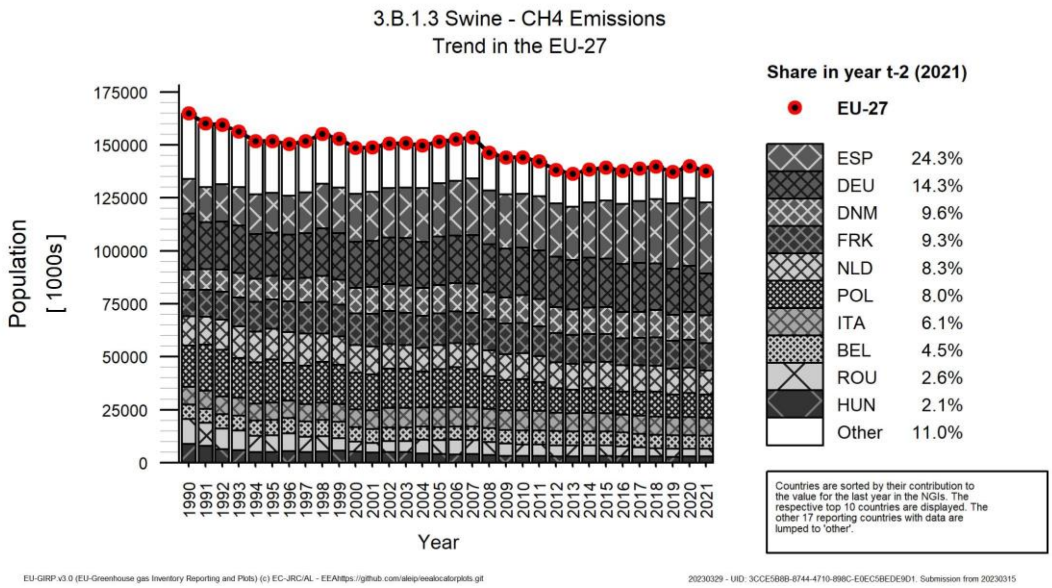
Figure 5.25: 3.B.1.3: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.B.1.3 - Swine - Population

The main activity data for CH_4 emissions from manure management - swine are the animal numbers. As swine are not a main animal type in the source category 3.A Enteric Fermentation its population data is discussed here. Swine population decreased considerably in EU by 16 % or 27 million heads in the period 1990 to 2021. Figure 5.26 shows the trend of swine population indicating the countries contributing most to EU total. The figure represents the trend in swine population for the different countries along the inventory period. The ten countries with the highest population accounted together for 89% of the total in 2021. Population decreased in twenty countries and increased in seven countries. The four countries with the largest decreases were Poland, Romania, Germany and Hungary with a total absolute decrease of 29.5 million heads. The largest increases occurred in Denmark and Spain, with a total absolute increase of 20.8 million heads.

Figure 5.26: 3.B.1.3: Trend in swine population in the EU and the countries contributing most to EU values including their share to EU population in 2021



5.3.2.2 Implied EFs and methodological issues

In this section, we discuss the implied emission factor for the category 3.B.1 for the main animal types. Furthermore, we present data on the typical animal mass as reported in CRF Tables 3B(a)s1 and average volatile solid (VS) daily excretion.

3.B.1.1 - Cattle - Implied emission factor

The implied emission factor for CH_4 emissions in source category *3.B.1.1 - Cattle* increased in EU considerably between 1990 and 2021 by 21 % or 1.6 kg/head/year. Table 5.19 shows the implied emission factor for CH_4 emissions in source category *3.B.1.1 - Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in five countries and increased in 22 countries. The four countries with the largest decreases were Spain, Malta, the Czech Republic and Greece with a mean absolute value of 3 kg/head/year. The four countries with the largest increases were Estonia, Denmark, Croatia and the Netherlands with a mean absolute value of 11 kg/head/year.

Table 5.19 3.B.1.1 - Cattle: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	6.5	9.7	|	Ireland	6.3	7.6
Belgium	5.1	7.8	|	Italy	14.6	14.8
Bulgaria	11.4	16.5	|	Lithuania	4.2	10.4

Country	1990	2021		Country	1990	2021
Cyprus	12.6	14.3	|	Luxembourg	11.0	13.7
Czech Republic	8.4	5.8	|	Latvia	3.1	7.1
Germany	9.4	13.1	|	Malta	10.6	7.8
Denmark	18.6	32.3	|	Netherlands	13.1	20.6
Spain	12.8	7.6	|	Poland	3.8	4.1
Estonia	2.8	19.1	|	Portugal	5.8	5.3
Finland	6.8	14.2	|	Romania	4.9	5.2
France	6.3	7.0	|	Slovakia	3.3	3.8
Greece	7.0	5.1	|	Slovenia	12.3	16.2
Croatia	10.9	18.9	|	Sweden	3.6	5.0
Hungary	14.7	16.5	|	EU	7.8	9.4

3.B.1.1.1 - Dairy Cattle - Implied emission factor

The implied emission factor for CH_4 emissions in source category *3.B.1.1.1 - Dairy Cattle* increased in EU very strongly between 1990 and 2021 by 58.5% or 7.9 kg/head/year. Figure 5.27 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.20 shows the implied emission factor for CH_4 emissions in source category *3.B.1.1.1 - Dairy Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in three countries and increased in 24 countries. The largest decrease occurred in Malta with an absolute value of 5 kg/head/year. The four countries with the largest increases were Estonia, Croatia, Denmark and Finland with a mean absolute value of 25 kg/head/year.

Figure 5.27: 3.B.1.1.1 - Dairy Cattle: Trend in implied emission factor in the EU and range of values reported by countries

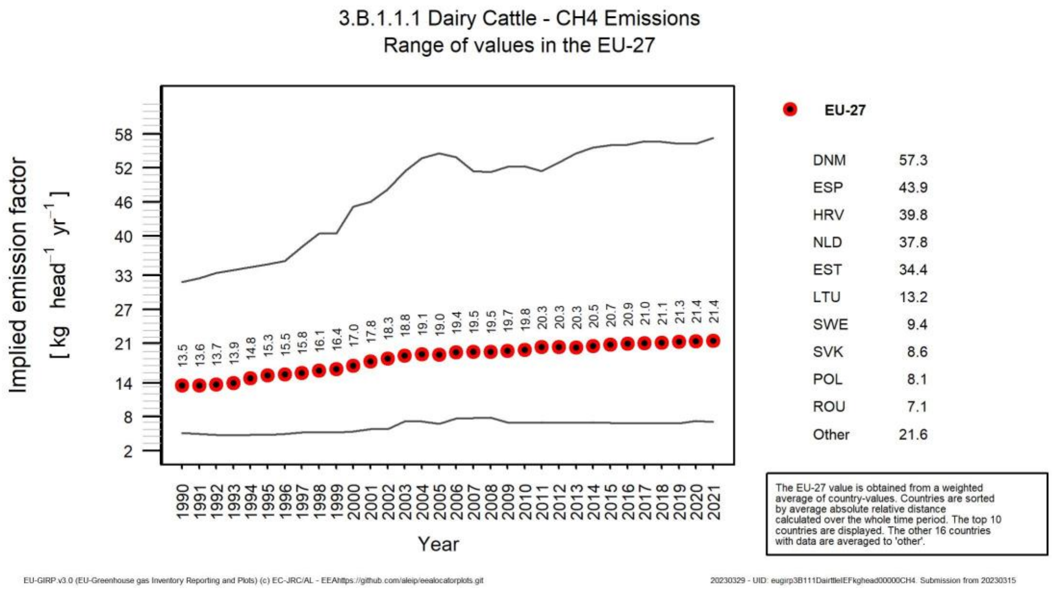


Table 5.20 3.B.1.1.1 - Dairy Cattle: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	11.3	17.1	|	Ireland	13.0	13.2
Belgium	11.1	26.0	|	Italy	22.5	24.6

Country	1990	2021		Country	1990	2021
Bulgaria	16.5	22.6	|	Lithuania	6.0	13.2
Cyprus	18.6	21.0	|	Luxembourg	23.7	37.0
Czech Republic	14.0	12.0	|	Latvia	6.4	18.4
Germany	13.9	23.2	|	Malta	19.3	14.0
Denmark	31.8	57.3	|	Netherlands	23.1	37.8
Spain	28.7	43.9	|	Poland	5.8	8.1
Estonia	5.1	34.4	|	Portugal	14.6	26.5
Finland	12.4	32.0	|	Romania	6.5	7.1
France	11.7	16.4	|	Slovakia	6.2	8.6
Greece	15.6	12.7	|	Slovenia	19.6	32.8
Croatia	13.9	39.8	|	Sweden	6.6	9.4
Hungary	24.8	33.4	|	EU	13.5	21.4

3.B.1.1.1 - Dairy Cattle - Typical animal mass

The typical animal mass, a parameter used for calculating CH_4 emissions in source category *3.B.1.1.1 - Dairy Cattle*, increased in EU slightly between 1990 and 2021 by 5% or 29 kg. Figure 5.28 shows the trend of the typical animal mass in EU indicating also the range of values used by the countries. Table 5.21 shows the typical animal mass in source category *3.B.1.1.1 - Dairy Cattle* for the years 1990 and 2021 for all countries and EU. Typical animal mass decreased in two countries and increased in sixteen countries. It was in 2021 at the level of 1990 in nine countries. Decreases occurred in France and Belgium with a mean absolute value of 7 kg. The largest increase occurred in Finland with an absolute value of 166 kg.

Figure 5.28: 3.B.1.1.1 - Dairy Cattle: Trend in typical animal mass in the EU and range of values reported by countries

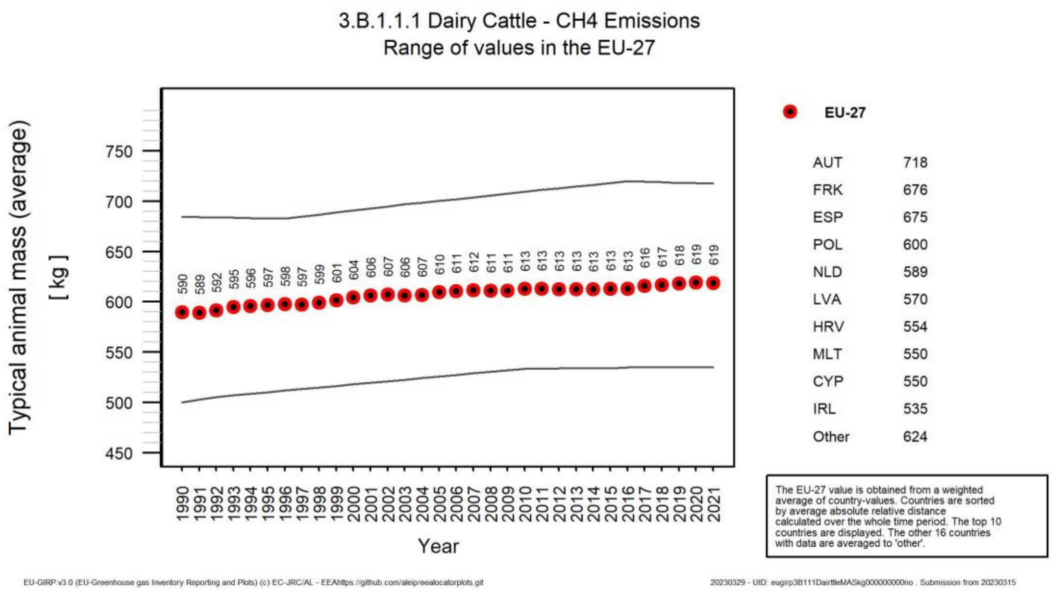


Table 5.21 3.B.1.1.1 - Dairy Cattle: countries' typical animal mass (kg)

Country	1990	2021		Country	1990	2021
Austria	676	718	|	Ireland	535	535

Country	1990	2021		Country	1990	2021
Belgium	623	618	|	Italy	603	603
Bulgaria	588	588	|	Lithuania	575	634
Cyprus	550	550	|	Luxembourg	650	650
Czech Republic	520	650	|	Latvia	550	570
Germany	567	601	|	Malta	550	550
Denmark	550	580	|	Netherlands	555	589
Spain	652	675	|	Poland	500	600
Estonia	545	636	|	Portugal	600	600
Finland	520	686	|	Romania	650	650
France	685	676	|	Slovakia	589	599
Greece	553	624	|	Slovenia	510	628
Croatia	502	554	|	Sweden	650	650
Hungary	633	640	|	EU	590	619

3.B.1.1.1 - Dairy Cattle - VS daily excretion

The VS daily excretion, a parameter used for calculating CH_4 emissions in source category *3.B.1.1.1 - Dairy Cattle*, increased in EU considerably between 1990 and 2021 by 19.6 % or 0.81 kg dm/head/day. Figure 5.29 shows the trend of the VS daily excretion in EU indicating also the range of values used by the countries. Table 5.22 shows the VS daily excretion in source category *3.B.1.1.1 - Dairy Cattle* for the years 1990 and 2021 for all countries and EU. VS daily excretion decreased in three countries and increased in 24 countries. The largest decrease occurred in Malta with an absolute value of 2 kg dm/head/day. The four countries with the largest increases were Denmark, the Czech Republic, Finland and Latvia with a mean absolute value of 3 kg dm/head/day.

Figure 5.29: 3.B.1.1.1 - Dairy Cattle: Trend in VS daily excretion in the EU and range of values reported by countries

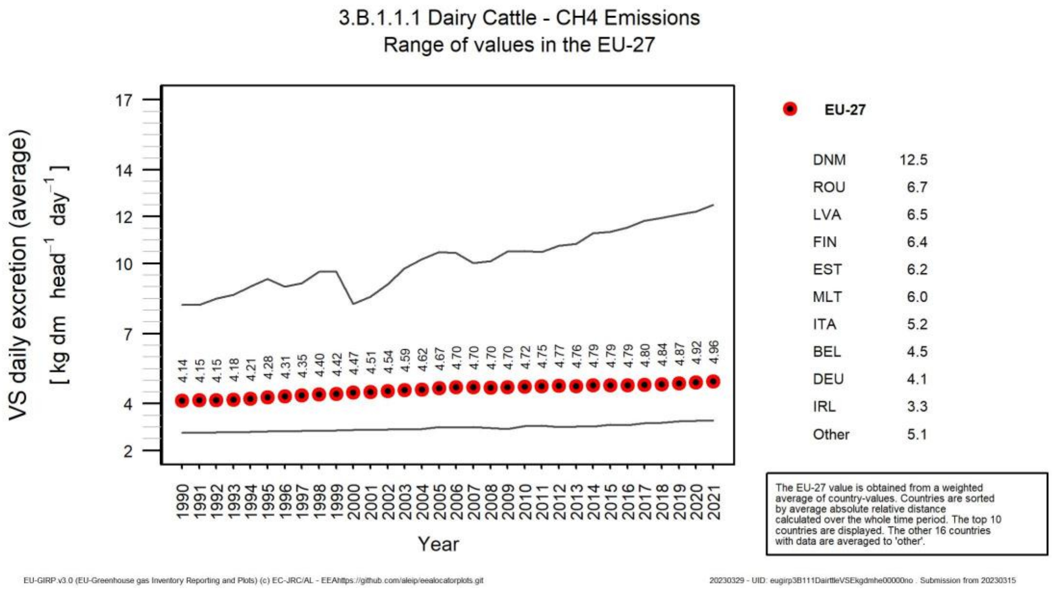


Table 5.22 3.B.1.1.1 - Dairy Cattle: countries' VS daily excretion (kg dm/head/day)

Country	1990	2021		Country	1990	2021
Austria	4.7	5.0	|	Ireland	2.7	3.3
Belgium	3.2	4.5	|	Italy	6.4	5.2
Bulgaria	4.0	4.2	|	Lithuania	4.6	5.6
Cyprus	4.2	5.4	|	Luxembourg	4.7	6.1
Czech Republic	4.2	6.2	|	Latvia	4.7	6.5
Germany	3.0	4.1	|	Malta	8.2	6.0
Denmark	6.5	12.5	|	Netherlands	3.8	4.8
Spain	3.9	5.2	|	Poland	4.5	5.0
Estonia	4.7	6.2	|	Portugal	3.5	4.9
Finland	4.4	6.4	|	Romania	5.1	6.7
France	3.5	4.3	|	Slovakia	3.6	4.7
Greece	5.5	4.5	|	Slovenia	4.5	5.3
Croatia	4.7	5.1	|	Sweden	5.1	5.4
Hungary	4.4	5.8	|	EU	4.1	5.0

3.B.1.1.2 - Non-Dairy Cattle - Implied emission factor

The implied emission factor for CH_4 emissions in source category *3.B.1.1.2 - Non-Dairy Cattle* increased in EU slightly between 1990 and 2021 by 4.8 % or 0.25 kg/head/year. Figure 5.30 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.23 shows the implied emission factor for CH_4 emissions in source category *3.B.1.1.2 - Non-Dairy Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in ten countries and increased in seventeen countries. The largest decreases occurred in Spain and the Czech Republic with a mean absolute value of 2 kg/head/year. The four countries with the largest increases were Estonia, Lithuania, Croatia and Denmark with a mean absolute value of 7 kg/head/year.

Figure 5.30: 3.B.1.1.2 - Non-Dairy Cattle: Trend in implied emission factor in the EU and range of values reported by countries

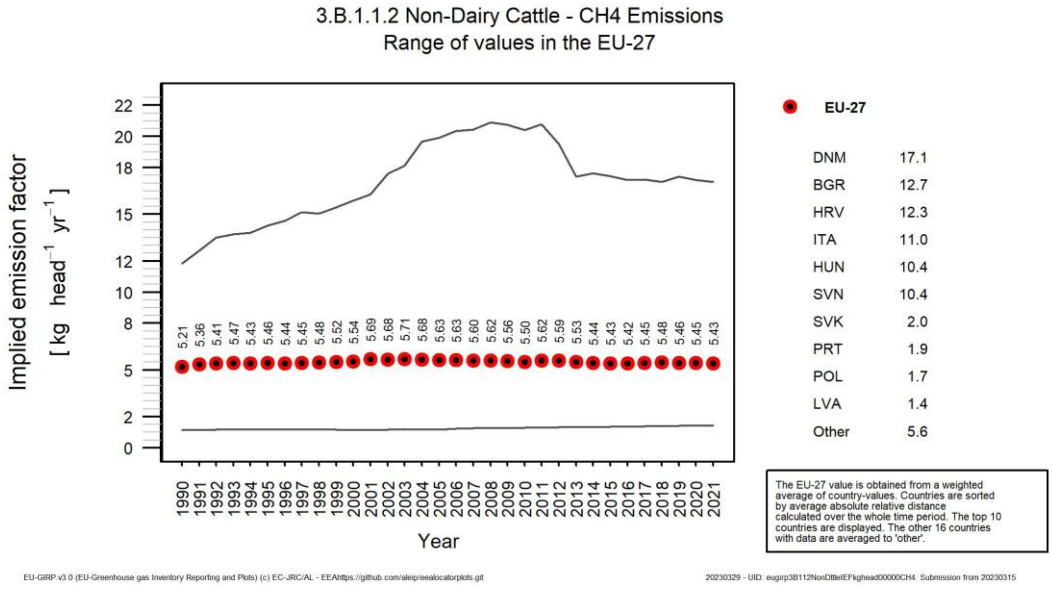


Table 5.23 3.B.1.1.2 - Non-Dairy Cattle: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	3.8	6.8	|	Ireland	4.7	6.0
Belgium	3.1	2.8	|	Italy	10.5	11.0
Bulgaria	8.2	12.7	|	Lithuania	3.3	8.8
Cyprus	8.5	7.4	|	Luxembourg	6.3	5.4
Czech Republic	5.5	3.7	|	Latvia	1.1	1.4
Germany	7.3	7.7	|	Malta	3.8	3.3
Denmark	11.8	17.1	|	Netherlands	6.9	8.1
Spain	5.7	2.6	|	Poland	2.0	1.7
Estonia	1.5	11.5	|	Portugal	2.2	1.9
Finland	3.7	6.6	|	Romania	2.9	2.5
France	4.5	4.7	|	Slovakia	2.2	2.0
Greece	3.3	3.6	|	Slovenia	6.9	10.4
Croatia	7.0	12.3	|	Sweden	2.1	3.8
Hungary	9.3	10.4	|	EU	5.1	5.3

3.B.1.1.2 - Non-Dairy Cattle - Typical animal mass

The typical animal mass, a parameter used for calculating CH_4 emissions in source category *3.B.1.1.2 - Non-Dairy Cattle*, increased in EU clearly between 1990 and 2021 by 10.8 % or 38 kg. Figure 5.31 shows the trend of the typical animal mass in EU indicating also the range of values used by the countries. Table 5.24 shows the typical animal mass in source category *3.B.1.1.2 - Non-Dairy Cattle* for the years 1990 and 2021 for all countries and EU. Typical animal mass decreased in four countries and increased in 22 countries. No data were available for Sweden. The three countries with the largest decreases were Cyprus, the Netherlands and Malta with a mean absolute value of 28 kg. The four countries with the largest increases were Finland, Bulgaria, Poland and the Czech Republic with a mean absolute value of 119 kg.

Figure 5.31: 3.B.1.1.2 - Non-Dairy Cattle: Trend in typical animal mass in the EU and range of values reported by countries

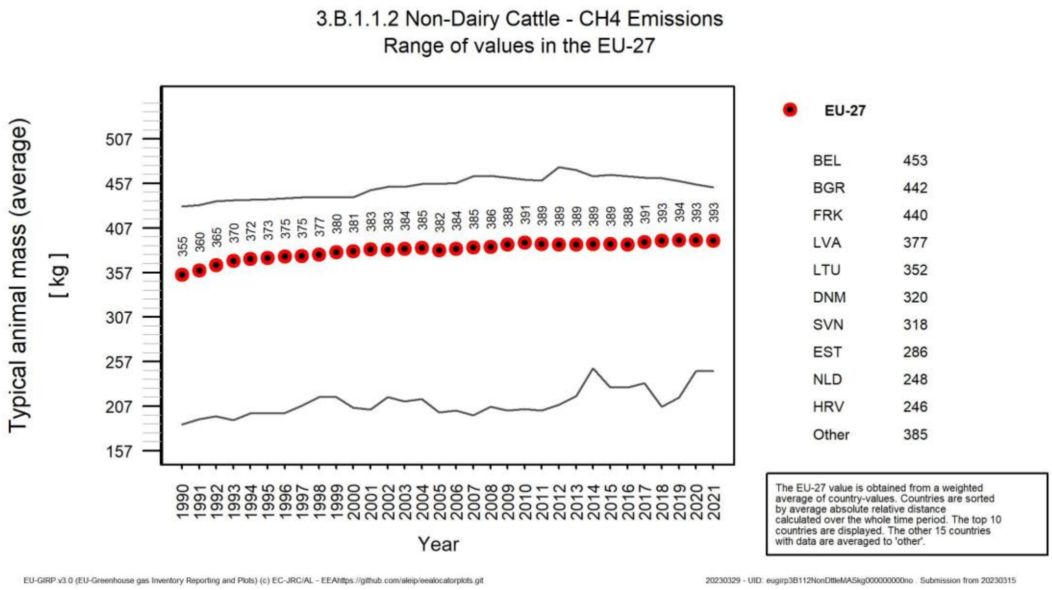


Table 5.24 *3.B.1.1.2 - Non-Dairy Cattle: countries' typical animal mass (kg)*

Country	1990	2021		Country	1990	2021
Austria	325	381	|	Ireland	362	343
Belgium	422	453	|	Italy	376	388
Bulgaria	298	442	|	Lithuania	327	352
Cyprus	359	323	|	Luxembourg	422	434
Czech Republic	326	418	|	Latvia	298	377
Germany	316	342	|	Malta	371	348
Denmark	290	320	|	Netherlands	272	248
Spain	413	424	|	Poland	316	410
Estonia	222	286	|	Portugal	399	442
Finland	278	424	|	Romania	338	359
France	431	440	|	Slovakia	330	391
Greece	375	418	|	Slovenia	289	318
Croatia	186	246	|	EU	355	393
Hungary	327	369	|			

3.B.1.1.2 - Non-Dairy Cattle - VS daily excretion

The VS daily excretion, a parameter used for calculating CH_4 emissions in source category *3.B.1.1.2 - Non-Dairy Cattle*, increased in EU slightly between 1990 and 2021 by 2.1% or 0.043 kg dm/head/day. Figure 5.32 shows the trend of the VS daily excretion in EU indicating also the range of values used by the countries. Table 5.25 shows the VS daily excretion in source category *3.B.1.1.2 - Non-Dairy Cattle* for the years 1990 and 2021 for all countries and EU. VS daily excretion decreased in eight countries and increased in eighteen countries. It was in 2021 at the level of 1990 in one country. The three countries with the largest decreases were Portugal, Italy and Malta with a mean absolute value of 0.4 kg dm/head/day. The four countries with the largest increases were the Czech Republic, Finland, Lithuania and Latvia with a mean absolute value of 1 kg dm/head/day.

Figure 5.32: 3.B.1.1.2 - Non-Dairy Cattle: Trend in VS daily excretion in the EU and range of values reported by countries

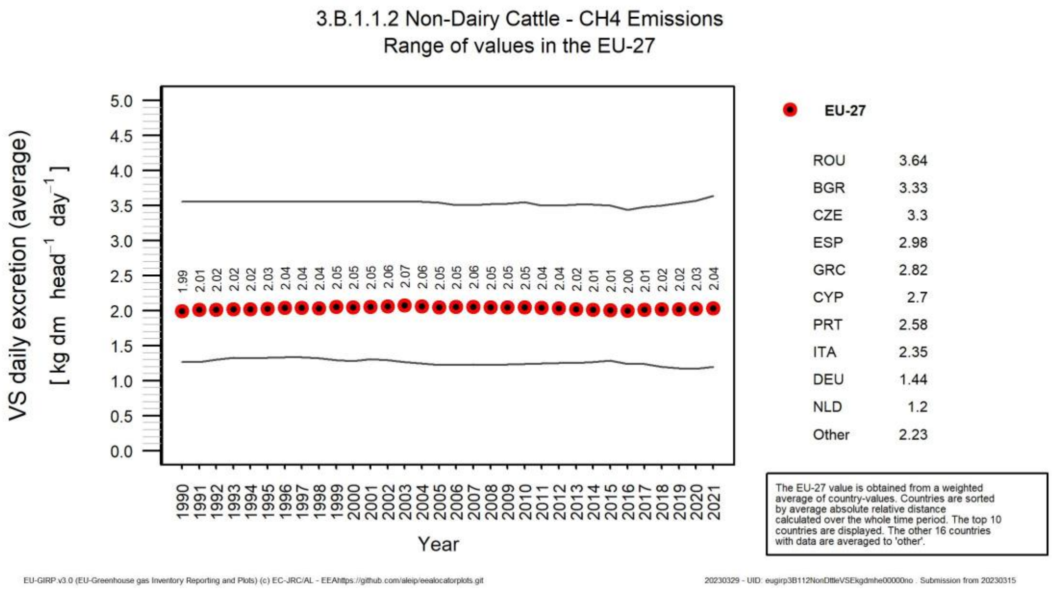


Table 5.25 3.B.1.1.2 - Non-Dairy Cattle: countries' VS daily excretion (kg dm/head/day)

Country	1990	2021	Country	1990	2021
Austria	1.9	2.4	Ireland	1.6	1.6
Belgium	1.5	1.5	Italy	2.8	2.4
Bulgaria	2.8	3.3	Lithuania	2.4	3.2
Cyprus	2.7	2.7	Luxembourg	2.1	2.2
Czech Republic	2.3	3.3	Latvia	1.7	2.3
Germany	1.3	1.4	Malta	2.1	1.9
Denmark	2.0	2.5	Netherlands	1.4	1.2
Spain	3.2	3.0	Poland	2.0	1.8
Estonia	2.5	2.5	Portugal	3.2	2.6
Finland	1.5	2.3	Romania	3.6	3.6
France	1.9	1.9	Slovakia	2.5	2.5
Greece	2.6	2.8	Slovenia	2.1	2.2
Croatia	2.5	2.7	Sweden	1.6	1.7
Hungary	2.5	2.6	EU	2.0	2.0

3.B.1.3 - Swine - Implied emission factor

The implied emission factor for CH_4 emissions in source category *3.B.1.3 - Swine* decreased in EU moderately between 1990 and 2021 by 5.4%. Figure 5.33 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.26 shows the implied emission factor for CH_4 emissions in source category *3.B.1.3 - Swine* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in sixteen countries and increased in ten countries. It was in 2021 at the level of 1990 in one country. The four countries with the largest increases were Croatia, Hungary, Finland and Sweden with a mean absolute value of 1 kg/head/year.

Figure 5.33: 3.B.1.3 - Swine: Trend in implied emission factor in the EU and range of values reported by countries

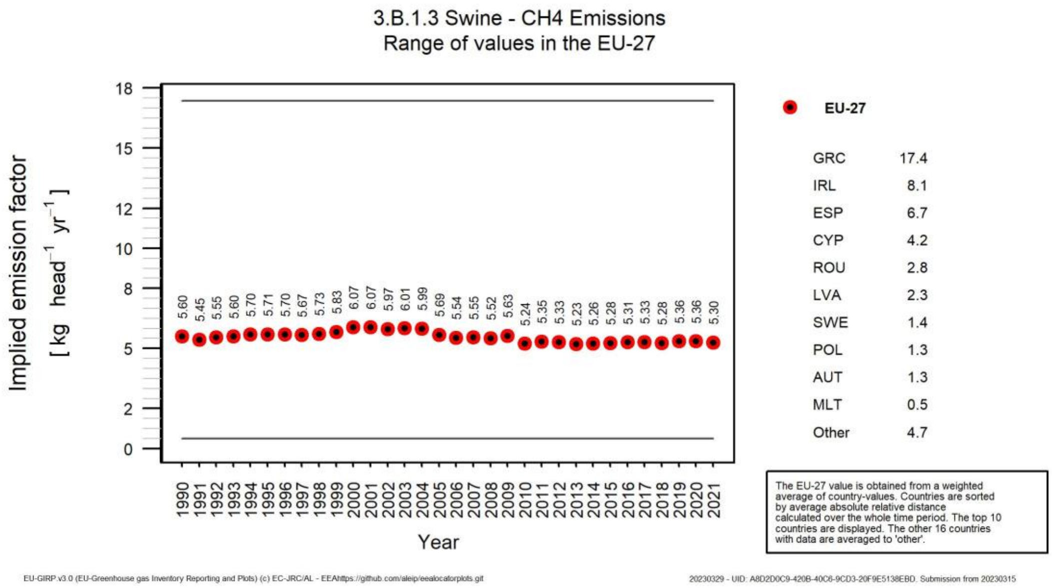


Table 5.26 3.B.1.3 - Swine: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	1.5	1.3	|	Ireland	8.4	8.1
Belgium	4.7	4.4	|	Italy	8.1	8.2
Bulgaria	5.1	4.2	|	Lithuania	5.1	2.7
Cyprus	11.4	4.2	|	Luxembourg	4.7	4.9
Czech Republic	4.7	2.0	|	Latvia	1.9	2.3
Germany	4.6	4.7	|	Malta	0.5	0.5
Denmark	4.9	4.5	|	Netherlands	9.7	5.4
Spain	12.1	6.7	|	Poland	1.9	1.3
Estonia	4.8	5.9	|	Portugal	8.0	7.4
Finland	2.0	3.2	|	Romania	3.4	2.8
France	6.0	6.9	|	Slovakia	4.6	2.3
Greece	17.4	17.4	|	Slovenia	8.7	3.9
Croatia	4.6	6.5	|	Sweden	1.0	1.4
Hungary	2.3	3.6	|	EU	5.6	5.3

3.B.1.3 - Swine - Typical animal mass

The typical animal mass, a parameter used for calculating CH_4 emissions in source category *3.B.1.3 - Swine*, decreased in EU barely between 1990 and 2021 by 0.64 %. Figure 5.34 shows the trend of the typical animal mass in EU indicating also the range of values used by the countries. Table 5.27 shows the typical animal mass in source category *3.B.1.3 - Swine* for the years 1990 and 2021 for all countries and EU. Typical animal mass decreased in sixteen countries and increased in five countries. It was in 2021 at the level of 1990 in one country. No data were available for five countries (Finland, the Netherlands, Poland, Slovenia and Sweden). The three countries with the largest decreases were Luxembourg, Latvia and Belgium with a mean absolute value of 10 kg. The three countries with the largest increases were Denmark, Estonia and Italy with a mean absolute value of 8 kg.

Figure 5.34: 3.B.1.3 - Swine: Trend in typical animal mass in the EU and range of values reported by countries

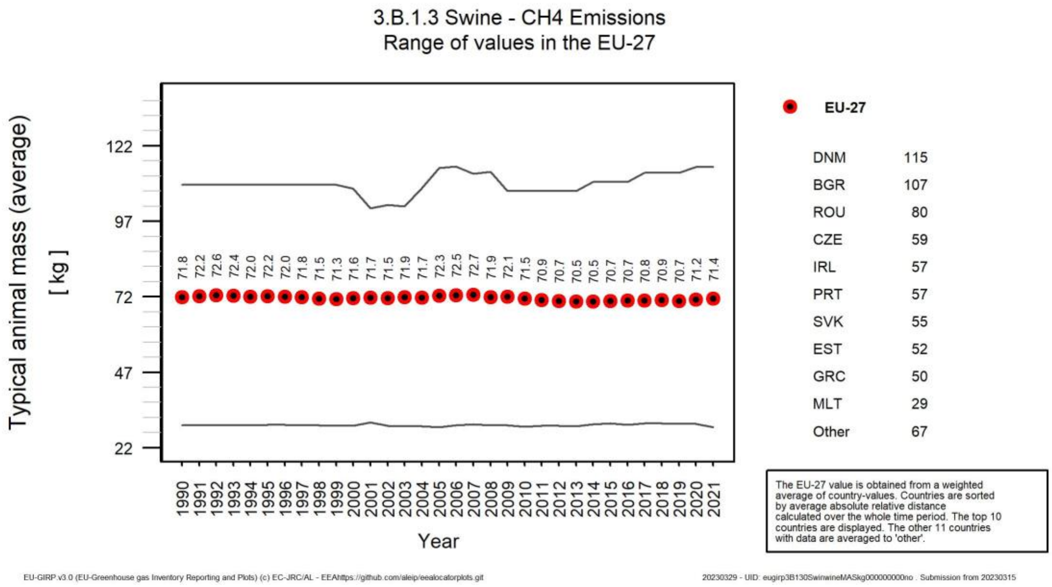


Table 5.27 3.B.1.3 - Swine: countries' typical animal mass (kg)

Country	1990	2021	Country	1990	2021
Austria	75	74	Hungary	63	64
Belgium	69	63	Ireland	63	57
Bulgaria	109	107	Italy	79	80
Cyprus	68	63	Lithuania	65	62
Czech Republic	62	59	Luxembourg	87	75
Germany	67	64	Latvia	75	63
Denmark	98	115	Malta	29	29
Spain	64	62	Portugal	62	57
Estonia	45	52	Romania	82	80
France	65	65	Slovakia	61	55
Greece	50	50	EU	72	71
Croatia	82	79			

3.B.1.3 - Swine - VS daily excretion

The VS daily excretion, a parameter used for calculating CH_4 emissions in source category *3.B.1.3 - Swine*, decreased in EU moderately between 1990 and 2021 by 8.1%. Figure 5.35 shows the trend of the VS daily excretion in EU indicating also the range of values used by the countries. Table 5.28 shows the VS daily excretion in source category *3.B.1.3 - Swine* for the years 1990 and 2021 for all countries and EU. VS daily excretion decreased in nineteen countries and increased in five countries. It was in 2021 at the level of 1990 in two countries. No data were available for Greece. The three countries with the largest decreases were Slovakia, the Netherlands and Lithuania with a mean absolute value of 0.2 kg dm/head/day. The three countries with the largest increases were Germany, Estonia and Sweden with a mean absolute value of 0.029 kg dm/head/day.

Figure 5.35: 3.B.1.3 - Swine: Trend in VS daily excretion in the EU and range of values reported by countries

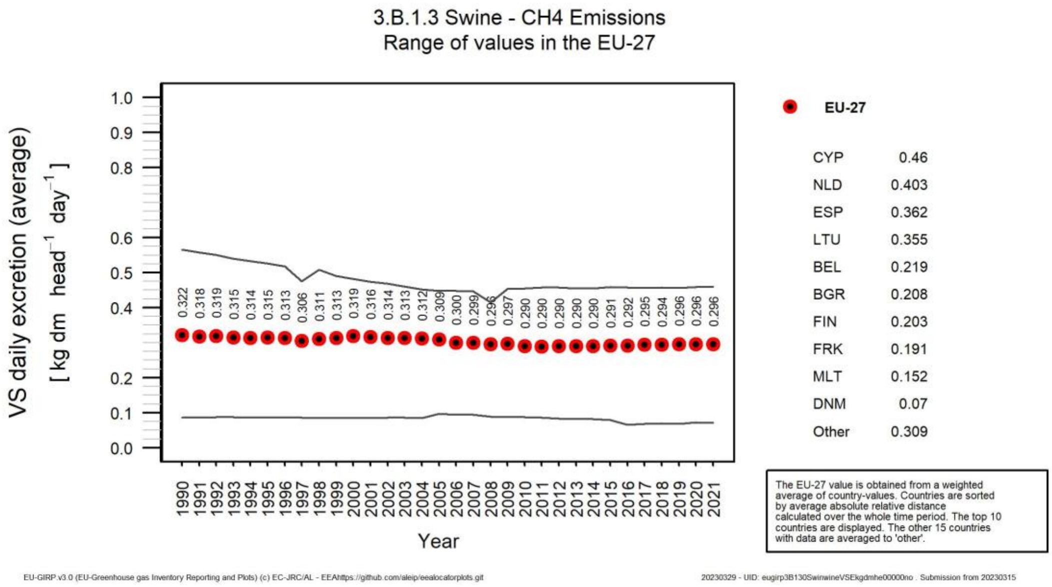


Table 5.28 3.B.1.3 - Swine: countries' VS daily excretion (kg DM/head/day)

Country	1990	2021	Country	1990	2021
Austria	0.326	0.32	Italy	0.370	0.33
Belgium	0.233	0.22	Lithuania	0.498	0.35
Bulgaria	0.252	0.21	Luxembourg	0.323	0.31
Cyprus	0.446	0.46	Latvia	0.397	0.35
Czech Republic	0.319	0.31	Malta	0.152	0.15
Germany	0.298	0.34	Netherlands	0.566	0.40
Denmark	0.086	0.07	Poland	0.318	0.31
Spain	0.440	0.36	Portugal	0.282	0.26
Estonia	0.291	0.32	Romania	0.287	0.28
Finland	0.218	0.20	Slovakia	0.448	0.23
France	0.172	0.19	Slovenia	0.319	0.31
Croatia	0.334	0.32	Sweden	0.277	0.30
Hungary	0.300	0.30	EU	0.322	0.30
Ireland	0.361	0.35			

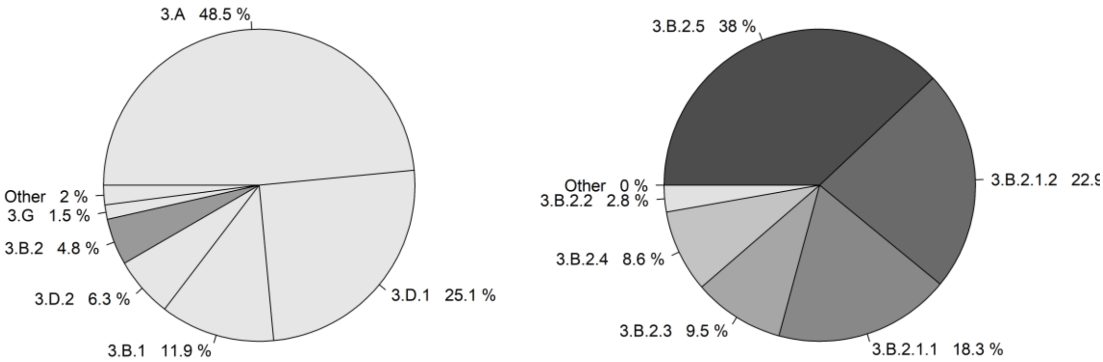
5.3.3 Manure Management - N_2O (CRF Source Category 3B2)

In 2021 N_2O emissions in source category *3.B.2 - Manure Management* in EU were 18130.6 kt CO_2 equivalent. This corresponds to 0.55 % of total EU GHG emissions and 10 % of total EU N_2O emissions. They make 4.8 % of total agricultural emissions and 13.3 % of total agricultural N_2O emissions. The main sub-categories are 3.B.2.5 (Indirect Emissions), 3.B.2.1.2 (Non-Dairy Cattle) and 3.B.2.1.1 (Dairy Cattle) as shown in Figure 5.36, but substantial emissions are also reported for Swine, and Poultry.

Regarding the origin of emissions in the different countries, Figure 5.37 shows the distribution of N_2O emissions from manure management by livestock category in all countries and in the EU. Each bar represents the total emissions of a country in the current emission category, where different shades of blue correspond to the emitting animal types.

Regarding the handling of manure in the different countries, Figure 5.38 shows the distribution of total manure nitrogen by manure system in all countries and in the EU. Each bar represents the total manure nitrogen handled in the current system for the country, where different shades correspond to the emitting manure systems.

Figure 5.36: Share of source category 3.B.2 on total EU agricultural emissions (left panel) and decomposition into its sub-categories (right panel). The percentages refer to the emissions in the year 2021.3.B.2.1-3.B.3.4: emissions by animal types (cattle, sheep, swine, other livestock); 3.B.2.5:Indirect emissions from manure management.



In the left panel, some minor differences in the numbers might be present due to automatic rounding of numbers.

Figure 5.37: Decomposition of N_2O emissions in source category 3.B.2 - Manure Management into its sub-categories by country in the year 2021.

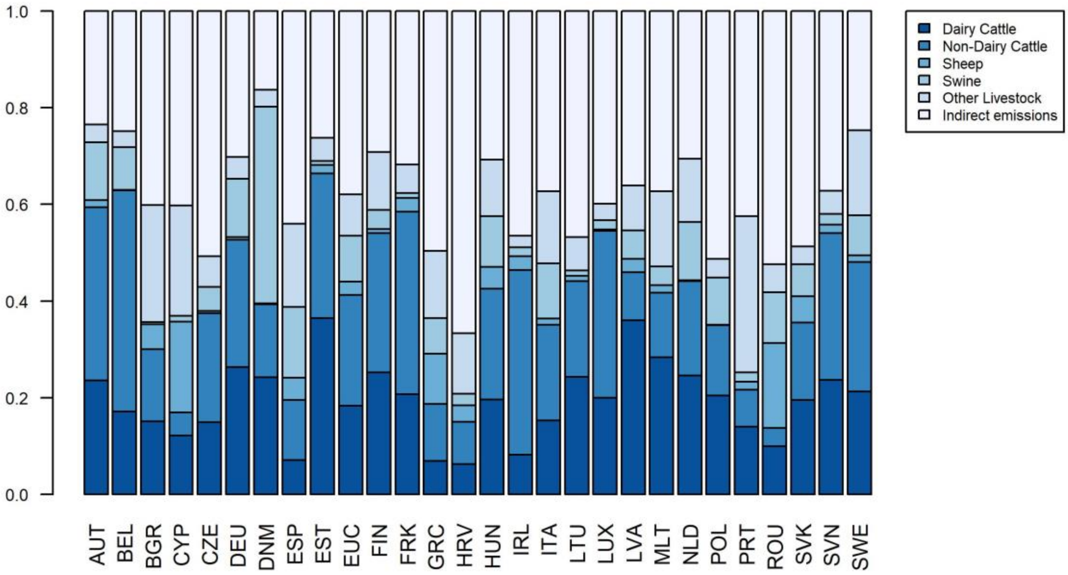
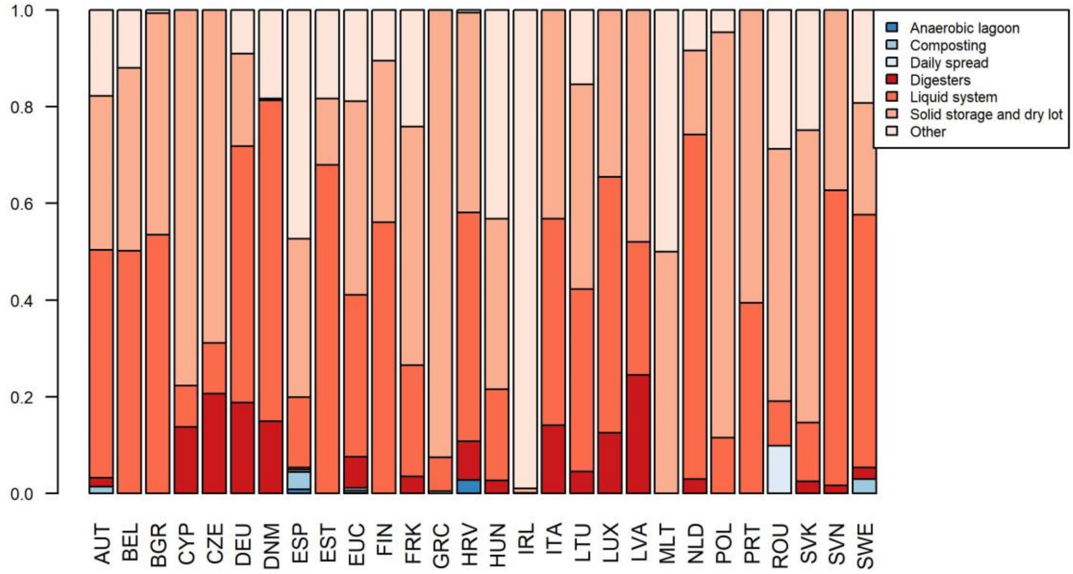


Figure 5.38: Decomposition of manure nitrogen handled in source category 3.B.2 - Manure Management into the different manure management systems by country in the year 2021.



Total GHG and N_2O emissions by country and for the total EU from 3.B.2 *Manure Management* are shown in Table 5.29 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, N_2O emission in this source category decreased by 29 % or 7.4 Mt CO_2-eq. The decrease was largest in Latvia in relative terms (74 %) and in Poland in absolute terms (1 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 1.7 %.

Table 5.29 3.B.2 - Manure Management: Countries' contributions to total EU-GHG and N_2O emissions

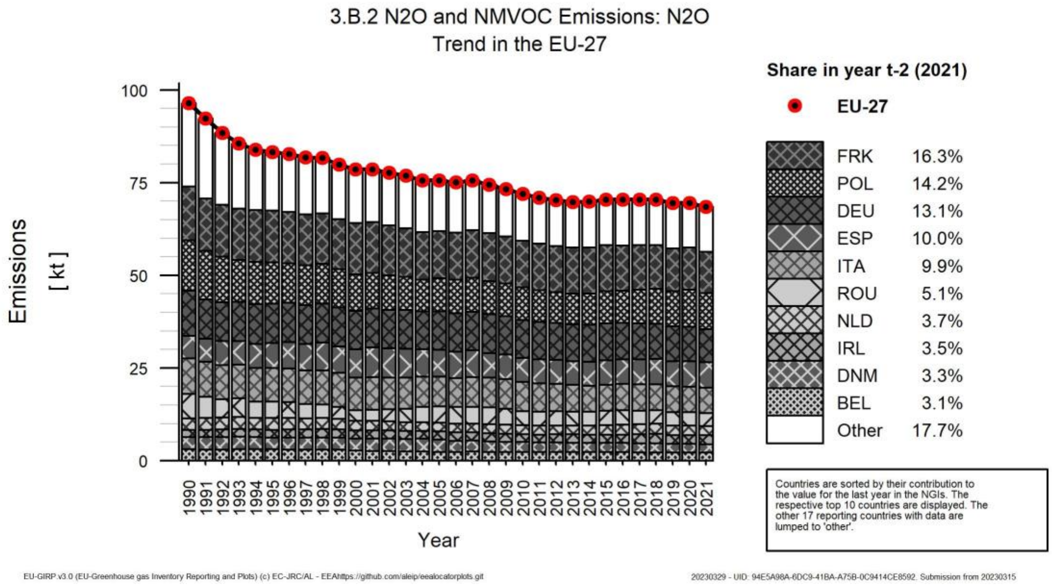
Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	509	469	471	2.6%	-37	-7%	3	1%	T2	D
Belgium	810	576	569	3.1%	-241	-30%	-7	-1%	T2	D
Bulgaria	790	253	257	1.4%	-533	-67%	4	2%	T1,T2	D
Croatia	284	111	108	0.6%	-176	-62%	-3	-3%	T2	CS,D
Cyprus	58	69	70	0.4%	12	20%	1	2%	T1	D
Czechia	996	392	392	2.2%	-604	-61%	1	0%	T2	CS,D
Denmark	860	622	596	3.3%	-264	-31%	-27	-4%	T2	D
Estonia	100	67	67	0.4%	-33	-33%	0	0%	T1,T2	CS,D
Finland	252	242	237	1.3%	-14	-6%	-5	-2%	T2	D
France	3 836	3 024	2 947	16.3%	-888	-23%	-77	-3%	T2	CS,D
Germany	3 211	2 451	2 373	13.1%	-839	-26%	-79	-3%	T2	CS,D
Greece	335	265	265	1.5%	-70	-21%	0	0%	D	D
Hungary	758	383	384	2.1%	-373	-49%	1	0%	T1,T2	CS,D
Ireland	515	622	637	3.5%	122	24%	15	2%	T2,T3	CS,D
Italy	2 518	1 835	1 800	9.9%	-718	-29%	-35	-2%	T2	CS,D
Latvia	252	66	66	0.4%	-186	-74%	0	0%	T1,T2	D
Lithuania	519	155	157	0.9%	-363	-70%	2	1%	T1,T2	D
Luxembourg	39	35	34	0.2%	-4	-12%	0	-1%	T2	CS
Malta	17	12	12	0.1%	-5	-31%	0	0%	T1,T2	CS,D
Netherlands	834	698	670	3.7%	-164	-20%	-28	-4%	T1	CS
Poland	3 624	2 631	2 579	14.2%	-1 045	-29%	-53	-2%	T1,T2	CS,D
Portugal	239	198	201	1.1%	-37	-16%	4	2%	T2	CS,D
Romania	1 763	940	931	5.1%	-832	-47%	-10	-1%	T2	D
Slovakia	407	134	125	0.7%	-282	-69%	-9	-6%	T1,T2	CS
Slovenia	81	73	73	0.4%	-8	-10%	0	0%	T1,T2	CS,D
Spain	1 620	1 822	1 820	10.0%	200	12%	-2	0%	T1,T2	D
Sweden	329	293	289	1.6%	-40	-12%	-4	-1%	CS,T2	CS,D
EU-27	**25 555**	**18 436**	**18 131**	**100%**	**-7 424**	**-29%**	**-305**	**-2%**	**-**	**-**

5.3.3.1 Trends in Emissions and Activity Data

3.B.2 - Manure Management - Emissions

Emissions in source category *3.B.2 - Manure Management* decreased strongly in EU by 29 % or 7.4 Mt CO_2-eq in the period 1990 to 2021. Figure 5.39 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from manure management for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 82.3 % of the total in 2021. Emissions decreased in 24 countries and increased in three countries. The four countries with the largest decreases were Poland, France, Germany and Romania with a total absolute decrease of 3.6 Mt CO_2-eq. The largest increases occurred in Ireland and Spain, with a total absolute increase of 322 kt CO_2-eq.

Figure 5.39: 3.B.2 Manure Management: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.B.2.1 - Cattle - Emissions

In 2021 N_2O emissions in source category *3.B.2.1 - Cattle* in EU were 7477.8 kt CO_2 equivalent. This corresponds to 0.23 % of total EU GHG emissions and 4 % of total EU N_2O emissions. They make 2 % of total agricultural emissions and 5.5 % of total agricultural N_2O emissions. Figure 5.40 and Figure 5.41 show the trend of emissions indicating the countries contributing most to the EU total. The figures represent the trend in N_2O emissions from manure management for the different countries along the inventory period.

Total GHG and N_2O emissions by country and for the total EU from 3.B.2.1 *Manure Management* are shown in Table 5.30 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, N_2O emission in this source category decreased by 28 % or 2.9 Mt CO_2-eq. The decrease was largest in Croatia in relative terms (80 %) and in France in absolute terms (527 kt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 1.2 %. The ten countries with the highest emissions accounted together for 84.6 % of the total in 2021. Emissions decreased in 22 countries and increased in five countries. The four countries with the largest decreases were France, Germany, Italy and Poland with a total absolute decrease of 1.8 Mt CO_2-eq. The largest increases occurred in Ireland and Spain, with a total absolute increase of 140 kt CO_2-eq.

Table 5.30 3.B.2.1 - Cattle: Countries' contributions to total EU-GHG and N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	294	278	280	3.7%	-14	-5%	2	1%	T2	D
Belgium	552	363	358	4.8%	-194	-35%	-5	-1%	T2	D
Bulgaria	189	73	77	1.0%	-112	-59%	4	6%	T2	D
Croatia	80	16	16	0.2%	-64	-80%	0	0%	T2	CS,D
Cyprus	7	11	12	0.2%	4	60%	1	9%	T1	D
Czechia	378	147	147	2.0%	-231	-61%	0	0%	T2	CS
Denmark	288	238	234	3.1%	-54	-19%	-4	-2%	T2	D
Estonia	54	44	45	0.6%	-9	-17%	0	1%	T2	CS,D
Finland	113	130	128	1.7%	15	13%	-2	-1%	T2	D
France	2 250	1 777	1 722	23.0%	-527	-23%	-54	-3%	T2	CS,D
Germany	1 724	1 277	1 249	16.7%	-475	-28%	-27	-2%	T2	CS,D
Greece	78	49	49	0.7%	-29	-37%	0	0%	D	D
Hungary	248	163	164	2.2%	-84	-34%	0	0%	T2	CS
Ireland	229	287	296	4.0%	67	29%	8	3%	T2	CS,D
Italy	1 067	647	632	8.4%	-435	-41%	-15	-2%	T2	CS,D
Latvia	107	31	30	0.4%	-77	-72%	0	-1%	T2	D
Lithuania	185	68	69	0.9%	-116	-63%	1	2%	T2	D
Luxembourg	23	19	19	0.2%	-5	-20%	0	-1%	T2	CS
Malta	8	5	5	0.1%	-3	-40%	0	-3%	T2	CS
Netherlands	304	307	295	3.9%	-9	-3%	-12	-4%	T1	CS
Poland	1 255	890	902	12.1%	-354	-28%	12	1%	T2	CS
Portugal	70	44	44	0.6%	-26	-37%	0	0%	T2	CS,D
Romania	294	132	128	1.7%	-166	-57%	-4	-3%	T2	D
Slovakia	136	47	44	0.6%	-91	-67%	-3	-5%	T2	CS
Slovenia	32	39	39	0.5%	7	22%	0	0%	T1,T2	CS,D
Spain	282	347	355	4.7%	73	26%	8	2%	T2	D
Sweden	156	139	139	1.9%	-18	-11%	0	0%	CS,T2	CS,D
EU-27	**10 403**	**7 567**	**7 478**	**100%**	**-2 925**	**-28%**	**-89**	**-1%**	**-**	**-**

Figure 5.40: 3.B.2.1 - Dairy cattle: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

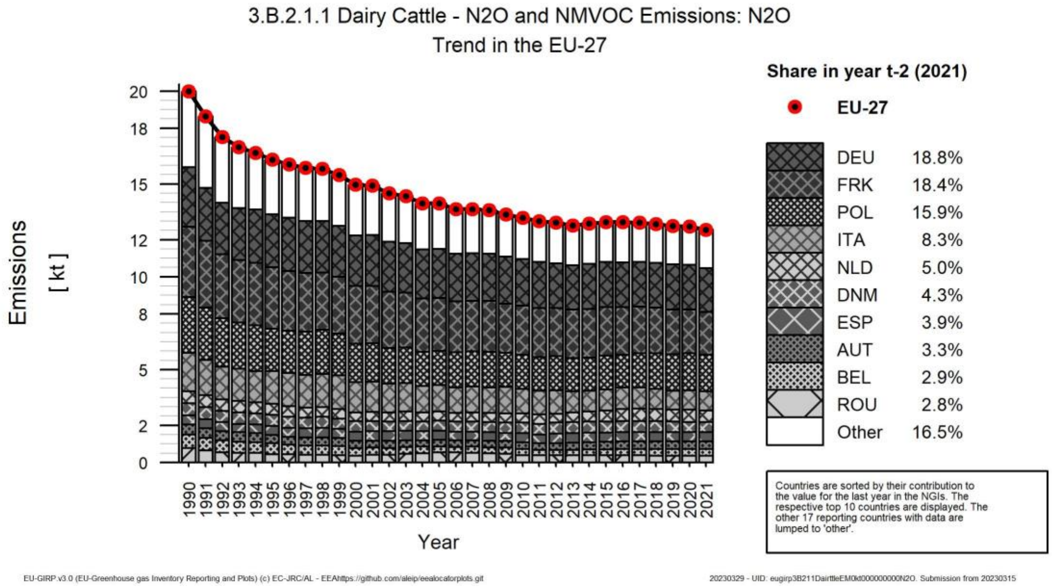
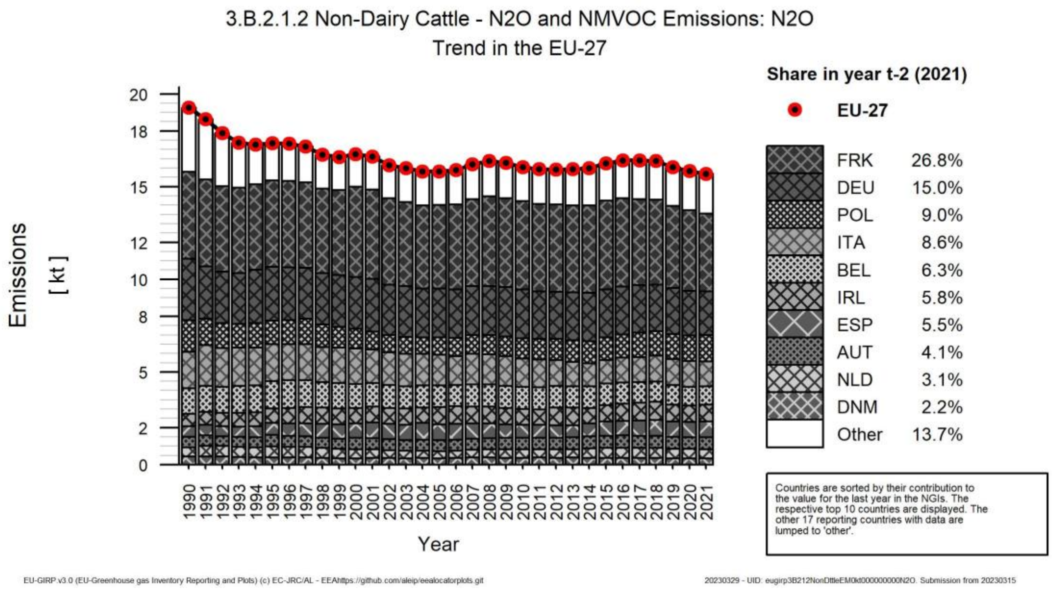


Figure 5.41: 3.B.2.1 - Non-dairy cattle: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.B.2.1 - Cattle - population

One of the main activity data for N_2O emissions from manure management - cattle is the animal numbers. Cattle numbers are already discussed under source category 3.A Enteric Fermentation and therefore not further discussed here.

Other activity data is:

- N-allocation by MMS.

3.B.2.3 - Swine - Emissions

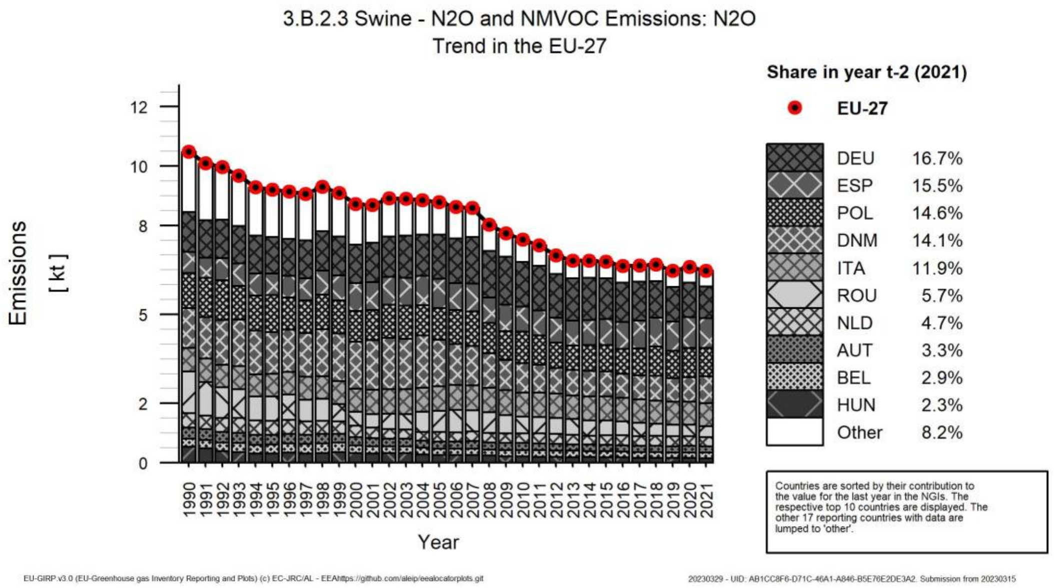
In 2021 N_2O emissions in source category *3.B.2.3 - Swine* in EU were 1716.7 kt CO_2 equivalent. This corresponds to 0.052 % of total EU GHG emissions and 0.93 % of total EU N_2O emissions. They make 0.45% of total agricultural emissions and 1.3% of total agricultural N_2O emissions. Figure 5.42 shows the trend of emissions indicating the countries contributing most to the EU total. The figure represents the trend in N_2O emissions from manure management for the different countries along the inventory period.

Total GHG and N_2O emissions by country and for the total EU from 3.B.2.3 *Manure Management* are shown in Table 5.31 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, N_2O emission in this source category decreased by 38 % or 1.1 Mt CO_2-eq. The decrease was largest in Lithuania in relative terms (98 %) and in Romania in absolute terms (278 kt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 1.9 %. The ten countries with the highest emissions accounted together for 91.8 % of the total in 2021. Emissions decreased in 24 countries and increased in three countries. The largest decreases occurred in Romania with a total absolute decrease of 278 kt CO_2-eq. The largest increases occurred in Spain, with a total absolute increase of 77 kt CO_2-eq.

Table 5.31 *3.B.2.3 - Swine: Countries' contributions to total EU-GHG and N_2O emissions*

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	99	57	57	3.3%	-42	-43%	0	0%	T2	D
Belgium	75	51	50	2.9%	-25	-34%	-1	-1%	T2	D
Bulgaria	9	1	1	0.1%	-8	-85%	0	17%	T2	D
Croatia	25	3	3	0.2%	-22	-89%	0	-6%	T2	CS,D
Cyprus	1	1	1	0.0%	0	21%	0	0%	T1	D
Czechia	116	19	19	1.1%	-97	-83%	1	3%	T2	CS
Denmark	355	217	242	14.1%	-113	-32%	25	11%	T2	D
Estonia	2	1	1	0.0%	-2	-76%	0	-8%	T2	CS,D
Finland	23	10	9	0.6%	-14	-59%	-1	-5%	T2	D
France	82	32	32	1.8%	-50	-61%	-1	-2%	T2	CS,D
Germany	356	310	286	16.7%	-70	-20%	-24	-8%	T2	CS,D
Greece	28	20	19	1.1%	-9	-31%	0	-1%	D	D
Hungary	141	41	40	2.3%	-100	-71%	0	-1%	T2	CS
Ireland	9	11	12	0.7%	3	32%	0	4%	T2,T3	CS,D
Italy	210	209	205	11.9%	-5	-3%	-4	-2%	T2	CS,D
Latvia	36	3	4	0.2%	-32	-89%	0	12%	T2	D
Lithuania	98	2	2	0.1%	-96	-98%	0	-2%	T1	D
Luxembourg	1	1	1	0.0%	0	-39%	0	-4%	T2	CS
Malta	1	0	0	0.0%	-1	-60%	0	0%	T1	D
Netherlands	125	87	81	4.7%	-44	-35%	-6	-7%	T1	CS
Poland	314	260	251	14.6%	-63	-20%	-9	-3%	T2	CS
Portugal	10	4	4	0.2%	-6	-61%	0	-1%	T2	CS,D
Romania	375	101	98	5.7%	-278	-74%	-4	-3%	T2	D
Slovakia	57	10	8	0.5%	-48	-85%	-2	-16%	T2	CS
Slovenia	6	2	2	0.1%	-5	-75%	0	-3%	T1	D
Spain	189	274	266	15.5%	77	41%	-9	-3%	T2	D
Sweden	38	24	24	1.4%	-14	-37%	0	0%	CS,NA,T2	CS,D,NA
EU-27	**2 780**	**1 750**	**1 717**	**100%**	**-1 063**	**-38%**	**-34**	**-2%**	**-**	**-**

Figure 5.42: 3.B.2.3 - Swine: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.B.2.4 - Other Livestock - Emissions

In 2021 N_2O emissions in source category *3.B.2.4 - Other Livestock* in EU were 1551.2 kt CO_2 equivalent. This corresponds to 0.047 % of total EU GHG emissions and 0.84 % of total EU N_2O emissions. They make 0.41 % of total agricultural emissions and 1.1 % of total agricultural N_2O emissions.

Total GHG and N_2O emissions by country and for the total EU from 3.B.2.4 *Manure Management* are shown in Table 5.32 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, N_2O emission in this source category decreased by 13 % or 231 kt CO_2-eq. The decrease was largest in Estonia in relative terms (71 %) and in Bulgaria in absolute terms (102 kt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 2.5 %. Figure 5.44 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from manure management for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 82.7 % of the total in 2021. Emissions decreased in sixteen countries and increased in eleven countries. The three countries with the largest decreases were Bulgaria, Poland and Hungary with a total absolute decrease of 207 kt CO_2-eq. The three countries with the largest increases were Portugal, Germany and the Netherlands, with a total absolute increase of 65 kt CO_2-eq.

Table 5.32 3.B.2.4 - Other Livestock: Countries' contributions to total EU-GHG and N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	8	17	17	1.1%	9	107%	0	1%	T2	D
Belgium	9	18	19	1.2%	10	107%	0	3%	T2	D
Bulgaria	164	66	62	4.0%	-102	-62%	-4	-6%	T1,T2	D
Croatia	29	14	14	0.9%	-16	-54%	-1	-5%	T2	CS,D
Cyprus	15	16	16	1.0%	1	4%	0	1%	T1	D
Czechia	56	25	25	1.6%	-31	-56%	0	-1%	T2	CS,D
Denmark	40	49	21	1.4%	-19	-48%	-27	-57%	T2	D
Estonia	11	3	3	0.2%	-8	-71%	0	2%	T1	D
Finland	26	29	28	1.8%	3	10%	-1	-3%	NA	NA
France	173	172	172	11.1%	0	0%	0	0%	T2	CS,D
Germany	87	106	107	6.9%	19	22%	0	0%	T2	CS,D
Greece	53	37	37	2.4%	-16	-30%	0	0%	D	D
Hungary	92	45	45	2.9%	-47	-51%	1	1%	T1,T2	CS,D
Ireland	16	16	15	1.0%	0	-2%	-1	-4%	T2	CS,D
Italy	260	271	270	17.4%	10	4%	-1	-1%	T2	CS,D
Latvia	18	6	6	0.4%	-12	-65%	0	4%	T1,T2	D
Lithuania	14	11	11	0.7%	-3	-24%	0	0%	T1	D
Luxembourg	0	1	1	0.1%	1	147%	0	-2%	T2	CS
Malta	1	2	2	0.1%	1	114%	0	9%	T1	CS,D
Netherlands	54	88	87	5.6%	34	62%	-1	-1%	T1	CS
Poland	158	107	100	6.4%	-58	-37%	-7	-6%	T1,T2	CS,D
Portugal	53	63	65	4.2%	12	22%	3	4%	T2	CS,D
Romania	71	54	54	3.5%	-17	-24%	0	0%	T2	D
Slovakia	8	5	5	0.3%	-3	-42%	0	-1%	T1	CS
Slovenia	4	3	3	0.2%	0	-1%	0	1%	T1	D
Spain	321	314	314	20.2%	-7	-2%	0	0%	T1,T2	D
Sweden	41	54	51	3.3%	10	25%	-3	-5%	T2	D
EU-27	**1 782**	**1 592**	**1 551**	**100%**	**-231**	**-13%**	**-40**	**-3%**	**-**	**-**

3.B.2.4.7 - Poultry - Emissions

Largest contribution to other livestock emissions comes from sub-category poultry with 47 % of total N_2O emissions in 2021. Other animal types with high emissions are horses with a share of 18% and Other Other Livestock with a share of 16%. Here only the most important animal type Poultry is discussed.

Emissions in source category *3.B.2.4.7 - Poultry* decreased considerably in EU by 17% or 149 kt CO_2-eq in the period 1990 to 2021. Figure 5.45 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from manure management for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 84.4 % of the total in 2021.Emissions decreased in nineteen countries and increased in eight countries. The three countries with the largest decreases were Bulgaria, the Czech Republic and Hungary with a total absolute decrease of 146 kt CO_2-eq. The three countries with the largest increases were Sweden, Germany and Portugal, with a total absolute increase of 55 kt CO_2-eq.

3.A.4.7 - Poultry - Population

As population data for poultry have not yet been discussed, this will be done here. Poultry population increased slightly in EU by 1.5 % or 22.9 million heads in the period 1990 to 2021. Figure 5.46 shows the trend of poultry population indicating the countries contributing most to EU total. The figure represents the trend in poultry population for the different countries along the inventory period. The ten countries with the highest population accounted together for 85 % of the total in 2021.Population decreased in thirteen countries and increased in thirteen countries. The four countries with the largest decreases were Romania, Poland, Hungary and Bulgaria with a total absolute decrease of 134 million heads. The four countries with the largest increases were Belgium, Portugal, France and Germany, with a total absolute increase of 128 million heads.

Other activity data related to this emission category are:

- Nitrogen managed on each manure management system

Figure 5.44: 3.B.2.4 - Other Livestock: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

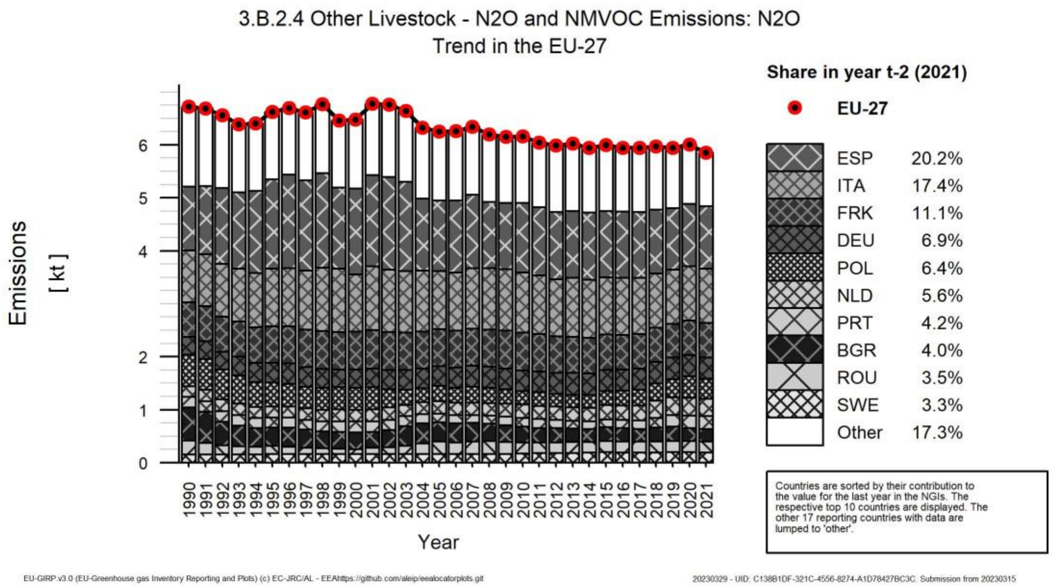


Figure 5.45: 3.B.2.4.7 - Poultry: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

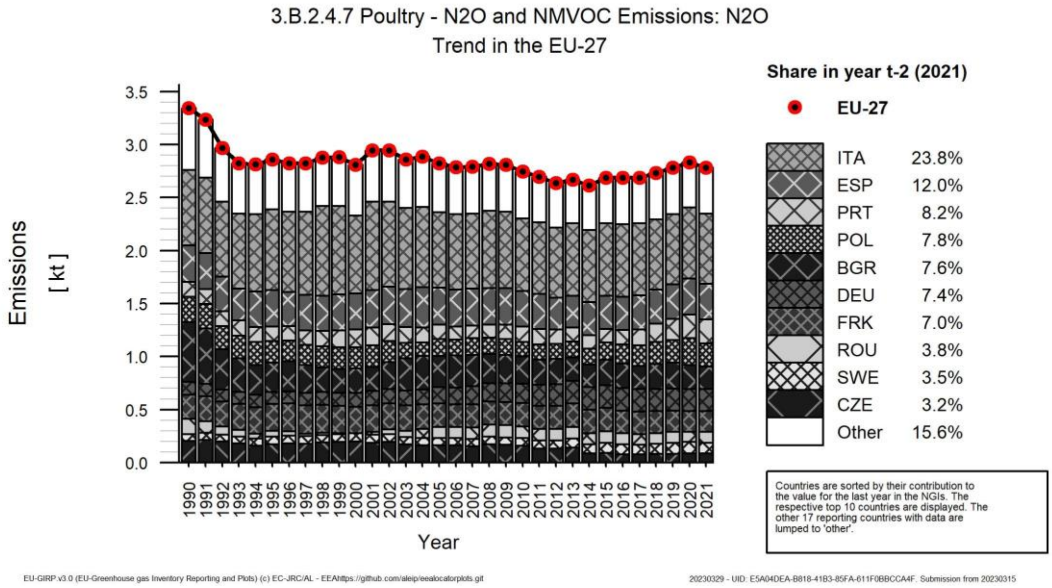
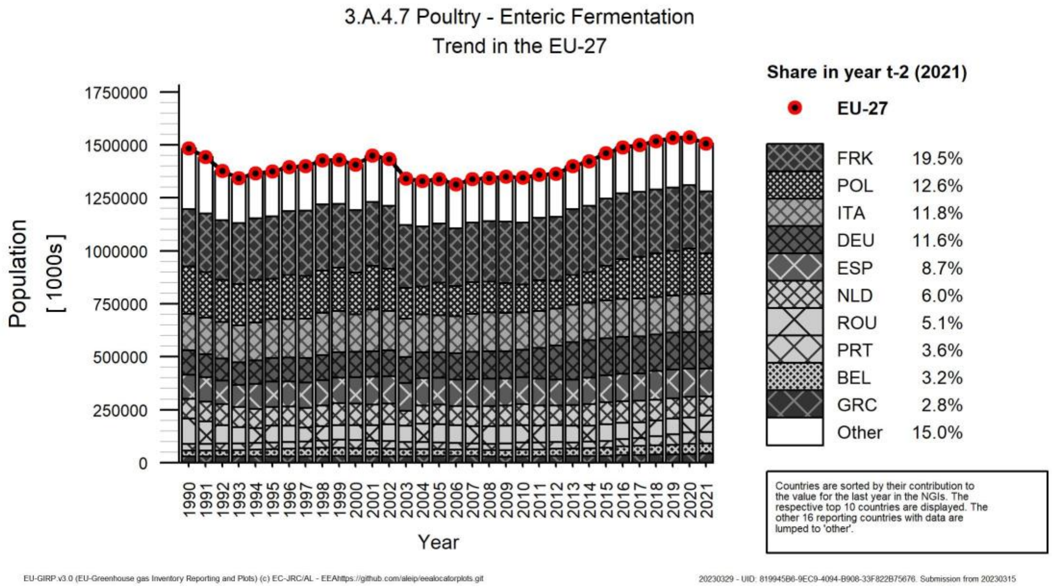


Figure 5.46: 3.A.4.7 - Poultry: Trend in poultry population in the EU and the countries contributing most to EU values including their share to EU population in 2021



5.3.3.2 Implied EFs and Methodological Issues

In this section, we discuss the implied emission factor for the main animal types. Furthermore, we present data on the nitrogen excretion rate for the different animal types.

3.B.2.1 - Cattle - Implied emission factor

The implied emission factor for N_2O emissions in source category *3.B.2.1 - Cattle* increased in EU slightly between 1990 and 2021 by 2 %. Table 5.33 shows the implied emission factor for N_2O emissions in source category *3.B.2.1 - Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in eleven countries and increased in sixteen countries. The largest decreases occurred in Croatia and Portugal with a mean absolute value of 0.2 kg/head/year. The four countries with the largest increases were Estonia, Finland, Austria and Lithuania with a mean absolute value of 0.2 kg/head/year.

Table 5.33   3.B.2.1 - Cattle: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	0.43	0.565	|	Ireland	0.13	0.153
Belgium	0.64	0.582	|	Italy	0.52	0.406
Bulgaria	0.45	0.502	|	Lithuania	0.29	0.407
Cyprus	0.51	0.507	|	Luxembourg	0.40	0.373
Czech Republic	0.41	0.395	|	Latvia	0.28	0.290
Germany	0.33	0.427	|	Malta	1.48	1.338
Denmark	0.48	0.593	|	Netherlands	0.23	0.299
Spain	0.21	0.198	|	Poland	0.47	0.532
Estonia	0.27	0.672	|	Portugal	0.19	0.099
Finland	0.31	0.573	|	Romania	0.21	0.266
France	0.39	0.375	|	Slovakia	0.33	0.386
Greece	0.42	0.360	|	Slovenia	0.23	0.308
Croatia	0.37	0.143	|	Sweden	0.34	0.361
Hungary	0.58	0.668	|	EU	0.34	0.35

3.B.2.1.1 - Dairy Cattle - Implied emission factor

The implied emission factor for N_2O emissions in source category *3.B.2.1.1 - Dairy Cattle* increased in EU clearly between 1990 and 2021 by 12.3 % or 0.067 kg/head/year. Figure 5.47 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.34 shows the implied emission factor for N_2O emissions in source category *3.B.2.1.1 - Dairy Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in ten countries and increased in seventeen countries. The largest decrease occurred in Croatia with an absolute value of 0.3 kg/head/year. The four countries with the largest increases were Estonia, Finland, Slovenia and Hungary with a mean absolute value of 0.4 kg/head/year.

Figure 5.47:   3.B.2.1.1 - Dairy Cattle: Trend in implied emission factor in the EU and range of values reported by countries

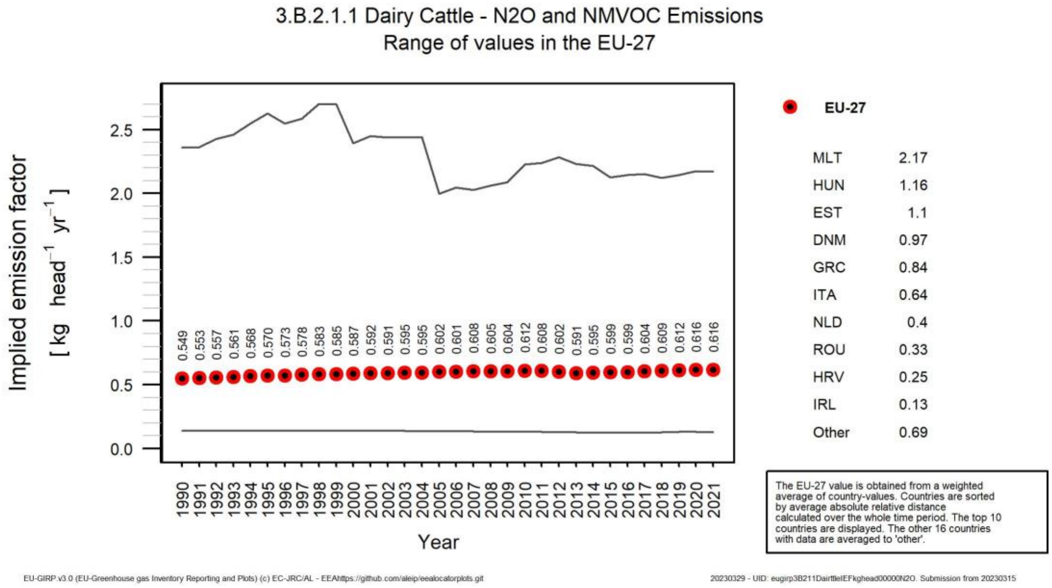


Table 5.34 *3.B.2.1.1 - Dairy Cattle: countries' implied emission factor (kg/head/year)*

Country	1990	2021		Country	1990	2021
Austria	0.60	0.80	|	Ireland	0.14	0.13
Belgium	0.84	0.73	|	Italy	0.78	0.64
Bulgaria	0.62	0.66	|	Lithuania	0.38	0.63
Cyprus	0.76	0.72	|	Luxembourg	0.63	0.52
Czech Republic	0.58	0.62	|	Latvia	0.60	0.68
Germany	0.50	0.61	|	Malta	2.36	2.17
Denmark	0.87	0.97	|	Netherlands	0.34	0.40
Spain	0.31	0.59	|	Poland	0.61	0.83
Estonia	0.48	1.10	|	Portugal	0.47	0.46
Finland	0.48	0.89	|	Romania	0.26	0.33
France	0.71	0.69	|	Slovakia	0.52	0.77
Greece	0.85	0.84	|	Slovenia	0.31	0.65
Croatia	0.54	0.25	|	Sweden	0.61	0.77
Hungary	0.88	1.16	|	EU	0.55	0.62

3.B.2.1.1 - Dairy Cattle - Nitrogen excretion rate

The nitrogen excretion rate, a parameter used for calculating N_2O emissions in source category *3.B.2.1.1 - Dairy Cattle*, increased in EU considerably between 1990 and 2021 by 20.1% or 20 kg/head/year. Figure 5.48 shows the trend of the nitrogen excretion rate in EU indicating also the range of values used by the countries. Table 5.35 shows the nitrogen excretion rate in source category *3.B.2.1.1 - Dairy Cattle* for the years 1990 and 2021 for all countries and EU. Nitrogen excretion rate decreased in three countries and increased in 21 countries. It was in 2021 at the level of 1990 in three countries. Decreases occurred in Malta, the Netherlands and Greece with a mean absolute value of 6 kg/head/year. The four countries with the largest increases were Estonia, Finland, Hungary and Slovakia with a mean absolute value of 52 kg/head/year.

Figure 5.48: 3.B.2.1.1 - Dairy Cattle: Trend in nitrogen excretion rate in the EU and range of values reported by countries

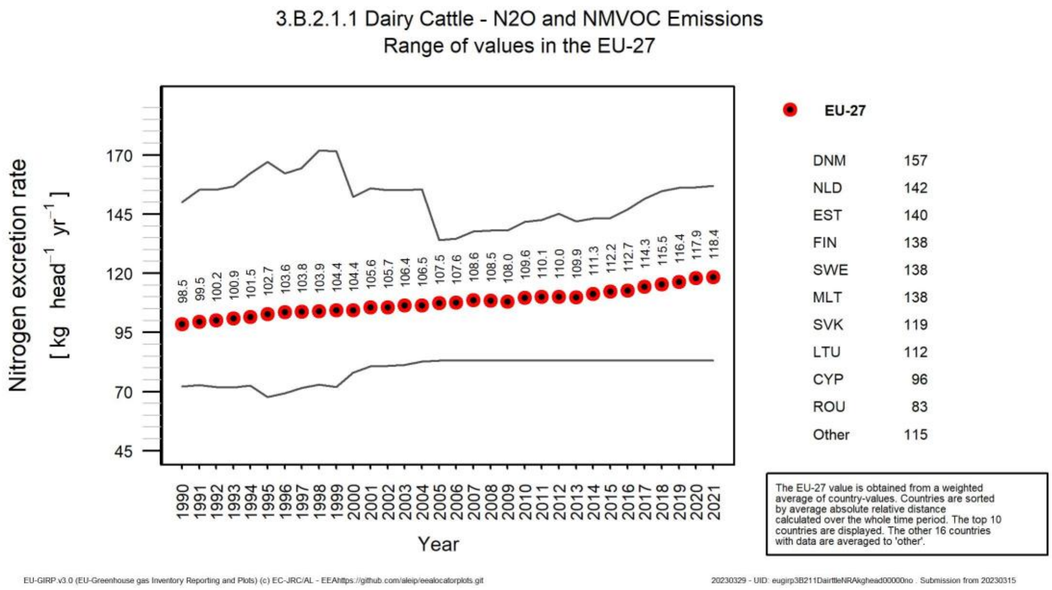


Table 5.35 3.B.2.1.1 - Dairy Cattle: countries' nitrogen excretion rate (kg/head/year)

Country	1990	2021	Country	1990	2021
Austria	91	107	Ireland	98	110
Belgium	114	122	Italy	105	111
Bulgaria	98	98	Lithuania	81	112
Cyprus	96	96	Luxembourg	110	123
Czech Republic	79	117	Latvia	86	120
Germany	92	122	Malta	150	138
Denmark	129	157	Netherlands	148	142
Spain	85	113	Poland	102	118
Estonia	74	140	Portugal	86	119
Finland	90	138	Romania	83	83
France	104	116	Slovakia	72	119
Greece	117	116	Slovenia	82	119
Croatia	96	96	Sweden	102	138
Hungary	83	131	EU	99	118

3.B.2.1.2 - Non-Dairy Cattle - Implied emission factor

The implied emission factor for N_2O emissions in source category *3.B.2.1.2 - Non-Dairy Cattle* increased in EU moderately between 1990 and 2021 by 5.4 % or 0.013 kg/head/year. Figure 5.49 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.36 shows the implied emission factor for N_2O emissions in source category *3.B.2.1.2 - Non-Dairy Cattle* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in eight countries and increased in nineteen countries. The largest decrease occurred in Portugal with an absolute value of 0.037 kg/head/year. The four countries with the largest increases were Estonia, Finland, Austria and Germany with a mean absolute value of 0.2 kg/head/year.

Figure 5.49: 3.B.2.1.2 - Non-Dairy Cattle: Trend in implied emission factor in the EU and range of values reported by countries

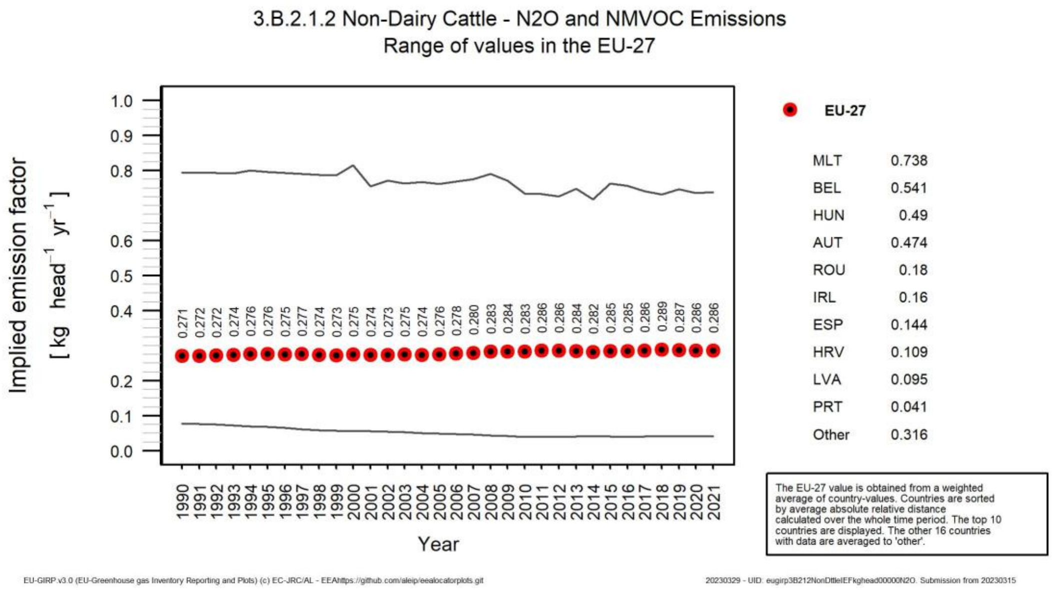


Table 5.36 3.B.2.1.2 - Non-Dairy Cattle: countries' implied emission factor (kg/head/year)

Country	1990	2021	Country	1990	2021
Austria	0.336	0.474	Ireland	0.123	0.160
Belgium	0.571	0.541	Italy	0.383	0.316
Bulgaria	0.340	0.403	Lithuania	0.242	0.284
Cyprus	0.340	0.290	Luxembourg	0.319	0.321
Czech Republic	0.317	0.319	Latvia	0.095	0.095
Germany	0.251	0.328	Malta	0.795	0.738
Denmark	0.290	0.366	Netherlands	0.167	0.228
Spain	0.159	0.144	Poland	0.336	0.352
Estonia	0.143	0.455	Portugal	0.078	0.041
Finland	0.223	0.437	Romania	0.140	0.180
France	0.289	0.300	Slovakia	0.261	0.241
Greece	0.241	0.269	Slovenia	0.171	0.223
Croatia	0.145	0.109	Sweden	0.209	0.253
Hungary	0.419	0.490	EU	0.249	0.262

3.B.2.1.2 - Non-Dairy Cattle - Nitrogen excretion rate

The nitrogen excretion rate, a parameter used for calculating N_2O emissions in source category *3.B.2.1.2 - Non-Dairy Cattle*, increased in EU moderately between 1990 and 2021 by 8.3 % or 4.1 kg/head/year. Figure 5.50 shows the trend of the nitrogen excretion rate in EU indicating also the range of values used by the countries. Table 5.37 shows the nitrogen excretion rate in source category *3.B.2.1.2 - Non-Dairy Cattle* for the years 1990 and 2021 for all countries and EU. Nitrogen excretion rate decreased in five countries and increased in 21 countries. It was in 2021 at the level of 1990 in one country. The largest decrease occurred in the Netherlands with an absolute value of 19 kg/head/year. The four countries with the largest increases were Finland, Estonia, the Czech Republic and Portugal with a mean absolute value of 16 kg/head/year.

Figure 5.50: 3.B.2.1.2 - Non-Dairy Cattle: Trend in nitrogen excretion rate in the EU and range of values reported by countries

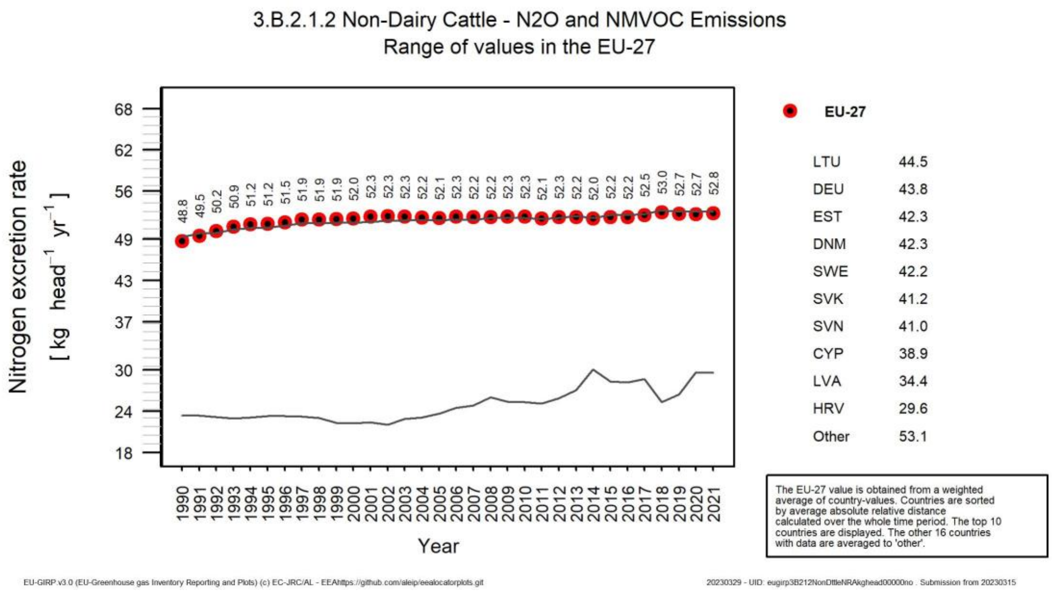


Table 5.37 3.B.2.1.2 - Non-Dairy Cattle: countries' nitrogen excretion rate (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	44	51	|	Ireland	52	57
Belgium	54	53	|	Italy	50	52
Bulgaria	54	59	|	Lithuania	41	44
Cyprus	43	39	|	Luxembourg	56	58
Czech Republic	46	59	|	Latvia	23	34
Germany	38	44	|	Malta	51	47
Denmark	36	42	|	Netherlands	57	38
Spain	57	57	|	Poland	54	51
Estonia	26	42	|	Portugal	44	56
Finland	34	56	|	Romania	43	46
France	58	60	|	Slovakia	39	41
Greece	48	53	|	Slovenia	41	41
Croatia	25	30	|	Sweden	39	42
Hungary	44	53	|	EU	49	53

3.B.2.3 - Swine - Implied emission factor

The implied emission factor for N_2O emissions in source category *3.B.2.3 - Swine* decreased in EU strongly between 1990 and 2021 by 26.1 %. Figure 5.51 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.38 shows the implied emission factor for N_2O emissions in source category *3.B.2.3 - Swine* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in 23 countries and increased in four countries. The largest increase occurred in Poland with an absolute value of 0.025 kg/head/year.

Figure 5.51: 3.B.2.3 - Swine: Trend in implied emission factor in the EU and range of values reported by countries

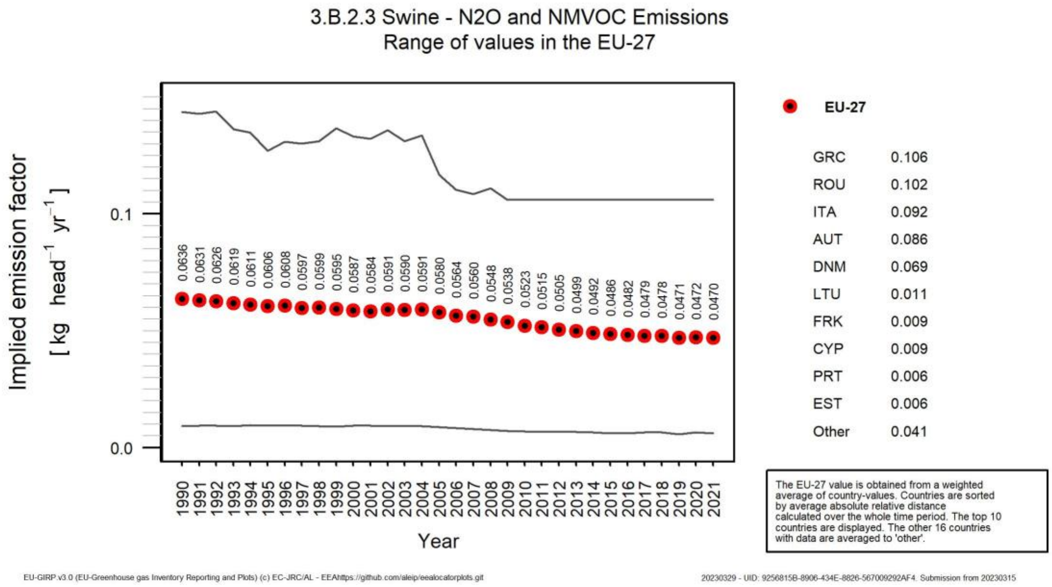


Table 5.38 3.B.2.3 - Swine: countries' implied emission factor (kg/head/year)

Country	1990	2021	Country	1990	2021
Austria	0.1073	0.0861	Ireland	0.0277	0.0262
Belgium	0.0425	0.0303	Italy	0.0944	0.0919
Bulgaria	0.0079	0.0075	Lithuania	0.1437	0.0108
Cyprus	0.0094	0.0088	Luxembourg	0.0659	0.0356
Czech Republic	0.0916	0.0482	Latvia	0.0964	0.0448
Germany	0.0507	0.0547	Malta	0.0434	0.0433
Denmark	0.1411	0.0694	Netherlands	0.0338	0.0269
Spain	0.0437	0.0300	Poland	0.0608	0.0859
Estonia	0.0092	0.0062	Portugal	0.0145	0.0064
Finland	0.0653	0.0326	Romania	0.1180	0.1017
France	0.0247	0.0093	Slovakia	0.0847	0.0692
Greece	0.1061	0.1061	Slovenia	0.0407	0.0281
Croatia	0.0590	0.0102	Sweden	0.0608	0.0626
Hungary	0.0609	0.0535	EU	0.0636	0.0470

3.B.2.3 - Swine - Nitrogen excretion rate

The nitrogen excretion rate, a parameter used for calculating N_2O emissions in source category *3.B.2.3 - Swine*, decreased in EU considerably between 1990 and 2021 by 16 %. Figure 5.52 shows the trend of the nitrogen excretion rate in EU indicating also the range of values used by the countries. Table 5.39 shows the nitrogen excretion rate in source category *3.B.2.3 - Swine* for the years 1990 and 2021 for all countries and EU. Nitrogen excretion rate decreased in 22 countries and increased in four countries. It was in 2021 at the level of 1990 in one country. The four countries with the largest decreases were Denmark, Belgium, Spain and the Netherlands with a mean absolute value of 4 kg/head/year. The three countries with the largest increases were Sweden, Poland and Estonia with a mean absolute value of 1 kg/head/year.

Sweden explains the large increase by an update of nitrogen production data for sows and pigs in 2002, due to more intense swine production. The time trend also shows steps because surveys are only done biannually and small percentage differences in the survey have a significant effect on emissions, as emission factors are differing considerably between the different systems.

Figure 5.52: **3.B.2.3 - Swine: Trend in nitrogen excretion rate in the EU and range of values reported by countries**

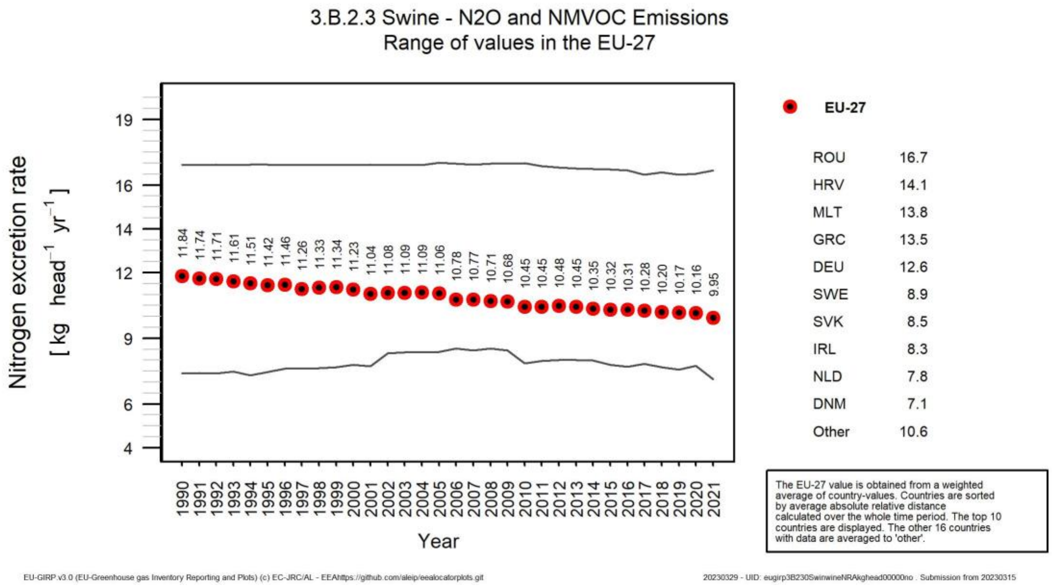


Table 5.39 3.B.2.3 - Swine: countries' nitrogen excretion rate (kg/head/year)

Country	1990	2021	Country	1990	2021
Austria	12.2	10.9	Ireland	8.8	8.3
Belgium	12.5	8.9	Italy	12.0	12.1
Bulgaria	12.5	11.6	Lithuania	12.4	11.9
Cyprus	11.9	11.1	Luxembourg	10.6	10.5
Czech Republic	11.5	11.2	Latvia	12.3	10.7
Germany	13.0	12.6	Malta	13.8	13.8
Denmark	11.9	7.1	Netherlands	10.8	7.8
Spain	11.9	8.8	Poland	10.0	10.9
Estonia	8.9	9.4	Portugal	10.3	8.9
Finland	12.2	11.3	Romania	16.9	16.7
France	10.6	9.5	Slovakia	10.4	8.5
Greece	13.5	13.5	Slovenia	12.7	12.4
Croatia	14.7	14.1	Sweden	7.4	8.9
Hungary	9.5	9.3	EU	11.8	9.9

3.B.2.4.7 - Poultry - Implied emission factor

Table 5.40 shows the implied emission factor for N_2O emissions in source category *3.B.2.4.7 - Poultry* for the years 1990 and 2021 for all countries and for the total EU. The implied emission factor decreased in nineteen countries and increased in six countries. It was in 2021 at the level of 1990 in one country. No data were available for Malta. The four countries with the largest decreases were the Czech Republic, Finland, Latvia and Denmark with a mean absolute value of 0.0013 kg/head/year.

Figure 5.53: 3.B.2.4.7 - Poultry: Trend in implied emission factor in the EU and range of values reported by countries

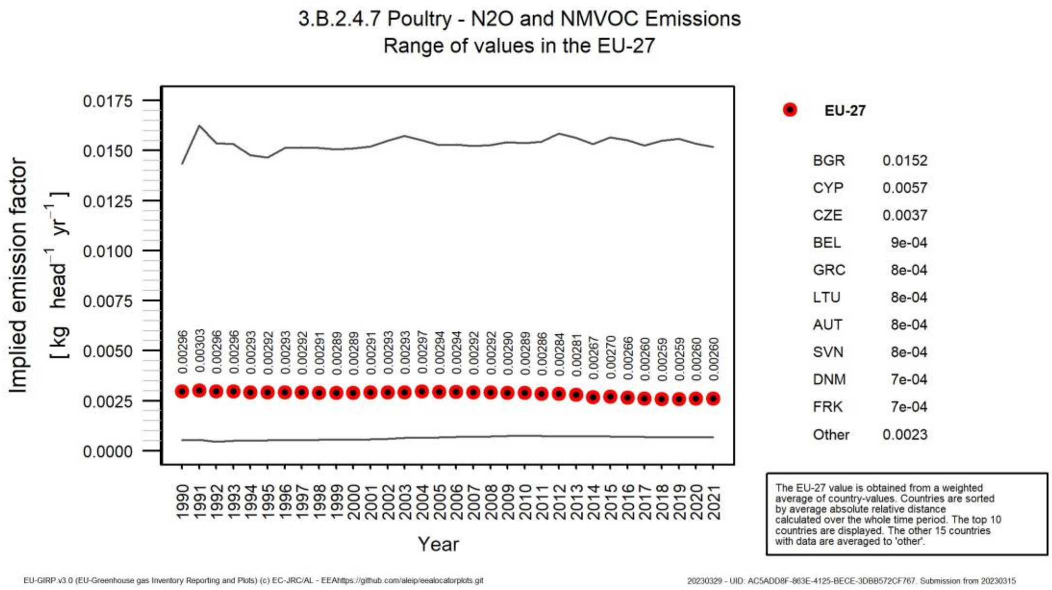


Table 5.40 3.B.2.4.7 - Poultry: countries' implied emission factor (kg/head/year)

Country	1990	2021		Country	1990	2021
Austria	0.00090	0.00080	|	Hungary	0.00232	0.00191
Belgium	0.00094	0.00089	|	Ireland	0.00109	0.00106
Bulgaria	0.01433	0.01518	|	Italy	0.00409	0.00372
Cyprus	0.00714	0.00571	|	Lithuania	0.00053	0.00081
Czech Republic	0.00643	0.00368	|	Luxembourg	0.00113	0.00103
Germany	0.00108	0.00119	|	Latvia	0.00342	0.00242
Denmark	0.00112	0.00073	|	Netherlands	0.00108	0.00094
Spain	0.00303	0.00254	|	Poland	0.00107	0.00114
Estonia	0.00383	0.00337	|	Portugal	0.00435	0.00419
Finland	0.00288	0.00163	|	Romania	0.00119	0.00135
France	0.00084	0.00067	|	Slovakia	0.00155	0.00143
Greece	0.00085	0.00085	|	Slovenia	0.00068	0.00075
Croatia	0.00448	0.00373	|	Sweden	0.00473	0.00438
				EU	0.00225	0.00185

3.B.2.4.7 - Poultry - Nitrogen excretion rate

The nitrogen excretion rate, a parameter used for calculating N_2O emissions in source category *3.B.2.4.7 - Poultry*, could not be evaluated at EU level. Table 5.41 shows the nitrogen excretion rate in source category *3.B.2.4.7 - Poultry* for the years 1990 and 2021 for all countries. Nitrogen excretion rate decreased in eighteen countries and increased in six countries. It was in 2021 at the level of 1990 in three countries. The three countries with the largest decreases were Belgium, the Czech Republic and Denmark with a mean absolute value of 0.3 kg/head/year. The largest increase occurred in Lithuania with an absolute value of 0.1 kg/head/year.

Figure 5.54: 3.B.2.4.7 - Poultry: Trend in nitrogen excretion rate in the EU and range of values reported by countries

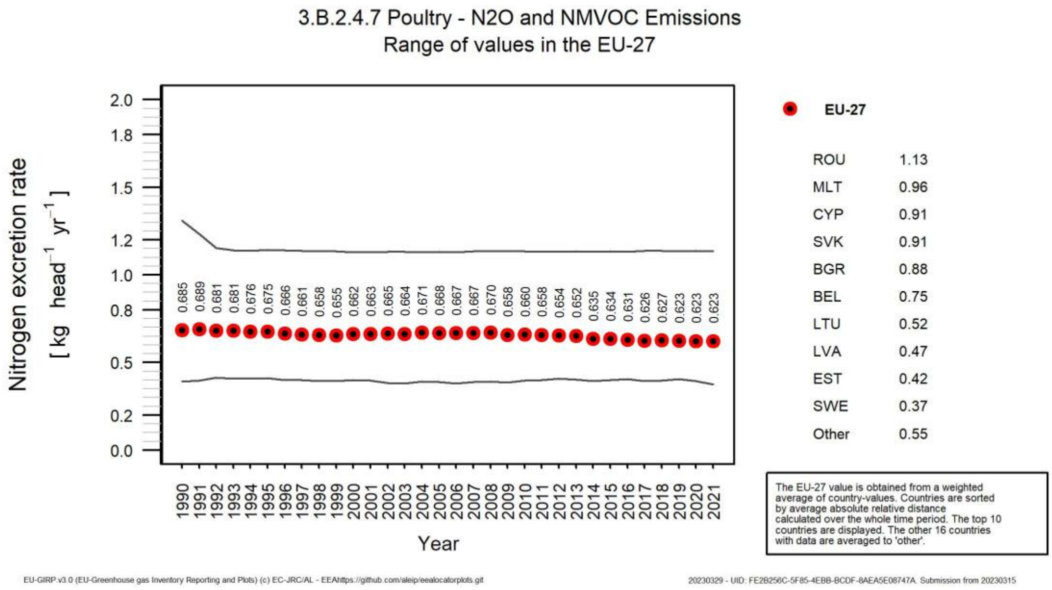


Table 5.41 3.B.2.4.7 - Poultry: countries' nitrogen excretion rate (kg/head/year)

Country	1990	2021	Country	1990	2021
Austria	0.59	0.52	Ireland	0.60	0.56
Belgium	1.31	0.75	Italy	0.52	0.48
Bulgaria	0.86	0.88	Lithuania	0.39	0.52
Cyprus	0.91	0.91	Luxembourg	0.72	0.66
Czech Republic	0.73	0.50	Latvia	0.45	0.47
Germany	0.68	0.66	Malta	0.96	0.96
Denmark	0.63	0.47	Netherlands	0.69	0.60
Spain	0.73	0.64	Poland	0.68	0.73
Estonia	0.44	0.42	Portugal	0.55	0.54
Finland	0.50	0.54	Romania	1.15	1.13
France	0.56	0.45	Slovakia	0.99	0.91
Greece	0.50	0.50	Slovenia	0.46	0.49
Croatia	0.67	0.50	Sweden	0.43	0.37
Hungary	0.83	0.66			

3.B.2.5 - Manure Management - Indirect Emissions - Emissions

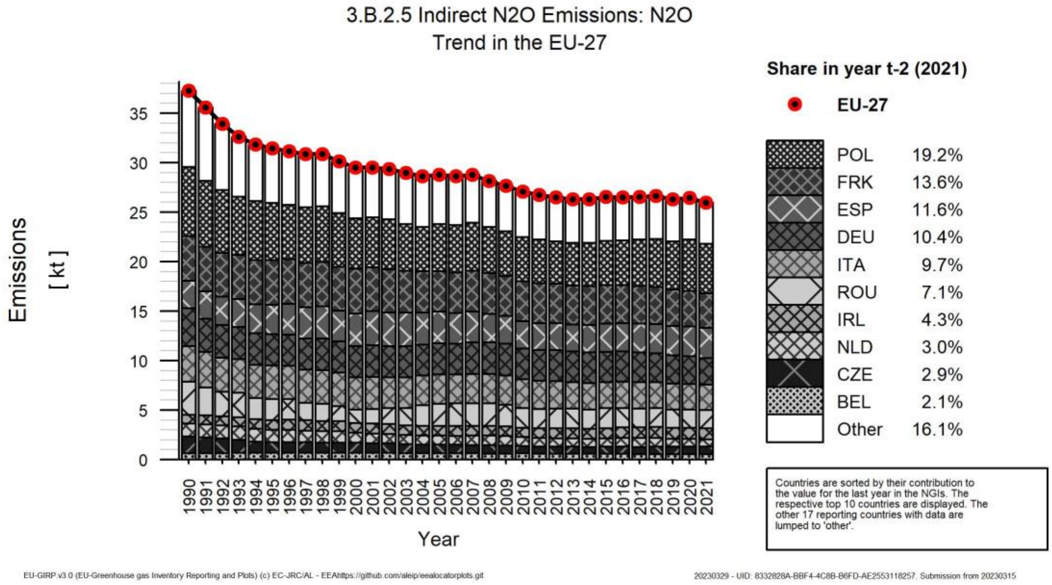
In 2021 N_2O emissions in source category *3.B.2.5 - Manure Management - Indirect Emissions - Indirect N_2O emissions* in EU were 6885.4 kt CO_2 equivalent. This corresponds to 0.2 % of total EU GHG emissions and 3.7 % of total EU N_2O emissions. They make 1.8 % of total agricultural emissions and 5 % of total agricultural N_2O emissions.

Total GHG and N_2O emissions by country and for the total EU from 3.B.2.5 *Manure Management - Indirect Emissions* are shown in Table 5.42 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, N_2O emission in this source category decreased by 30 % or 3 Mt CO_2-eq. The decrease was largest in Latvia in relative terms (73 %) and in Poland in absolute terms (525 kt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 1.9 %. Figure 5.55 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from manure management - indirect emissions for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 83.9 % of the total in 2021. Emissions decreased in 23 countries and increased in four countries. The largest decreases occurred in Poland and Romania with a total absolute decrease of 929 kt CO_2-eq. The largest increases occurred in Ireland and Spain, with a total absolute increase of 134 kt CO_2-eq.

Table 5.42 3.B.2.5 - Manure Management - Indirect Emissions: Countries' contributions to total EU-GHG and N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%
Austria	103	110	111	1.6%	8	8%	1	1%
Belgium	172	143	142	2.1%	-31	-18%	-2	-1%
Bulgaria	343	100	103	1.5%	-240	-70%	4	4%
Croatia	147	74	72	1.0%	-75	-51%	-2	-3%
Cyprus	23	28	28	0.4%	6	25%	1	2%
Czechia	442	199	199	2.9%	-243	-55%	0	0%
Denmark	175	117	97	1.4%	-78	-44%	-20	-17%
Estonia	31	18	18	0.3%	-13	-42%	0	0%
Finland	87	71	69	1.0%	-18	-21%	-2	-2%
France	1 198	958	937	13.6%	-262	-22%	-21	-2%
Germany	1 018	745	716	10.4%	-302	-30%	-28	-4%
Greece	149	131	131	1.9%	-18	-12%	0	0%
Hungary	248	116	118	1.7%	-130	-52%	2	2%
Ireland	235	289	296	4.3%	61	26%	7	2%
Italy	951	684	671	9.7%	-280	-29%	-13	-2%
Latvia	86	24	24	0.3%	-63	-73%	0	0%
Lithuania	221	73	73	1.1%	-148	-67%	1	1%
Luxembourg	14	14	14	0.2%	0	-1%	0	-1%
Malta	7	4	4	0.1%	-2	-34%	0	0%
Netherlands	345	214	205	3.0%	-140	-41%	-9	-4%
Poland	1 848	1 372	1 323	19.2%	-525	-28%	-49	-4%
Portugal	96	84	85	1.2%	-10	-11%	1	1%
Romania	892	487	488	7.1%	-404	-45%	0	0%
Slovakia	192	65	61	0.9%	-131	-68%	-4	-6%
Slovenia	38	27	27	0.4%	-11	-29%	0	0%
Spain	729	800	802	11.6%	73	10%	2	0%
Sweden	92	73	71	1.0%	-20	-22%	-1	-2%
EU-27	**9 882**	**7 018**	**6 885**	**100%**	**-2 997**	**-30%**	**-132**	**-2%**

Figure 5.55: 3.B.2.5 - Manure Management - Indirect Emissions: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.B.2.5 - Manure Management - Indirect N_2O emissions - Atmospheric deposition

The implied emission factor for N_2O emissions in source category *3.B.2.5 - Manure Management - Indirect N_2O emissions* increased in EU barely between 1990 and 2021 by 0.86 %. Figure 5.56 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.43 shows the implied emission factor for N_2O emissions in source category *3.B.2.5 - Manure Management - Indirect N_2O emissions* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in three countries and increased in two countries. It was in 2021 at the level of 1990 in 22 countries.

Table 5.43 3.B.2.5 - Manure Management: countries' implied emission factor (kg N_2O/kg N)

Country	1990	2021	Country	1990	2021
Austria	0.016	0.016	Ireland	0.022	0.022
Belgium	0.016	0.016	Italy	0.016	0.016
Bulgaria	0.016	0.016	Lithuania	0.016	0.016
Cyprus	0.016	0.016	Luxembourg	0.022	0.022
Czech Republic	0.016	0.016	Latvia	0.016	0.016
Germany	0.016	0.016	Malta	0.016	0.016
Denmark	0.016	0.016	Netherlands	0.016	0.016
Spain	0.016	0.016	Poland	0.016	0.016
Estonia	0.016	0.016	Portugal	0.016	0.016
Finland	0.016	0.016	Romania	0.016	0.016
France	0.017	0.017	Slovakia	0.016	0.016
Greece	0.016	0.016	Slovenia	0.016	0.016
Croatia	0.016	0.016	Sweden	0.016	0.016
Hungary	0.016	0.016	EU	0.016	0.016

3.B.2.5 - Manure Management - Implied emission factor - Leaching and run-off

The implied emission factor for N_2O emissions in source category *3.B.2.5 - Manure Management - Indirect N_2O emissions* increased in EU slightly between 1990 and 2021 by 1.1 %. Figure 5.57 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.44 shows the implied emission factor for N_2O emissions in source category *3.B.2.5 - Manure Management - Indirect N_2O emissions* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in ten countries and increased in five countries. It was in 2021 at the level of 1990 in three countries. No data were available for nine countries (Austria, Bulgaria, Denmark, Ireland, Luxembourg, the Netherlands, Slovakia, Slovenia and Sweden).

Figure 5.57: 3.B.2.5 - Manure Management: Trend in implied emission factor in the EU and range of values reported by countries

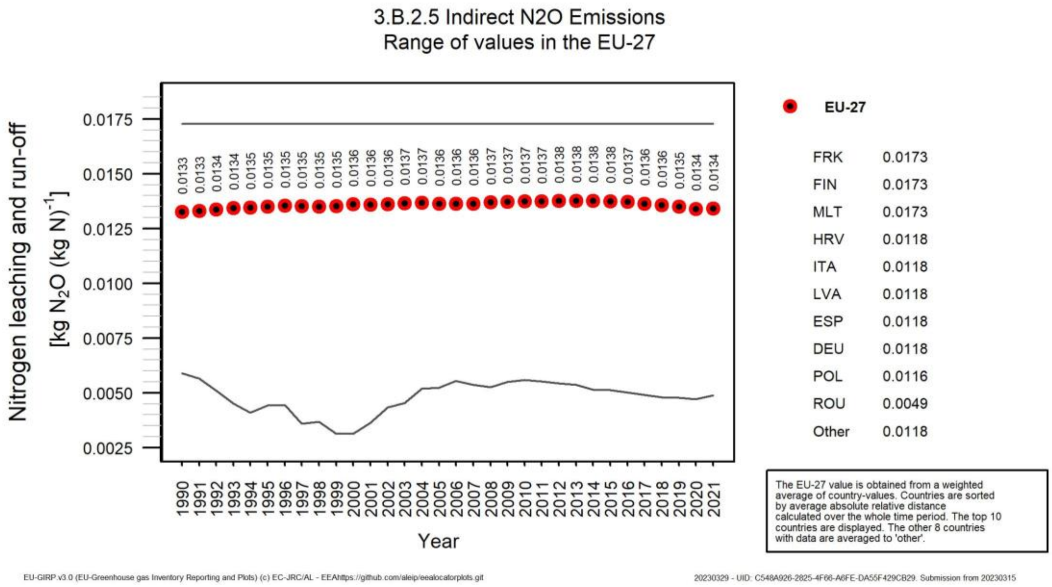


Table 5.44 3.B.2.5 - Manure Management: countries' implied emission factor (kg N_2O/kg N)

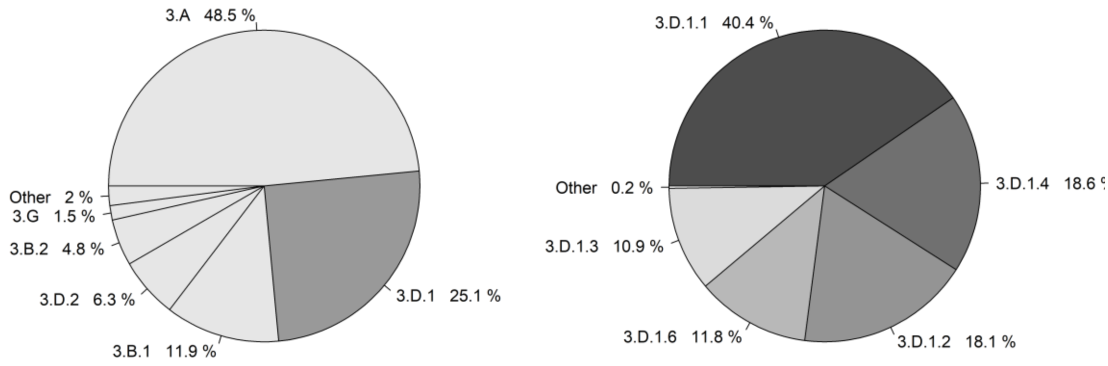
Country	1990	2021	Country	1990	2021
Belgium	0.0118	0.0118	Hungary	0.0118	0.0118
Cyprus	0.0118	0.0118	Italy	0.0118	0.0118
Czech Republic	0.0118	0.0118	Lithuania	0.0118	0.0118
Germany	0.0118	0.0118	Latvia	0.0118	0.0118
Spain	0.0118	0.0118	Malta	0.0173	0.0173
Estonia	0.0118	0.0118	Poland	0.0117	0.0116
Finland	0.0173	0.0173	Portugal	0.0118	0.0118
France	0.0173	0.0173	Romania	0.0059	0.0049
Greece	0.0118	0.0118	EU	0.0133	0.0134
Croatia	0.0118	0.0118			

5.3.4 Direct Emissions from Managed Soils - N_2O (CRF Source Category 3D1)

In 2021 N_2O emissions in source category *3.D.1 - Direct N_2O Emissions From Managed Soils* in EU were 94410.4 kt CO_2 equivalent. This corresponds to 2.9 % of total EU GHG emissions and 50.9 % of total EU N_2O emissions. They make 24.9 % of total agricultural emissions and 69 % of total agricultural

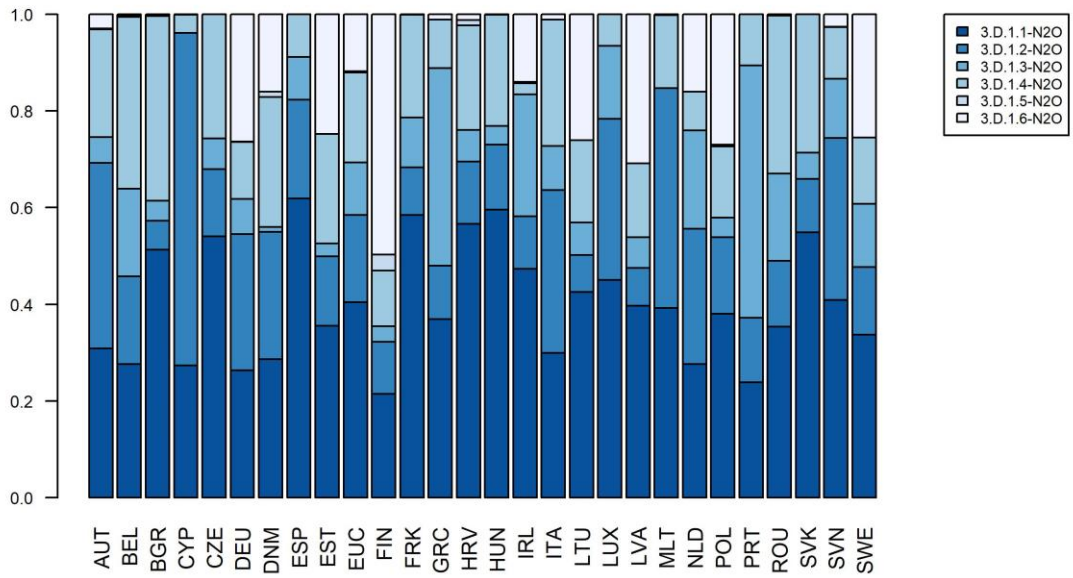
N_2O emissions. The main sub-categories are 3.D.1.1 (Inorganic N Fertilizers), 3.D.1.4 (Crop Residues) and 3.D.1.2 (Organic N Fertilizers) as shown in Figure 5.58. Regarding the origin of emissions in the different countries, Figure 5.59 shows the distribution of direct N_2O emissions from managed soils by emission source in all countries and in the EU. Each bar represents the total emissions of a country in the current emission category, where different shades of blue correspond to the emitting sub-categories.

Figure 5.58: Share of source category 3.D.1 on total EU agricultural emissions (left panel) and decomposition into its sub-categories (right panel). The percentages refer to the emissions in the year 2021. Categories 3.D.1.1-3.D.1.5: direct N_2O emissions by N source (inorganic fertilizers, organic fertilizers, urine and dung deposited by grazing animals, crop residues and mineralization of soil organic matter); category 3.D.1.6: cultivation of histosols.



In the left panel, some minor differences in the numbers might be present due to automatic rounding of numbers.

Figure 5.59: Decomposition of emissions in source category 3.D.1 - Direct N_2O Emissions From Managed Soils into its sub-categories by country in the year 2021. 3.D.1.1 inorganic N fertilizers, 3.D.1.2 organic N fertilizers, 3.D.1.3 urine and dung deposited by grazing animals, 3.D.1.4 crop residues incorporated in the soil, 3.D.1.5 mineralisation/immobilisation associated with loss/gain of soil organic matter, and 3.D.1.6 cultivation of organic soils (histosols).



Total GHG and N_2O emissions by country and for the total EU from 3.D.1 *Direct N_2O Emissions From Managed Soils* are shown in Table 5.45 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, N_2O emission in this source category decreased by 19 % or 22.4 Mt CO_2-eq. The decrease was largest in the Netherlands in relative terms (42 %) and in Poland in absolute terms (3.3 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 0.5 %.

Table 5.45 3.D.1 - Direct N_2O Emissions From Managed Soils: Countries' contributions to total EU-GHG and N_2O emissions

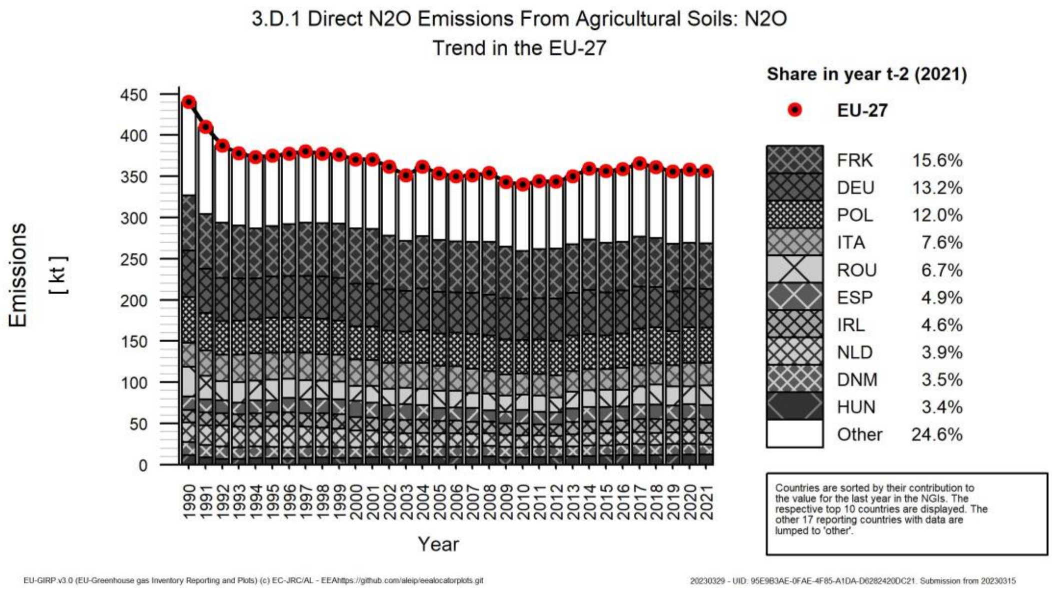
Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	1 776	1 492	1 500	1.6%	-277	-16%	8	1%	CS,T1,T2	D
Belgium	2 979	2 282	2 261	2.4%	-717	-24%	-20	-1%	T1	D
Bulgaria	3 619	2 732	2 785	2.9%	-834	-23%	53	2%	T1	D
Croatia	952	744	752	0.8%	-201	-21%	7	1%	T1	D
Cyprus	117	107	102	0.1%	-14	-12%	-4	-4%	T1	D
Czechia	3 519	2 289	2 385	2.5%	-1 134	-32%	96	4%	T1,T2	CS,D
Denmark	4 196	3 572	3 321	3.5%	-875	-21%	-251	-7%	CS,T1,T2	D
Estonia	800	549	548	0.6%	-252	-31%	0	0%	T1	D
Finland	2 906	2 867	2 829	3.0%	-77	-3%	-38	-1%	T1,T2,T3	CS,D
France	17 692	14 682	14 741	15.6%	-2 951	-17%	59	0%	T1,T2	D
Germany	15 016	12 609	12 471	13.2%	-2 544	-17%	-138	-1%	T1,T2	CS,D
Greece	3 320	2 144	2 062	2.2%	-1 258	-38%	-82	-4%	T1	D
Hungary	3 086	3 201	3 192	3.4%	106	3%	-9	0%	T1,T2	D
Ireland	4 097	4 127	4 320	4.6%	223	5%	194	5%	T1	D
Italy	7 755	7 531	7 218	7.6%	-537	-7%	-314	-4%	D,T1	CS,D
Latvia	1 436	896	888	0.9%	-549	-38%	-9	-1%	T1	CS,D
Lithuania	2 296	1 880	1 715	1.8%	-581	-25%	-165	-9%	T1,T2	D
Luxembourg	124	102	103	0.1%	-20	-16%	2	2%	T1,T2	CS
Malta	17	23	22	0.0%	5	29%	-1	-4%	T1	D
Netherlands	6 288	3 772	3 651	3.9%	-2 637	-42%	-121	-3%	T1,T1b,T2	CS,D
Poland	14 720	11 408	11 371	12.0%	-3 349	-23%	-38	0%	T1	CS,D
Portugal	1 600	1 598	1 552	1.6%	-48	-3%	-46	-3%	T1	CS,D
Romania	9 438	5 763	6 350	6.7%	-3 088	-33%	586	10%	T1	D
Slovakia	1 551	976	968	1.0%	-583	-38%	-8	-1%	T1	CS,D
Slovenia	298	293	297	0.3%	0	0%	4	1%	T1,T2	D
Spain	4 310	4 705	4 595	4.9%	285	7%	-111	-2%	CS,T1	D
Sweden	2 869	2 542	2 413	2.6%	-456	-16%	-129	-5%	T1,T2	CS,D
EU-27	**116 774**	**94 885**	**94 410**	**100%**	**-22 363**	**-19%**	**-475**	**-1%**	**-**	**-**

5.3.4.1 Trends in Emissions and Activity Data

3.D.1 - Direct N_2O Emissions From Managed Soils - Emissions

Emissions in source category *3.D.1 - Direct N_2O Emissions From Managed Soils* decreased considerably in EU by 19 % or 22.4 Mt CO_2-eq in the period 1990 to 2021. Figure 5.60 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from direct N_2O emissions from managed soils for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 75.4 % of the total in 2021. Emissions decreased in 23 countries and increased in four countries. The five countries with the largest decreases were Poland, Romania, France, the Netherlands and Germany with a total absolute decrease of 14.6 Mt CO_2-eq. The three countries with the largest increases were Hungary, Ireland and Spain, with a total absolute increase of 614 kt CO_2-eq.

Figure 5.60: 3.D.1 Direct N_2O Emissions From Managed Soils: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



The main driving force of direct N_2O emissions from agricultural soils is the use of nitrogen fertiliser and animal manure, which were 25 % and 14 % below 1990 levels in 2021, respectively. N_2O emissions from agricultural land can be decreased by overall efficiency improvements of nitrogen uptake by crops, which should lead to lower fertiliser consumption on agricultural land. The decrease of fertiliser use is partly due to the effects of the 1992 reform of the Common Agricultural Policy and the resulting shift from production-based support mechanisms to direct area payments in arable production. This has tended to lead to an optimisation and overall reduction in fertiliser use. In addition, reduction in fertiliser use is also due to directives such as the Nitrate Directive and to the extensification measures included in the Agro-Environment Programmes (EC, 2001).

Another policy affecting GHG emissions, in this case through the application of sewage sludge, is the Urban Wastewater Treatment Directive[46]. In Ireland, a significant increase (over double) in the quantity of sewage sludge applied to agricultural land took place around 1998 as a result of its diversion away from disposal at solid waste disposal sites.

3.D.1.1 - Direct N_2O emissions from inorganic N fertilizers - Emissions

Emissions in source category *3.D.1.1 - Direct N_2O Emissions From Inorganic N fertilizers* decreased considerably in EU by 24 % or 12.4 Mt CO_2-eq in the period 1990 to 2021. Figure 5.61 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from inorganic N fertilizers for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 79 % of the total in 2021.Emissions decreased in 23 countries and increased in four countries. The largest decreases occurred in France and Germany with a total absolute decrease of 5.2 Mt CO_2-eq. The largest increases occurred in Ireland and Hungary, with a total absolute increase of 535 kt CO_2-eq.

3.D.1.1 - Direct N_2O emissions from inorganic N fertilizers - Application of inorganic fertilizers

Application of inorganic fertilizers decreased strongly in EU by 25 % or 3318 kt N/year in the period 1990 to 2021. Figure 5.62 shows the trend of application of inorganic fertilizers indicating the countries contributing most to EU total. The figure represents the trend in N applied from inorganic N fertilizers for the different countries along the inventory period. The ten countries with the highest application of inorganic fertilizers accounted together for 80.4 % of the total in 2021. Application of inorganic fertilizers

46 http://ec.europa.eu/environment/water/water-urbanwaste/legislation/directive_en.htm

decreased in 23 countries and increased in four countries. The largest decreases occurred in Germany and France with a total absolute decrease of 1574 kt N/year. The largest increases occurred in Ireland and Hungary, with a total absolute increase of 118 kt N/year.

Figure 5.61: 3.D.1.1 - Direct N_2O Emissions From Inorganic N fertilizers: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

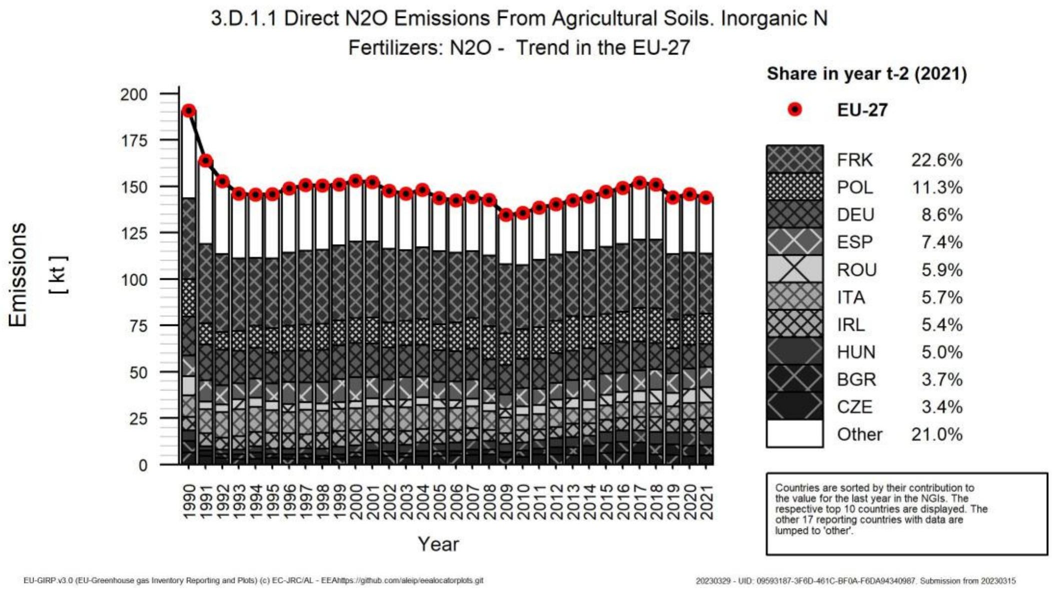
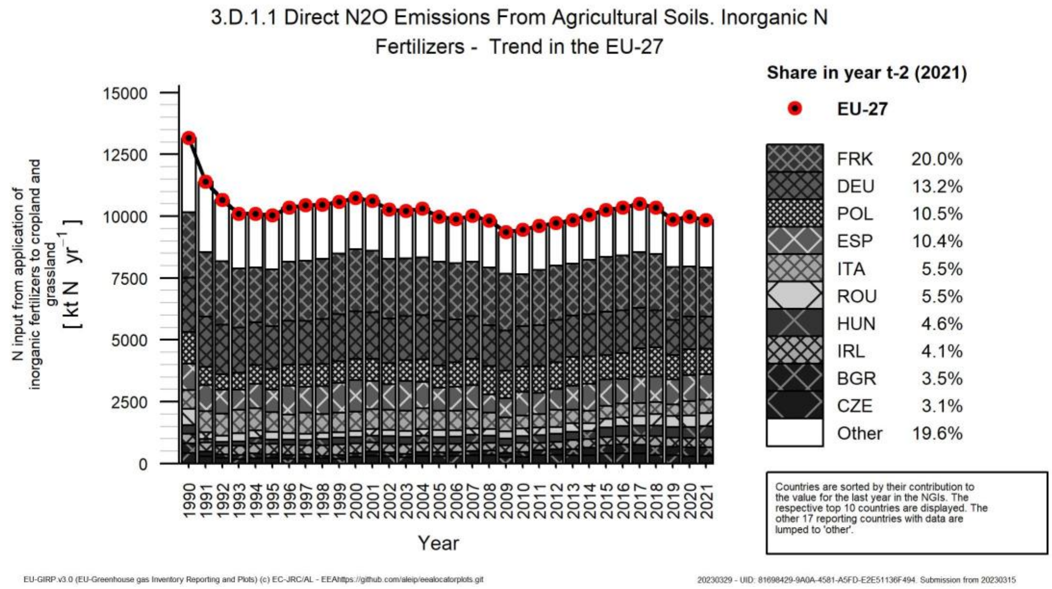


Figure 5.62: 3.D.1.1 - Direct N_2O Emissions From Inorganic N fertilizers: Trend in application of inorganic fertilizers in the EU and the countries contributing most to EU values including their share to EU application of inorganic fertilizers in 2021



3.D.1.2 - Direct N_2O emissions from organic N fertilizers - Emissions

Emissions in source category *3.D.1.2 - Direct N_2O Emissions from organic N fertilizers* decreased considerably in EU by 16 % or 3.2 Mt CO_2-eq in the period 1990 to 2021. Figure 5.63 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from organic N fertilizers for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 81.7 % of the total in 2021. Emissions decreased in eighteen countries and increased in nine countries. The largest decreases occurred in Romania and Poland with a total absolute decrease of 2 Mt CO_2-eq. The five countries with the largest increases were Ireland, Spain, Italy, Germany and the Netherlands, with a total absolute increase of 1.1 Mt CO_2-eq.

3.D.1.2 - Direct N_2O emissions from organic N fertilizers - amount of N applied

N from applied organic N fertilizers decreased clearly in EU by 14% or 860 kt N/year in the period 1990 to 2021. Figure 5.64 shows the trend of N from applied organic N fertilizers indicating the countries contributing most to EU total. The figure represents the trend in N applied from organic N fertilizers for the different countries along the inventory period. The ten countries with the highest N from applied organic N fertilizers accounted together for 85.5 % of the total in 2021. N from applied organic N fertilizers decreased in nineteen countries and increased in eight countries. The largest decreases occurred in Romania and Poland with a total absolute decrease of 470 kt N/year. The four countries with the largest increases were Italy, Ireland, Spain and Germany, with a total absolute increase of 278 kt N/year.

Figure 5.63: 3.D.1.2 - Direct N_2O Emissions From Organic N fertilizers: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

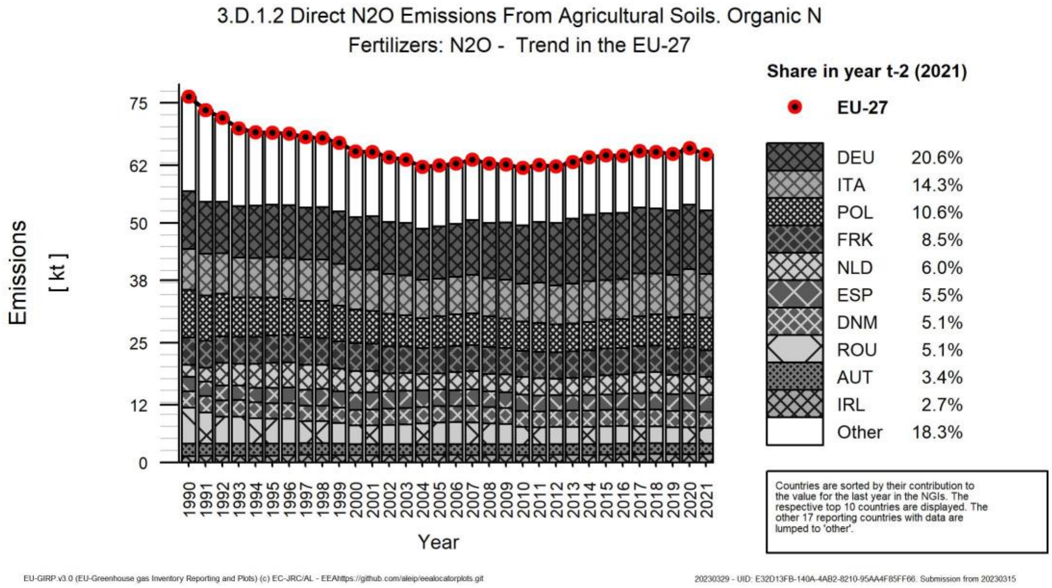
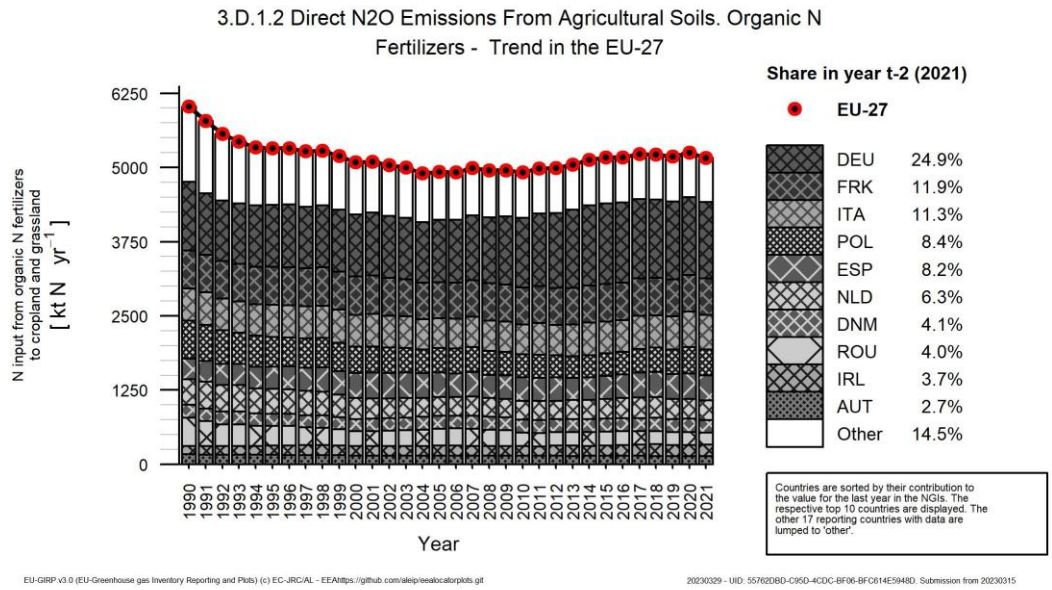


Figure 5.64: 3.D.1.2 - Direct N_2O Emissions From Organic N fertilizers: Trend in application of organic fertilizers in the EU and the countries contributing most to EU values including their share to EU application of organic fertilizers in 2021



3.D.1.3 - Urine and Dung Deposited by Grazing Animals - Emissions

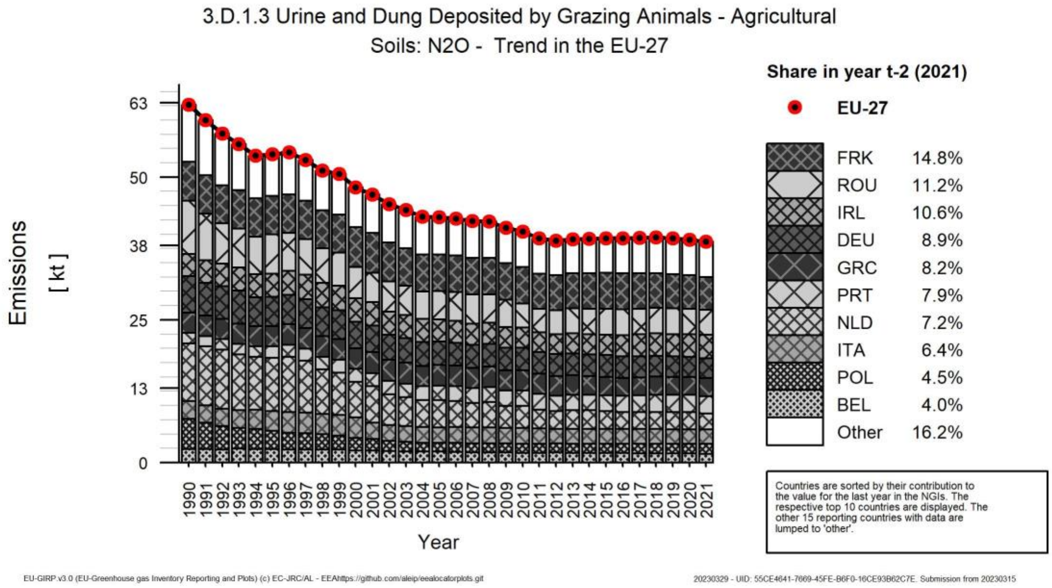
In 2021 N_2O emissions in source category *3.D.1.3 - Urine and Dung Deposited by Grazing Animals* in EU were 10262.5 kt CO_2 equivalent. This corresponds to 0.31 % of total EU GHG emissions and 5.5 % of total EU N_2O emissions. They make 2.7 % of total agricultural emissions and 7.5 % of total agricultural N_2O emissions.

Total GHG and N_2O emissions by country and for the total EU from 3.D.1.3 *Grazing Animals* are shown in Table 5.46 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, N_2O emission in this source category decreased by 38 % or 6.3 Mt CO_2-eq. The decrease was largest in Bulgaria in relative terms (79 %) and in the Netherlands in absolute terms (1.9 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 0.9 %. Figure 5.65 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from grazing animals for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 83.8 % of the total in 2021. Emissions decreased in twenty countries and increased in five countries. The four countries with the largest decreases were the Netherlands, Romania, Poland and Germany with a total absolute decrease of 5 Mt CO_2-eq. The three countries with the largest increases were Ireland, Spain and Portugal, with a total absolute increase of 520 kt CO_2-eq.

Table 5.46 3.D.1.3 - Urine and Dung Deposited by Grazing Animals: Countries' contributions to total EU-GHG and N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Information
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	148	80	79	0.8%	-68	-46%	0	0%	T2	D
Belgium	615	414	409	4.0%	-205	-33%	-5	-1%	T1	D
Bulgaria	548	115	115	1.1%	-432	-79%	0	0%	T1	D
Croatia	120	50	50	0.5%	-70	-58%	0	0%	T1	D
Cyprus	NO	NO	NO	-	-	-	-	-	NA	NA
Czechia	163	153	152	1.5%	-11	-7%	-1	0%	T1	D
Denmark	55	34	33	0.3%	-21	-39%	0	-1%	T2	D
Estonia	67	14	15	0.1%	-52	-78%	0	1%	T1	D
Finland	133	93	92	0.9%	-42	-31%	-2	-2%	T1	D
France	1 803	1 558	1 522	14.8%	-281	-16%	-36	-2%	T1,T2	D
Germany	1 695	934	916	8.9%	-779	-46%	-18	-2%	T1	D
Greece	943	838	844	8.2%	-99	-11%	6	1%	T1	D
Hungary	172	126	122	1.2%	-50	-29%	-4	-3%	T1	D
Ireland	1 016	1 046	1 089	10.6%	73	7%	44	4%	T1	D
Italy	818	679	660	6.4%	-159	-19%	-19	-3%	T1	CS,D
Latvia	133	56	56	0.5%	-77	-58%	0	0%	T1	D
Lithuania	378	116	115	1.1%	-262	-69%	-1	-1%	T1	D
Luxembourg	19	16	16	0.2%	-3	-17%	-1	-3%	T2	CS
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	2 693	786	743	7.2%	-1 949	-72%	-43	-5%	T1	D
Poland	1 413	453	460	4.5%	-953	-67%	7	1%	T1	CS,D
Portugal	479	807	810	7.9%	331	69%	3	0%	T1	D
Romania	2 477	1 174	1 150	11.2%	-1 327	-54%	-25	-2%	T1	D
Slovakia	97	50	53	0.5%	-44	-46%	3	5%	T1	CS
Slovenia	17	36	36	0.4%	19	109%	0	1%	T1	D
Spain	292	409	408	4.0%	116	40%	-1	0%	CS,T1	D
Sweden	315	316	317	3.1%	2	1%	1	0%	T1	D
EU-27	**16 608**	**10 354**	**10 262**	**100%**	**-6 346**	**-38%**	**-91**	**-1%**	**-**	**-**

Figure 5.65: 3.D.1.3 - Urine and Dung Deposited by Grazing Animals: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.D.1.6 – Cultivation of Organic Soils – Area of organic soils

Following an UNFCCC's recommendation, the following table presents areas of histosols reported in the LULUCF and agriculture sectors comparing organic soils area for countries reporting N_2O emissions from histosol in agriculture and for the total EU. For all the countries concerned, the area reported in the

LULUCF sector is either equal or higher than the area reported in agriculture. This can be explained as some grasslands are not considered "cultivated".

Table 5.47 3.D.1.6 – Cultivation of organic soils – Comparison of areas of organic soils between agriculture and LULUCF sectors

	3D - Area of histosols (ha) in 2021	4B - Cropland / Area of organic soils (ha) in 2021	4C - Grassland / Area of organic soils (ha) in 2021	Total LULUCF (4B+4C)	Difference between LULUCF and agriculture (ha)
Austria	12 954	0	12 954	12 954	0
Belgium	2 520	1 899	821	2 720	200
Bulgaria	3 201	1 367	1 834	3 201	0
Croatia	2 685	2 460	226	2 685	0
Denmark	172 124	91 414	80 709	172 124	0
Estonia	40 810	30 848	52 517	83 365	42 555
Finland	342 249	278 805	63 444	342 249	0
France	12 872	2 047	10 825	12 872	0
Germany	1 268 137	328 971	967 492	1 296 463	28 326
Greece	6 664.5	6 665	0	6 665	0
Ireland	338 703	0	338 937	338 937	233
Italy	24 285	23 206	1 079	24 285	0
Latvia	166 304	89 331	76 973	166 304	0
Lithuania	134 198	60 227	73 971	134 198	0
Netherlands	315 236	63 227	277 498	340 725	25 489
Poland	921 333	159 989	797 426	957 415	36 082
Romania	4 662	4 662	3 618	8 281	3 618
Slovenia	2 311	2 311	1 190	3 501	1 190
Sweden	113 840	115 692	49 638	165 331	51 491
Total EU	**3 885 090**	**1 263 122**	**2 811 153**	**4 074 275**	**189 185**

5.3.4.2 Implied EFs and Methodological Issues

In this section we discuss the implied emission factor for the main N sources contributing to direct N_2O emissions from managed soils.

3.D.1.1 - Direct N_2O Emissions From Inorganic N fertilizers - Implied emission factor

The implied emission factor for N_2O emissions in source category *3.D.1.1 - Direct N_2O Emissions From Inorganic N fertilizers* increased in EU barely between 1990 and 2021 by 0.97 %. Figure 5.66 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.48 shows the implied emission factor for N_2O emissions in source category *3.D.1.1 - Direct N_2O Emissions From Inorganic N fertilizers* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in four countries and increased in three countries. It was in 2021 at the level of 1990 in twenty countries.

Figure 5.66: 3.D.1.1 - Direct N_2O Emissions From Inorganic N fertilizers: Trend in implied emission factor in the EU and range of values reported by countries

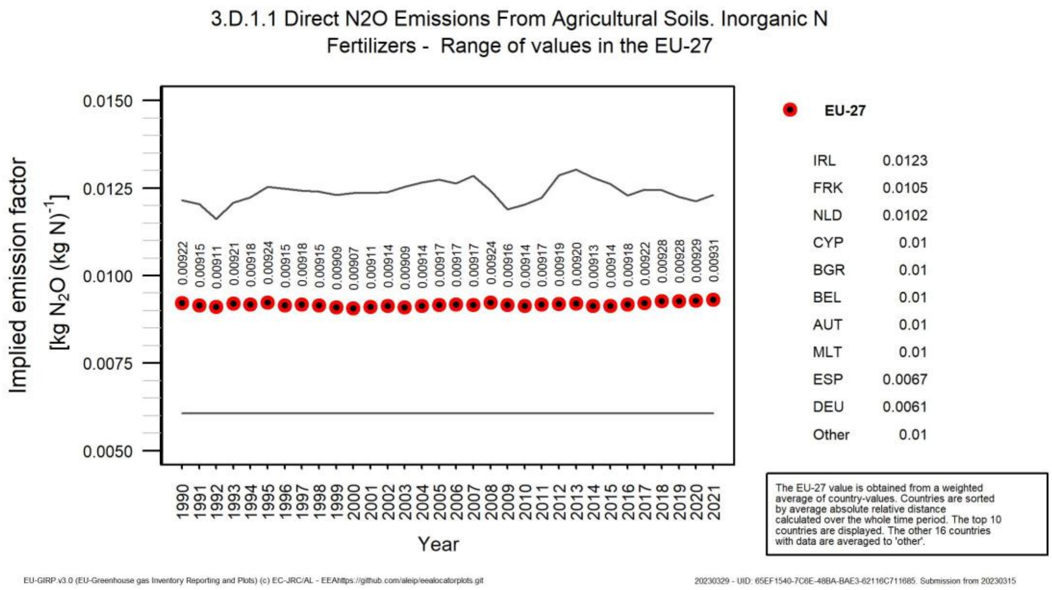


Table 5.48 3.D.1.1 - Direct N_2O Emissions From Inorganic N fertilizers: countries' implied emission factor (kg N_2O-N/kg N)

Country	1990	2021	Country	1990	2021
Austria	0.0100	0.0100	Ireland	0.0122	0.0123
Belgium	0.0100	0.0100	Italy	0.0097	0.0096
Bulgaria	0.0100	0.0100	Lithuania	0.0100	0.0100
Cyprus	0.0100	0.0100	Luxembourg	0.0088	0.0088
Czech Republic	0.0100	0.0100	Latvia	0.0100	0.0100
Germany	0.0061	0.0061	Malta	0.0100	0.0100
Denmark	0.0100	0.0100	Netherlands	0.0103	0.0102
Spain	0.0067	0.0067	Poland	0.0100	0.0100
Estonia	0.0100	0.0100	Portugal	0.0098	0.0097
Finland	0.0100	0.0100	Romania	0.0100	0.0100
France	0.0105	0.0105	Slovakia	0.0100	0.0100
Greece	0.0100	0.0100	Slovenia	0.0100	0.0100
Croatia	0.0100	0.0100	Sweden	0.0100	0.0100
Hungary	0.0100	0.0100	EU	0.0092	0.0093

3.D.1.2 - Direct N_2O Emissions From Organic N fertilizers - Implied emission factor

The implied emission factor for N_2O emissions in source category *3.D.1.2 - Direct N_2O Emissions From Organic N fertilizers* decreased in EU slightly between 1990 and 2021 by 1.8 %. Figure 5.67 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.49 shows the implied emission factor for N_2O emissions in source category *3.D.1.2 - Direct N_2O Emissions From Organic N fertilizers* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in three countries and increased in two countries. It was in 2021 at the level of 1990 in 22 countries. The largest increase occurred in the Netherlands with an absolute value of 0.0036 kg N_2O-N/kg N.

Figure 5.67: 3.D.1.2 - Direct N_2O Emissions From Organic N fertilizers: Trend in implied emission factor in the EU and range of values reported by countries

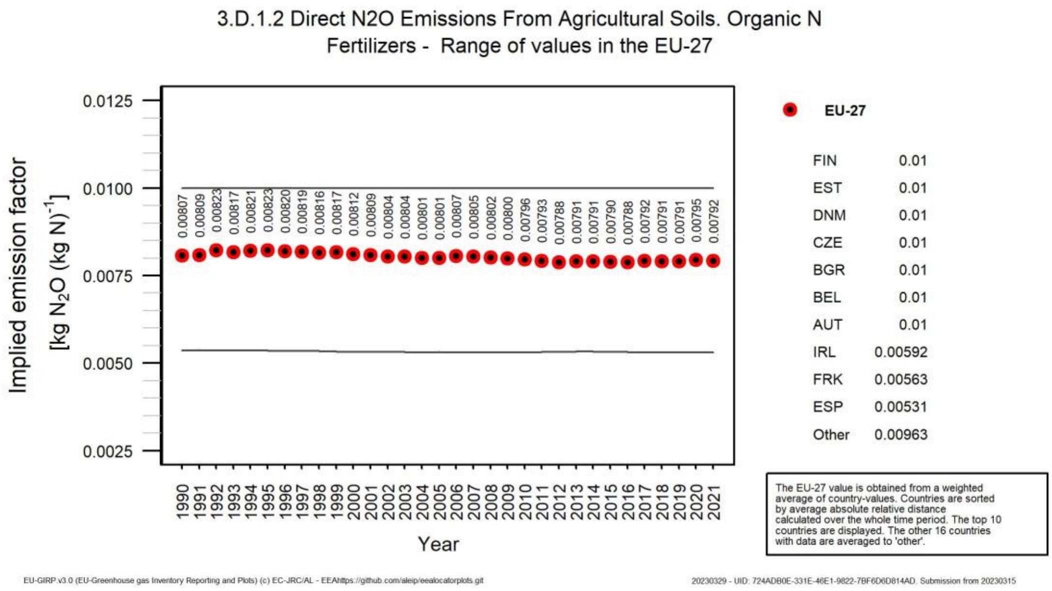


Table 5.49 3.D.1.2 - Direct N_2O Emissions From Organic N fertilizers: countries' implied emission factor (kg N_2O-N/kg N)

Country	1990	2021		Country	1990	2021
Austria	0.0100	0.0100	|	Ireland	0.0059	0.0059
Belgium	0.0100	0.0100	|	Italy	0.0100	0.0100
Bulgaria	0.0100	0.0100	|	Lithuania	0.0100	0.0100
Cyprus	0.0100	0.0100	|	Luxembourg	0.0088	0.0088
Czech Republic	0.0100	0.0100	|	Latvia	0.0100	0.0100
Germany	0.0066	0.0066	|	Malta	0.0100	0.0100
Denmark	0.0100	0.0100	|	Netherlands	0.0039	0.0075
Spain	0.0054	0.0053	|	Poland	0.0100	0.0100
Estonia	0.0100	0.0100	|	Portugal	0.0100	0.0100
Finland	0.0100	0.0100	|	Romania	0.0100	0.0100
France	0.0056	0.0056	|	Slovakia	0.0100	0.0100
Greece	0.0100	0.0100	|	Slovenia	0.0100	0.0100
Croatia	0.0100	0.0100	|	Sweden	0.0100	0.0100
Hungary	0.0100	0.0100	|	EU	0.0081	0.0079

3.D.1.3 - Urine and Dung Deposited by Grazing Animals - Implied emission factor

The implied emission factor for N_2O emissions in source category *3.D.1.3 - Urine and Dung Deposited by Grazing Animals* strongly decreased in EU between 1990 and 2021 by 19 %. Table 5.50 shows the implied emission factor for N_2O emissions in source category *3.D.1.3 - Urine and Dung Deposited by Grazing Animals* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in fifteen countries and increased in nine countries. It was in 2021 at the level of 1990 in one country. No data were available for two countries (Cyprus and Malta). The three countries with the largest decreases were Croatia, Romania and the Netherlands with a mean absolute value of 0.0025 kg N_2O-N/kg N. The three countries with the largest increases were Hungary, Portugal and Poland with a mean absolute value of 0.0015 kg N_2O-N/kg N.

Table 5.50 3.D.1.3 - Urine and Dung Deposited by Grazing Animals: countries' implied emission factor (kg N_2O-N/kg N)

Country	1990	2021		Country	1990	2021
Austria	0.0188	0.0169	|	Ireland	0.0076	0.0078
Belgium	0.0197	0.0194	|	Italy	0.0111	0.0111
Bulgaria	0.0120	0.0128	|	Lithuania	0.0191	0.0190
Czech Republic	0.0185	0.0189	|	Luxembourg	0.0088	0.0088
Germany	0.0191	0.0189	|	Latvia	0.0196	0.0188
Denmark	0.0039	0.0038	|	Netherlands	0.0330	0.0309
Spain	0.0030	0.0031	|	Poland	0.0185	0.0194
Estonia	0.0184	0.0165	|	Portugal	0.0163	0.0179
Finland	0.0179	0.0170	|	Romania	0.0155	0.0129
France	0.0044	0.0044	|	Slovakia	0.0158	0.0163
Greece	0.0104	0.0104	|	Slovenia	0.0185	0.0174
Croatia	0.0135	0.0107	|	Sweden	0.0176	0.0173
Hungary	0.0138	0.0157	|	EU	0.0116	0.0094

3.D.1.4 – Crop residues - Implied emission factor

The implied emission factor for N_2O emissions in source category 3.D.1.4 - Direct N_2O Emissions From Crop Residues has almost remained constant from 1990 to 2021 at a value of 0.0081 to 0.0081 kg N_2O-N/kg N at EU level. For most of the countries, the implied emission factor remained constant at 1990 levels, except for the Netherlands (the IEF decreased) and Romania (the IEF increased).

3.D.1.5 – Mineralization of Soil Organic Matter - Implied emission factor

The implied emission factor for N_2O emissions in source category 3.D.1.5 - Direct N_2O Emissions From Mineralization of Soil Organic Matter increased in EU between 1990 and 2021 by 8.6 %. Not all the countries report emissions for this category and some countries only report emissions for some years. For the countries reporting emissions, the implied emission factor remained constant at 1990 levels. For most of the countries, this IEF is equal to the default value of 0.01 kg N_2O-N/kg N, except for Ireland (0.006 kg N_2O-N/kg N) and Luxembourg (0.0088 kg N_2O-N/kg N).

3.D.1.6 – Cultivation of Organic Soils - Implied emission factor

The implied emission factor for N_2O emissions in source category *3.D.1.6 - Direct N_2O Emissions From Cultivation of Organic Soils* in EU decreased by 0.1 % between 1990 and 2021. Table 5.51 shows the implied emission factor for N_2O emissions for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in two countries and increased in one country. It was in 2021 at the level of 1990 in 16 countries. The largest increase occurred in Finland with an absolute value of 0.57 kg N_2O-N/ha and the largest decrease in Latvia with an absolute value of 1.06 kg N_2O-N/ha.

Table 5.51 3.D.1.6 - Cultivation of Organic Soils: countries' implied emission factor (kg N_2O-N/ha)

Country	1990	2021	Country	1990	2021
Austria	8.20	8.20	**Ireland**	4.30	4.30
Belgium	8.00	8.00	**Italy**	8.00	8.00
Bulgari	8.00	8.00	**Lithuania**	8.00	8.00
Germany	6.21	6.21	**Latvia**	5.01	3.95
Denmark	8.11	7.42	**Netherlands**	4.45	4.45
Estonia	8.00	8.00	**Poland**	8.00	8.00
Finland	9.31	9.88	**Romania**	8.00	8.00

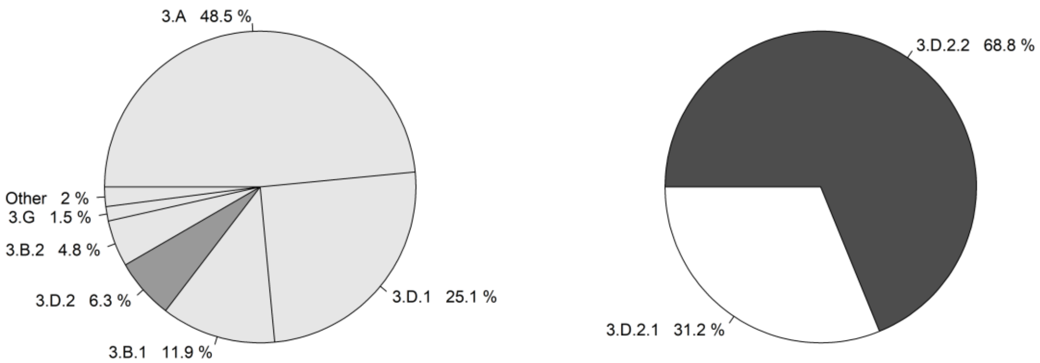
France	3.42	3.42	**Slovenia**	8.00	8.00
Greece	8.00	8.00	**Sweden**	13.00	13.00
Croatia	8.00	8.00	**EU**	6.91	6.90

The N_2O IEF for cultivation of organic soils is lower than the range of the 2006 IPCC default values for 5 of the 19 member States that reported emissions for this source category (Germany, France, Ireland, Latvia and Netherlands). The emissions reported by these member States account for 43 % of total EU emissions under this source category. Germany used country specific N_2O EFs that differs between cropland and grassland (respectively 11.1 kg N_2O-N/ha and 4.6 kg N_2O-N/ha). Ireland, which used an EF of 4.3 kg N_2O-N/ha, estimated emissions from drainage/management of organic soils using the area of drained/managed organic soils also adopted to estimate emissions and removals for category 4.C (grasslands) and the EF for nutrient-poor grasslands from table 2.5 of the Wetlands Supplement. The Netherlands, with an EF of 4.45 kg N_2O-N/ha, adopted a Tier 1 approach, together with the IPCC default EFs for temperate and boreal organic nutrient-rich (0.6 kg N_2O-N ha-1) and nutrient-poor (0.1 kg N_2O-N ha-1) forest soils (2006 IPCC Guidelines, vol. 4, table 11.1). France uses the emission factors proposed in the 2013 IPCC supplement on wetlands (Chapter 2 - Table 2.5 p 33) with values that differs between cropland and grassland. Latvia estimates N_2O emissions from cultivated organic soils with country specific emissions factors that differs between cropland and grassland (respectively 7.1 kg N_2O-N/ha/yr for drained cropland and 0.3 kg N_2O-N/ha/yr for drained grassland).

5.3.5 Indirect Emissions from Managed Soils - N_2O (CRF Source Category 3D2)

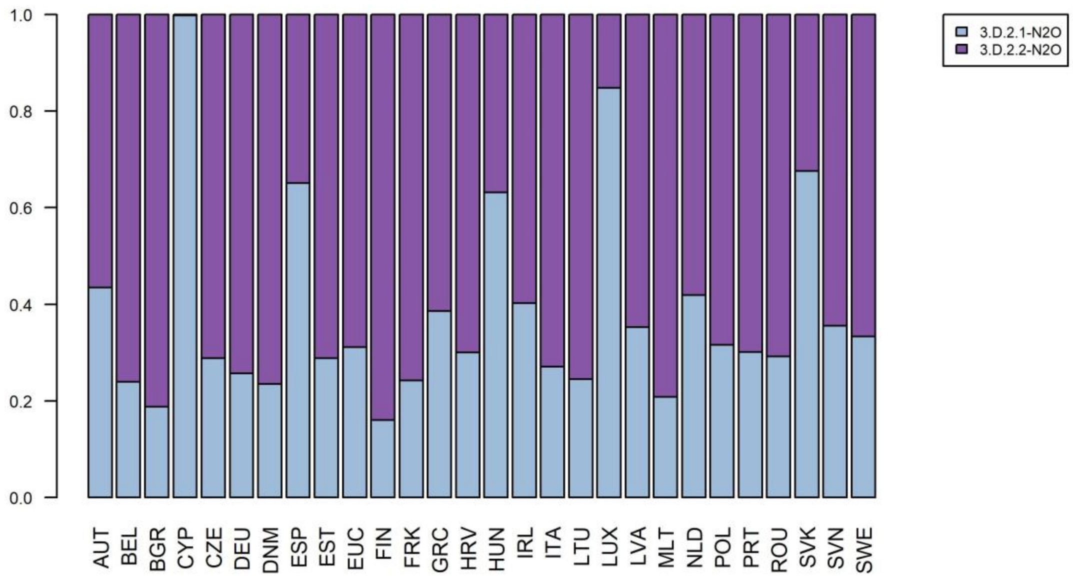
In 2021 N_2O emissions in source category *3.D.2 - Indirect Emissions from Managed Soils* in EU were 23583.7 kt CO_2 equivalent. This corresponds to 0.71 % of total EU GHG emissions and 13 % of total EU N_2O emissions. They make 6.2 % of total agricultural emissions and 17 % of total agricultural N_2O emissions. The main sub-categories are 3.D.2.2 (Nitrogen Leaching and Run-off), and 3.D.2.1 (Atmospheric Deposition) as shown in Figure 5.68. Regarding the origin of emissions in the different countries, Figure 5.69 shows the distribution of indirect N_2O emissions from managed soils by emission source in all countries and in the EU. Each bar represents the total emissions of a country in the current emission category, where different shades of purple correspond to the emitting sub-categories.

Figure 5.68: Share of source category 3.D.2 on total EU agricultural emissions (left panel) and decomposition into its sub-categories (right panel). The percentages refer to the emissions in the year 2021.



In the left panel, some minor differences in the numbers might be present due to automatic rounding of numbers.

Figure 5.69: Decomposition of emissions in source category 3.D.2 - Indirect Emissions from Managed Soils into its sub-categories by country in the year 2021. 3.D.2.1 Atmospheric Deposition and 3.D.2.2 Nitrogen Leaching and Run-off.



Total GHG and N_2O emissions by country and for the total EU from 3.D.2 *Indirect Emissions from Managed Soils* are shown in Table 5.52 for the first and the last year of the inventory (1990 and 2021). Values are given in kt CO_2-eq. Between 1990 and 2021, N_2O emission in this source category decreased by 25 % or 8 Mt CO_2-eq. The decrease was largest in Slovakia in relative terms (72 %) and in Germany in absolute terms (1.2 Mt CO_2-eq). From 2020 to 2021 emissions in the current category decreased by 0.7 %.

Table 5.52 3.D.2 - Indirect Emissions from Managed Soils: Countries' contributions to total EU-GHG and N_2O emissions

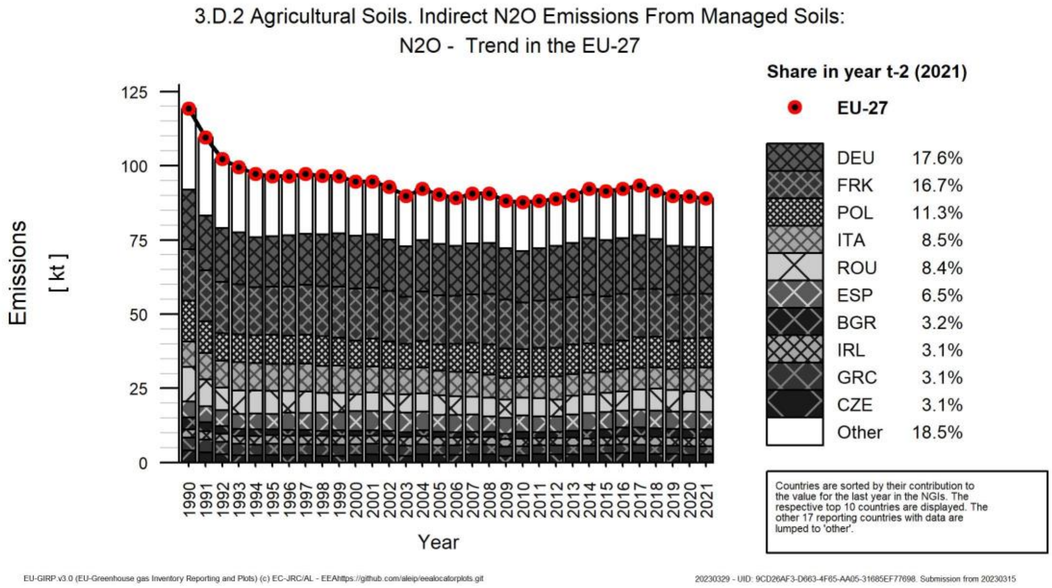
Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	341	286	286	1.2%	-54	-16%	1	0%	CS	D
Belgium	966	613	607	2.6%	-359	-37%	-6	-1%	T1	D
Bulgaria	1 102	755	762	3.2%	-340	-31%	7	1%	T1	D
Croatia	310	235	238	1.0%	-72	-23%	2	1%	T1	D
Cyprus	17	17	17	0.1%	0	2%	0	-2%	T1	D
Czechia	1 089	700	731	3.1%	-358	-33%	32	5%	T1	D
Denmark	1 214	682	672	2.9%	-542	-45%	-10	-1%	T2	D
Estonia	204	126	129	0.5%	-75	-37%	2	2%	T1	D
Finland	309	261	253	1.1%	-56	-18%	-9	-3%	T2	D
France	4 568	3 915	3 928	16.7%	-640	-14%	13	0%	T1,T2	CS,D
Germany	5 323	4 205	4 149	17.6%	-1 175	-22%	-56	-1%	T1	D
Greece	1 148	760	735	3.1%	-414	-36%	-26	-3%	T1	D
Hungary	329	249	247	1.0%	-82	-25%	-2	-1%	T1	D
Ireland	706	727	743	3.1%	37	5%	16	2%	T1	CS,D
Italy	2 256	2 103	2 010	8.5%	-246	-11%	-93	-4%	T1	CS,D
Latvia	277	159	156	0.7%	-121	-44%	-3	-2%	T1	D
Lithuania	524	406	361	1.5%	-162	-31%	-45	-11%	T1	D
Luxembourg	22	21	20	0.1%	-2	-8%	0	-1%	T1,T2	D
Malta	6	8	7	0.0%	2	27%	0	-4%	T1	D
Netherlands	1 423	525	521	2.2%	-902	-63%	-4	-1%	T1	D
Poland	3 663	2 670	2 658	11.3%	-1 005	-27%	-12	0%	T1	D
Portugal	439	400	387	1.6%	-52	-12%	-13	-3%	T2	D
Romania	3 072	1 822	1 974	8.4%	-1 098	-36%	153	8%	T1	D
Slovakia	432	170	120	0.5%	-312	-72%	-50	-30%	T1,T2	CS,D
Slovenia	105	96	97	0.4%	-8	-8%	1	1%	T1	D
Spain	1 417	1 580	1 526	6.5%	109	8%	-54	-3%	CS,T2	D
Sweden	328	252	250	1.1%	-78	-24%	-3	-1%	CS	D
EU-27	**31 590**	**23 744**	**23 584**	**100%**	**-8 006**	**-25%**	**-160**	**-1%**	**-**	**-**

5.3.5.1 Trends in Emissions and Activity Data

3.D.2 - Indirect Emissions from Managed Soils - Emissions

Emissions in source category *3.D.2 - Indirect Emissions from Managed Soils* decreased strongly in EU by 25 % or 8 Mt CO_2-eq in the period 1990 to 2021. Figure 5.70 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from indirect emissions from managed soils for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 81.5 % of the total in 2021. Emissions decreased in 23 countries and increased in four countries. The four countries with the largest decreases were Germany, Romania, Poland and the Netherlands with a total absolute decrease of 4.2 Mt CO_2-eq. The largest increases occurred in Ireland and Spain, with a total absolute increase of 146 kt CO_2-eq.

Figure 5.70: 3.D.2 Indirect Emissions from Managed Soils: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021



3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition - Emissions

Emissions in source category *3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition* decreased strongly in EU by 32 % or 3.4 Mt CO_2-eq in the period 1990 to 2021. Figure 5.71 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions from atmospheric deposition for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 81.4 % of the total in 2021. Emissions decreased in 24 countries and increased in three countries. The four countries with the largest decreases were the Netherlands, Germany, Romania and Poland with a total absolute decrease of 1.9 Mt CO_2-eq. The largest increases occurred in Ireland, with a total absolute increase of 5 kt CO_2-eq.

3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition - Volatilized N from agricultural N inputs

Volatilized N from agricultural N inputs decreased strongly in EU by 32 % or 837 kt N/year in the period 1990 to 2021. Figure 5.72 shows the trend of volatilized N from agricultural N inputs indicating the countries contributing most to EU total. The figure represents the trend in volatilized N from agricultural N inputs from atmospheric deposition for the different countries along the inventory period. The ten countries with the highest volatilized N from agricultural N inputs accounted together for 82.1 % of the total in 2021. Volatilized N from agricultural N inputs decreased in 24 countries and increased in three countries. The four countries with the largest decreases were the Netherlands, Germany, Romania and Poland with a total absolute decrease of 449 kt N/year. The largest increases occurred in Malta and Ireland, with a total absolute increase of 1 kt N/year.

Figure 5.71: 3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

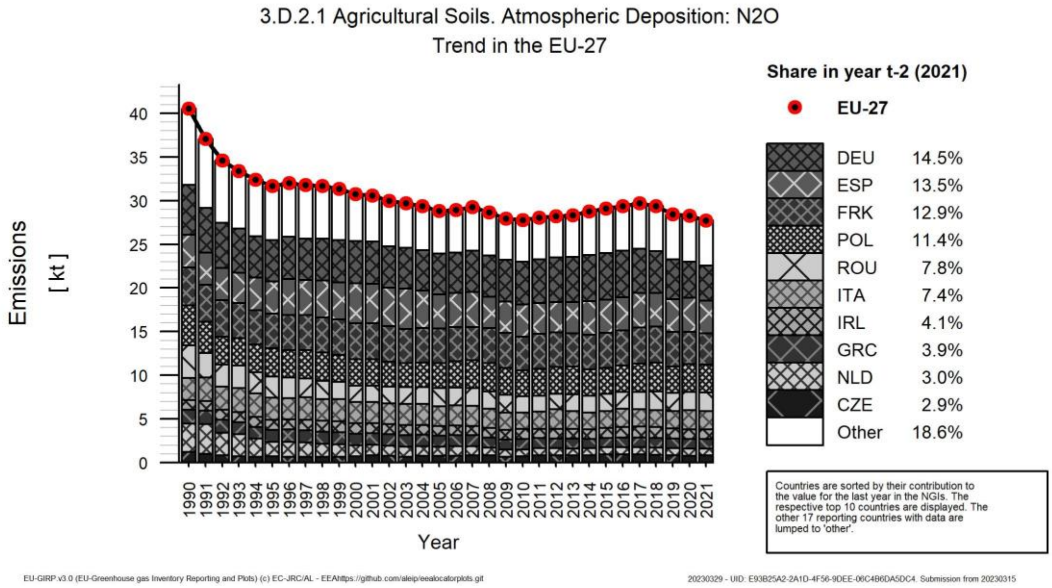
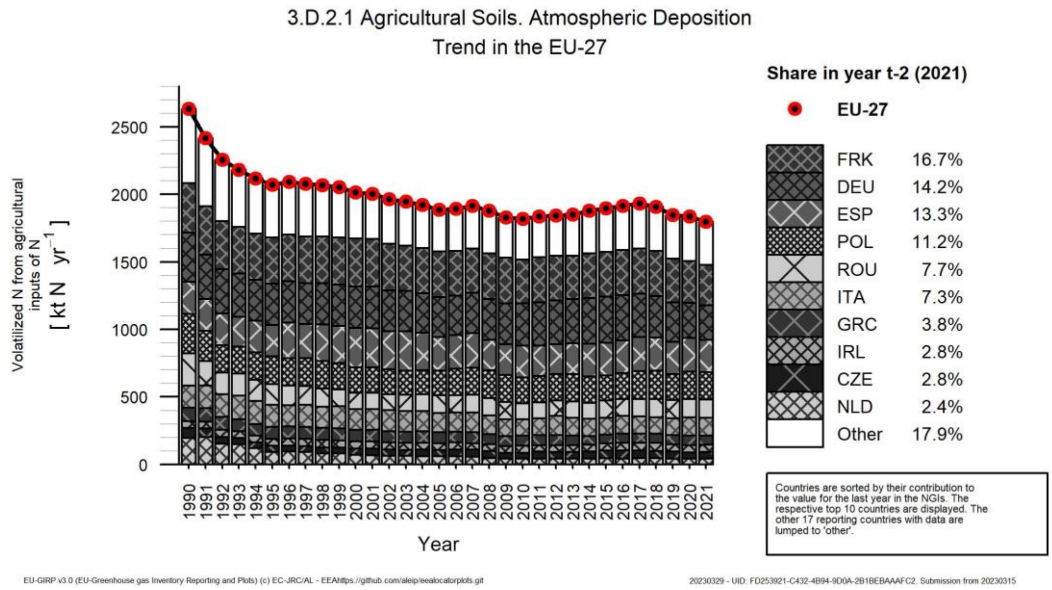


Figure 5.72: 3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition: Trend in volatilized N from agricultural N inputs in the EU and the countries contributing most to EU values including their share to EU volatilized N from agricultural N inputs in 2021



3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off - Emissions

Emissions in source category *3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off* decreased considerably in EU by 22 % or 4.6 Mt CO_2-eq in the period 1990 to 2021. Figure 5.73 shows the trend of emissions indicating the countries contributing most to EU total. The figure represents the trend in N_2O emissions for the different countries along the inventory period. The ten countries with the highest emissions accounted together for 82.5 % of the total in 2021. Emissions decreased in 23 countries and increased in four countries. The three countries with the largest decreases were Germany, Romania and Poland with a total absolute decrease of 2 Mt CO_2-eq. The largest increases occurred in Ireland and Spain, with a total absolute increase of 143 kt CO_2-eq.

3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off - N from fertilizers and other agricultural inputs that is lost through leaching and run-off

N from fertilizers and other agricultural inputs that is lost through leaching and run-off decreased considerably in EU by 23 % or 1459 kt N/year in the period 1990 to 2021. Figure 5.74 shows the trend of N from fertilizers and other agricultural inputs that is lost through leaching and run-off indicating the countries contributing most to EU total. The figure represents the trend in N from fertilizers and other agricultural inputs that is lost through leaching and run-off for the different countries along the inventory period. The ten countries with the highest N from fertilizers and other agricultural inputs that is lost through leaching and run-off accounted together for 82.9 % of the total in 2021. N from fertilizers and other agricultural inputs that is lost through leaching and run-off decreased in 23 countries and increased in four countries. The three countries with the largest decreases were Germany, Romania and Poland with a total absolute decrease of 652 kt N/year. The largest increases occurred in Ireland and Spain, with a total absolute increase of 43 kt N/year.

Figure 5.73: 3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off: Trend in emissions in the EU and the countries contributing most to EU values including their share to EU emissions in 2021

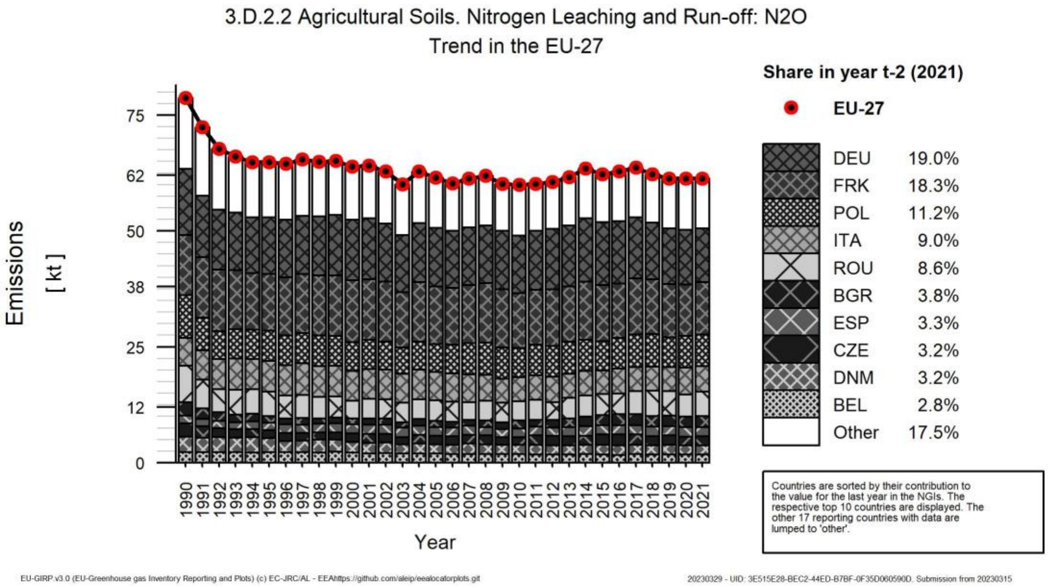
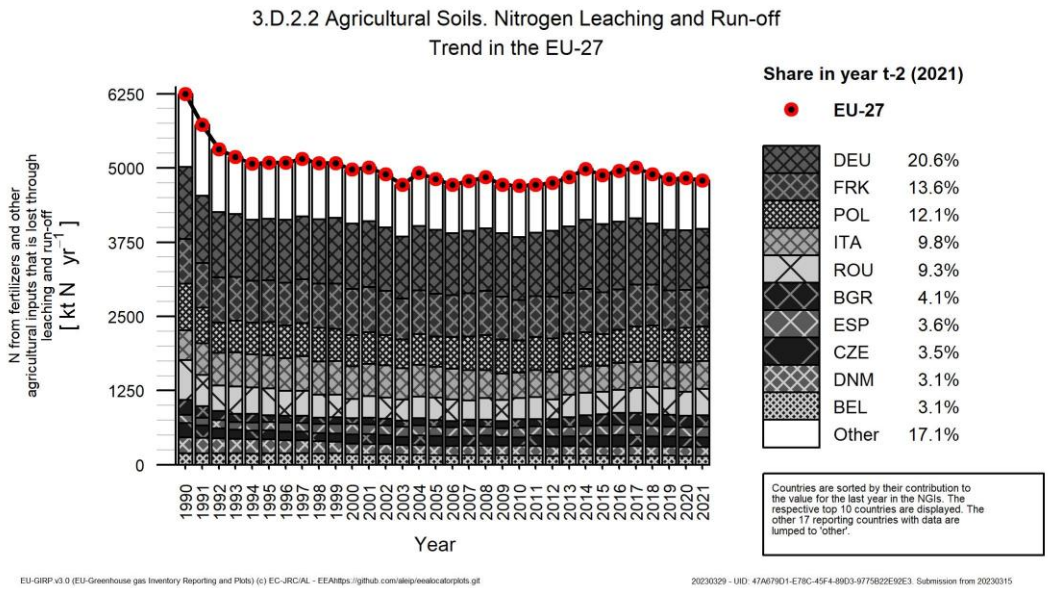


Figure 5.74: 3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off: Trend N leached from fertilizers and other agricultural inputs in the EU and the countries contributing most to EU values including their share to EU N leached from fertilizers and other agricultural inputs in 2021



5.3.5.2 Implied EFs and Methodological Issues

In this section we discuss the implied emission factor for the main N sources contributing to indirect N_2O emissions from managed soils. Furthermore, we present the most relevant parameters related with indirect N_2O emissions:

- $Frac_{GASF}$: Fraction of synthetic fertiliser N applied to soils that volatilises as NH_3 and NO_X
- $Frac_{GASM}$: Fraction of livestock N excretion that volatilises as NH_3 and NO_X
- $Frac_{LEACH}$: Fraction of N input to managed soils that is lost through leaching and run-off.

3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition

The implied emission factor for N_2O emissions in source category *3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition* increased in EU barely between 1990 and 2021 by 0.25 %. Figure 5.75 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.53 shows the implied emission factor for N_2O emissions in source category *3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition* for the years 1990 and 2021 for all countries and EU. The reported implied emission factor in 2021 was at the level of 1990 in 22 countries and increased in all reporting other five countries. The largest increase occurred in Portugal with an absolute value of 0.0031 kg N_2O-N/kg N.

Figure 5.75: 3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition: Trend in implied emission factor in the EU and range of values reported by countries

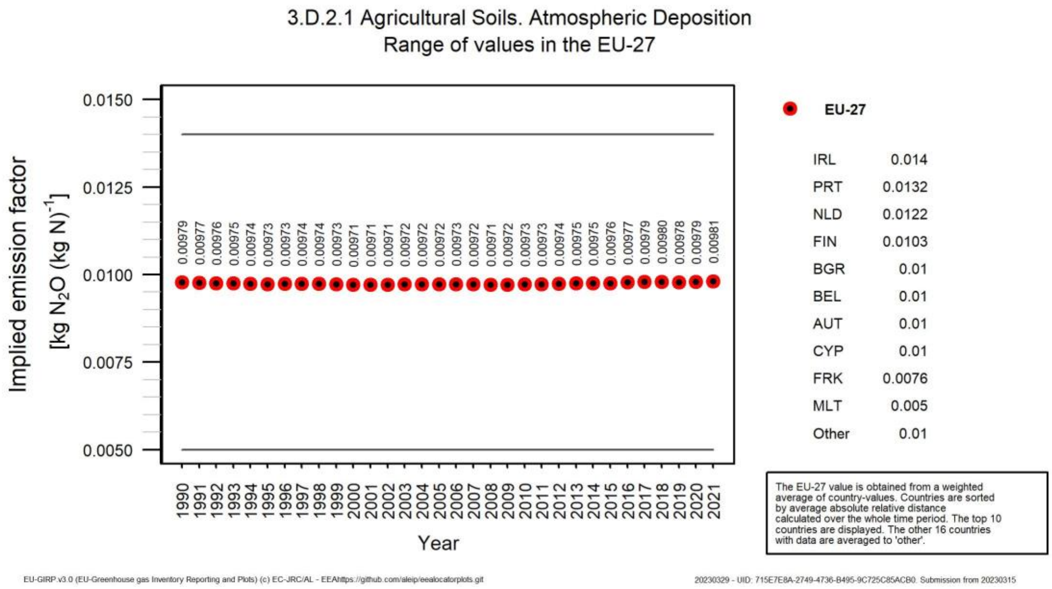


Table 5.53 3.D.2.1 - Indirect N_2O Emissions from Atmospheric Deposition: countries' implied emission factor (kg N_2O-N/kg N)

Country	1990	2021	Country	1990	2021
Austria	0.0100	0.0100	Ireland	0.0140	0.0140
Belgium	0.0100	0.0100	Italy	0.0100	0.0100
Bulgaria	0.0100	0.0100	Lithuania	0.0100	0.0100
Cyprus	0.0100	0.0100	Luxembourg	0.0140	0.0140
Czech Republic	0.0100	0.0100	Latvia	0.0100	0.0100
Germany	0.0100	0.0100	Malta	0.0050	0.0050
Denmark	0.0100	0.0100	Netherlands	0.0107	0.0122
Spain	0.0100	0.0100	Poland	0.0100	0.0100
Estonia	0.0100	0.0100	Portugal	0.0101	0.0132
Finland	0.0101	0.0103	Romania	0.0100	0.0100
France	0.0075	0.0076	Slovakia	0.0100	0.0100
Greece	0.0100	0.0100	Slovenia	0.0100	0.0100
Croatia	0.0100	0.0100	Sweden	0.0100	0.0100

Hungary	0.0100	0.0100	EU	0.0098	0.0098

3.D.2.1 - Indirect emissions from Atmospheric Deposition - $Frac_{GASF}$

The $Frac_{GASF}$, a parameter used for calculating N_2O emissions in source category *3.D.2.1 - Indirect emissions from Atmospheric Deposition*, decreased in EU barely between 1990 and 2021 by 0.79 %. Table 5.54 shows the $Frac_{GASF}$ in source category *3.D.2.1 - Indirect emissions from Atmospheric Deposition* for the years 1990 and 2021 for all countries and EU. The $Frac_{GASF}$ decreased in nine countries and increased in seven countries. It was in 2021 at the level of 1990 in eleven countries. The three countries with the largest decreases were Hungary, Spain and Portugal with a mean absolute value of 0.012. The three countries with the largest increases were Lithuania, Italy and the Netherlands with a mean absolute value of 0.0098.

Table 5.54 3.D.2.1 - Indirect emissions from Atmospheric Deposition: countries' $Frac_{GASF}$ (-)

Country	1990	2021	Country	1990	2021
Austria	0.049	0.050	Ireland	0.030	0.023
Belgium	0.064	0.068	Italy	0.088	0.097
Bulgaria	0.064	0.064	Lithuania	0.056	0.068
Cyprus	0.100	0.100	Luxembourg	0.032	0.038
Czech Republic	0.100	0.100	Latvia	0.100	0.100
Germany	0.042	0.034	Malta	0.110	0.110
Denmark	0.053	0.053	Netherlands	0.040	0.047
Spain	0.083	0.070	Poland	0.100	0.100
Estonia	0.100	0.100	Portugal	0.060	0.052
Finland	0.016	0.015	Romania	0.100	0.100
France	0.066	0.067	Slovakia	0.100	0.100
Greece	0.100	0.100	Slovenia	0.057	0.053
Croatia	0.100	0.100	Sweden	0.022	0.019
Hungary	0.069	0.055			

3.D.2.2 - Indirect emissions from Atmospheric Deposition - $Frac_{GASM}$

The $Frac_{GASM}$, a parameter used for calculating N_2O emissions in source category *3.D.2.2 - Indirect emissions from Atmospheric Deposition*, decreased in EU moderately between 1990 and 2021 by 5.6 %. Table 5.55 shows the $Frac_{GASM}$ in source category *3.D.2.2 - Indirect emissions from Atmospheric Deposition* for the years 1990 and 2021 for all countries and EU. The $Frac_{GASM}$ decreased in ten countries and increased in four countries. It was in 2021 at the level of 1990 in twelve countries. No data were available for the Netherlands. The largest decreases occurred in Denmark and Hungary with a mean absolute value of 0.1. The three countries with the largest increases were Finland, Belgium and France with a mean absolute value of 0.008.

Table 5.55 3.D.2.2 - Indirect emissions from Atmospheric Deposition: countries' $Frac_{GASM}$ (-)

Country	1990	2021	Country	1990	2021
Austria	0.161	0.163	Ireland	0.084	0.080

Country	1990	2021	Country	1990	2021
Belgium	0.156	0.166	Italy	0.242	0.204
Bulgaria	0.200	0.200	Lithuania	0.200	0.200
Cyprus	0.200	0.200	Luxembourg	0.185	0.182
Czech Republic	0.200	0.200	Latvia	0.200	0.200
Germany	0.199	0.151	Malta	0.210	0.210
Denmark	0.182	0.087	Poland	0.200	0.200
Spain	0.218	0.202	Portugal	0.141	0.134
Estonia	0.200	0.200	Romania	0.200	0.200
Finland	0.076	0.088	Slovakia	0.200	0.200
France	0.117	0.119	Slovenia	0.221	0.201
Greece	0.200	0.200	Sweden	0.173	0.158
Croatia	0.200	0.200			
Hungary	0.142	0.097			

3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off

The implied emission factor for N_2O emissions in source category *3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off* increased in EU slightly between 1990 and 2021 by 1.6 %. Figure 5.76 shows the trend of the implied emission factor in EU indicating also the range of values used by the countries. Table 5.56 shows the implied emission factor for N_2O emissions in source category *3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off* for the years 1990 and 2021 for all countries and EU. The implied emission factor decreased in three countries and increased in four countries. It was in 2021 at the level of 1990 in twenty countries. The largest increase occurred in Portugal with an absolute value of 0.0035 kg N_2O-N/kg N.

Figure 5.76: 3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off: Trend in implied emission factor in the EU and range of values reported by countries

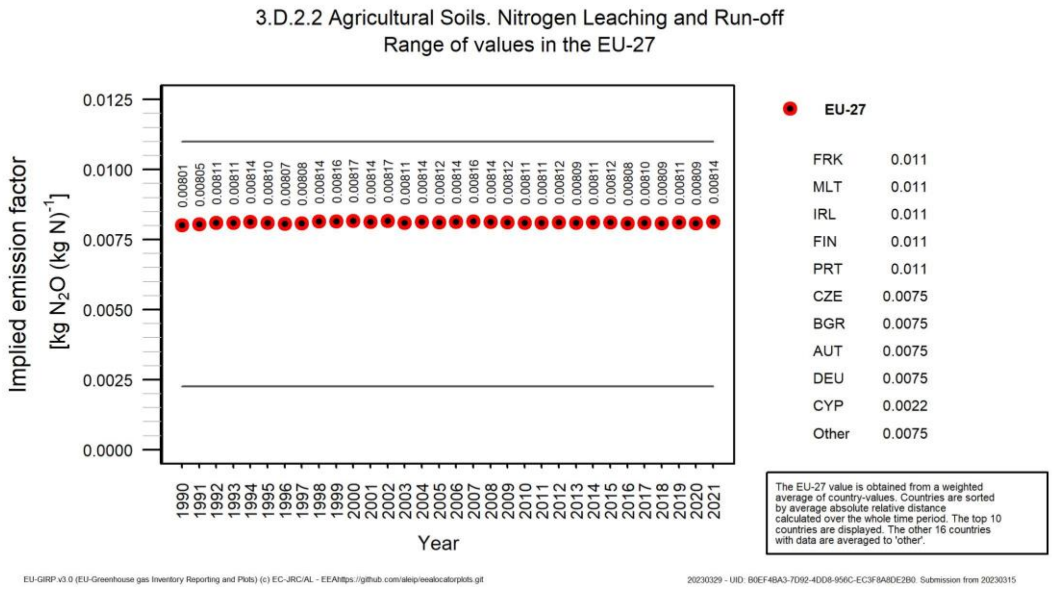


Table 5.56 3.D.2.2 - Indirect N_2O Emissions from Nitrogen leaching and run-off: countries' implied emission factor (kg N_2O-N/kg N)

Country	1990	2021	Country	1990	2021
Austria	0.0075	0.0075	Ireland	0.0110	0.0110
Belgium	0.0075	0.0075	Italy	0.0075	0.0075
Bulgaria	0.0075	0.0075	Lithuania	0.0075	0.0075
Cyprus	0.0022	0.0022	Luxembourg	0.0011	0.0011
Czech Republic	0.0075	0.0075	Latvia	0.0075	0.0075
Germany	0.0075	0.0075	Malta	0.0110	0.0110
Denmark	0.0079	0.0083	Netherlands	0.0075	0.0075
Spain	0.0075	0.0075	Poland	0.0075	0.0075
Estonia	0.0075	0.0075	Portugal	0.0075	0.0110
Finland	0.0110	0.0110	Romania	0.0075	0.0075
France	0.0110	0.0110	Slovakia	0.0075	0.0075
Greece	0.0075	0.0075	Slovenia	0.0075	0.0075
Croatia	0.0075	0.0075	Sweden	0.0075	0.0075
Hungary	0.0075	0.0075	EU	0.0080	0.0081

3.D.2.2 - Indirect emissions from Nitrogen Leaching and Run-off - $Frac_{LEACH}$

The $Frac_{LEACH}$, a parameter used for calculating N_2O emissions in source category *3.D.2.2 - Indirect emissions from Nitrogen Leaching and Run-off*, decreased in EU moderately between 1990 and 2021 by 5.2 %. Table 5.57 shows the $Frac_{LEACH}$ in source category *3.D.2.2 - Indirect emissions from Nitrogen Leaching and Run-off* for the years 1990 and 2021 for all countries and EU. $Frac_{leach}$ decreased in five countries and increased in one country. It was in 2021 at the level of 1990 in twenty countries. No data were available for Cyprus. The largest decreases occurred in Slovakia and Denmark with a mean absolute value of 0.1. There was an increase in Spain with an absolute value of 0.0065.

Table 5.57 3.D.2.2 - Indirect emissions from Nitrogen Leaching and Run-off: countries' $Frac_{LEACH}$ (-)

Country	1990	2021	Country	1990	2021
Austria	0.152	0.152	Italy	0.274	0.273
Belgium	0.300	0.300	Lithuania	0.300	0.300
Bulgaria	0.300	0.300	Luxembourg	0.240	0.240
Czech Republic	0.300	0.300	Latvia	0.230	0.230
Germany	0.300	0.300	Malta	0.240	0.240
Denmark	0.313	0.219	Netherlands	0.150	0.130
Spain	0.077	0.083	Poland	0.300	0.300
Estonia	0.300	0.300	Portugal	0.300	0.300
Finland	0.144	0.144	Romania	0.300	0.300
France	0.135	0.135	Slovakia	0.241	0.055
Greece	0.300	0.300	Slovenia	0.300	0.300
Croatia	0.300	0.300	Sweden	0.170	0.133
Hungary	0.300	0.300			
Ireland	0.100	0.100			

5.3.6 Agriculture- non-key categories

Table 5.58 shows the aggregated GHG emissions of non-key categories from source categories 3C, 3E, 3F and 3G-I by each country for the year 2021. Total CO_2 emissions is around 9818.57 kt, with the highest CO_2 emissions by Germany. CH_4 emissions from 'Rice Cultivation' is the largest by Italy (63.42kt), followed by Spain (16.74kt). Total CH_4 emissions from 'Rice Cultivation' is 97.91 kt. CH_4 emissions from 'Field burning of agricultural residues', is the largest by Romania (12.98 kt), whilst total EU is 19.55 kt. Total CH_4 EU emissions ('Rice Cultivation' and Field burning of agricultural residues') is 117.46 kt, with the highest top emitters being Italy, Spain and Romania. Total N_2O emissions for EU from 'Field burning of agricultural residues' is 0.58 kt in 2021, with Romania having the highest emissions (0.4 kt). CH_4 and N_2O emissions from 'Prescribed burning of savannas' are not reported by the countries.

Table 5.58 Aggregated GHG emissions from non-key categories in the agriculture sector

Country	2021	CO_2 (kt)	CH_4 (kt) Rice Cultivation	CH_4 (kt) Field burning of agricultural residues	N_2O (kt) Field burning of agricultural residues
AUT		149.2885	-	0.00	-
BEL		190.9257	-	-	-
BGR		58.56179	4.34	1.23	0.03
CYP		0.298833	-	0.02	0.00
CZE		321.9052	-	-	-
DEU		2588.011	-	-	-
DNM		275.6619	-	0.10	0.01
ESP		393.6262	16.53	0.73	0.02
EST		28.61782	-	-	-
FIN		201.4158	-	0.08	-
FRK		1955.517	1.53	1.00	0.03
GRC		33.49912	5.31	0.60	0.02
HRV		102.8495	-	-	-
HUN		236.2362	0.80	0.01	0.00
IRL		699.4494	-	-	-
ISL		461.2639	-	-	-
ITA		115.1873	62.70	0.57	0.01
LTU		13.61492	-	-	-
LUX		83.33453	-	-	-
LVA		83.16502	-	-	-

Country	2021	CO_2 (kt)	CH_4 (kt) Rice Cultivation	CH_4 (kt) Field burning of agricultural residues	N_2O (kt) Field burning of agricultural residues
NLD		1412.121	-	-	-
POL		31.03684	-	1.13	0.04
PRT		161.2529	6.2	0.25	0.01
ROU		69.5701	0.71	13.88	0.42
SVK		29.37002	-	-	-
SVN		122.7924	-	-	-
SWE			-	-	-
EU		9,818.573	97.91	19.55	0.58

5.4 Uncertainties

Table 5.59 shows the total EU uncertainty estimates for the sector Agriculture and the uncertainty estimates for the relevant gases of each source category. The highest-level uncertainty was estimated for N_2O from 3D and the lowest for CH_4 from sector 3A. With regard to the uncertainty on trend N_2O from sector 3J shows the highest uncertainty estimates, CH_4 from sector 3A the lowest. For a description of the Tier 1 uncertainty analysis carried out for the EU-28 see Chapter 1.6.

Table 5.59 Sector Agriculture: EU uncertainty estimates

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
3.A Enteric Fermentation	CO2	0	0	0.0%	0.0%	0.0%
3.A Enteric Fermentation	CH4	237 020	182 545	-23.0%	11.9%	1.5%
3.A Enteric Fermentation	N2O	0	0	0.0%	0.0%	0.0%
3.B Manure Mangement	CO2	0	0	0.0%	0.0%	0.0%
3.B Manure Mangement	CH4	54 426	44 772	-17.7%	18.9%	1.3%
3.B Manure Mangement	N2O	25 555	18 131	-29.1%	68.4%	11.1%
3.C Rice Cultivation	CO2	0	0	0.0%	0.0%	0.0%
3.C Rice Cultivation	CH4	2 739	2 279	-16.8%	17.6%	20.8%
3.C Rice Cultivation	N2O	0	0	0.0%	0.0%	0.0%
3.D Agricultural Soils	CO2	0	0	0.0%	0.0%	0.0%
3.D Agricultural Soils	CH4	0	0	0.0%	0.0%	0.0%
3.D Agricultural Soils	N2O	148 364	117 994	-20.5%	75.7%	7.9%
3.E Prescribed burning of savannas	CO2	0	0	0.0%	0.0%	0.0%
3.E Prescribed burning of savannas	CH4	0	0	0.0%	0.0%	0.0%
3.E Prescribed burning of savannas	N2O	0	0	0.0%	0.0%	0.0%
3.F Field Burning of Agricultural Residues	CO2	0	0	0.0%	0.0%	0.0%
3.F Field Burning of Agricultural Residues	CH4	804	527	-34.5%	48.7%	14.9%
3.F Field Burning of Agricultural Residues	N2O	226	148	-34.4%	47.6%	15.4%
3.G Liming	CO2	9 352	5 599	-40.1%	24.3%	6.3%
3.G Liming	CH4	0	0	0.0%	0.0%	0.0%
3.G Liming	N2O	0	0	0.0%	0.0%	0.0%
3.H Urea application	CO2	3 197	3 171	-0.8%	22.7%	2.7%
3.H Urea application	CH4	0	0	0.0%	0.0%	0.0%
3.H Urea application	N2O	0	0	0.0%	0.0%	0.0%
3.I Other carbon-containing fertilizers	CO2	967	623	-35.6%	15.4%	4.8%
3.I Other carbon-containing fertilizers	CH4	0	0	0.0%	0.0%	0.0%
3.I Other carbon-containing fertilizers	N2O	0	0	0.0%	0.0%	0.0%
3.J Other	CO2	0	0	0.0%	0.0%	0.0%
3.J Other	CH4	0	1 500	485379.4%	22.4%	108534.1%
3.J Other	N2O	0	227	205276.7%	97.6%	200281.6%
3 (where no subsector data were submitted)	all	1 955	914	-53.2%	35.8%	30.9%
Total - 3	**all**	**484 607**	**378 430**	**-21.9%**	**24.7%**	**2.6%**

Note: Emissions are in Gg CO_2 equivalents; trend uncertainty is presented as percentage points; the sum of the source category emissions may not be the total sector emissions of the EU-NIR because uncertainty estimates are not available for all source categories in each of this EU countries

5.5 Sector-specific quality assurance and quality control and verification

5.5.1 Introduction

This section gives an overview of the QA/QC procedures applied specifically for the agriculture sector of the EU GHG inventory. It first gives an overview of the development of the agriculture QA/QC system with an outlook of further improvements to be discussed and/or implemented in coming years. A brief description of the QA/QC procedures used to process the data and interact with the countries is given. A brief summary of selected activities that have been carried out in the past to improve and/or verify national and EU wide GHG emissions from agriculture in the frame of the EU GHG inventory system is found in the inventory report of 2020[21].

5.5.1.1 Main improvements since 2019

Since the 2019 submission, a new check has been introduced on the correlation between milk yield versus feed digestibility and nitrogen excretion rates. Several parts of the code have been revised to align with current programming libraries the system implemented in 2015 was further developed. In 2022, an analysis of the contribution of each member state to the total dairy cattle population of the EU as a driver for the CH_4 IEF for enteric fermentation from dairy cattle was added (Table 5.13), in order to address a recommendation received from the UNFCCC's expert review team (ERT). In the 2023 submission, following two recommendations received from the UNFCCC's expert review team, milk yield data from Netherlands have been included in table 5-10, and areas of histosols reported in the LULUCF and agriculture sectors comparing organic soils area have been added (table 5-47).

5.5.2 QA/QC system in the agriculture sector

5.5.2.1 Quality checks

Several quality checks are performed in the EU-GIRP[22] software. They are documented in various modules of EU-GIRP and can be examined in the open source repository. The checks include:

- **Recommendations**: Country were checked if they had implemented last years' recommendations from the ESD review and from the UNFCCC review.
- **Check on NEs**[23] and empty cells has been done by extracting all reported 'NE's from the data base.
- **Notation keys**: we identified emission categories where a country reported a notation key, while 22 or more countries reported emission estimates, in order to assess the potential over/underestimations (these also contained in NE checks and reporting of identical values as in previous submission).
- **Outliers in activity data and emissions**: Data were checked on outliers in AD and emissions. For each source category the share of AD and emissions by the countries to total EU values were determined. A share above 95 % was further assessed and in case this was not linked to a source category which is dominated by single countries (such as emissions from buffalo, which are dominated by Italy) the country was notified.
- **Check on erroneous units**: In several case, countries report background data using different units (e.g. fractions instead of percent values or vice versa; values per day instead of per year of vice versa; absolute values instead of values per head etc.). While these inconsistencies do not influence the reported emission estimates, a harmonization (at EU level) is important to ensure correct comparison of countries' values and a correct calculation of EU background data. An automated check[24] is carried out detecting *three* cases which can easily be recognised. Other 'mistakes' in units used were detected following the outlier analysis (see below). The countries were notified via the review tool and in many cases corrections have already been implemented.
- **Within-country outliers**: within-country outliers in IEFs and other parameters are detected on the basis of the distribution of the values provided[25]. We used the method based on the mean values and the standard deviation. Specifically, those values were identified as outliers which were more distant from than 1.5 time the standard deviation in the data from the mean (both in positive and negative direction). As an additional criterium, the relation to the median was used. In case the value was within 10 % of the median it was not considered as an outlier. This removed cases where a country uses a country-specific parameter while most countries use the default value.
- **Identification of potentially significant issues**: For each of the outliers identified it was determined whether or not this could be a potentially significant issue based on the criterium of a share of 0.5 % of national total GHG emissions. The 'size' of the possible over- or under-estimation was quantified comparing the reported value with an estimate using the median IEF or parameter as reported by all countries[26]. All outliers were 'manually' cross-checked and analysed. Countries were notified on the results of the analysis.
- **Time series outliers/inconsistencies**: Time series outliers were detected on the basis of the same method as also used for the within-country-outlier check. Basis for the underlying distribution of data in this case, however, was not the values reported from all countries during the whole time series, but only the data reported by the country assessed. Only growth rates larger than ±3 % could qualify as 'outliers'. However, this generated a large number of potential

outliers which require further assessment. The following types of ‘issues’ were identified, which might be linked either to an inconsistent time series or be the consequence of ‘real’ trends:

Period outphased: Relative constant trend with few years above/below the trend that ‘looks plausible’.

Trend break: Timeseries in steps, in a stair shape: a few similar values, then a jump, and the same again.

One break group trend: Regular timeseries with a different trend for a group of years, and a step when jumping from/coming back to the general trend.

Inflection point: Trend suddenly changes from a specific year from which the growth of the values changes sign.

Single outlier: One or few isolated year(s) where the value is out of the general trend

Smooth group trend change: A series of years where the trend changes compared to the rest of the time series, but without any jumps

Trend jump: There is a jump at some point in the time trend but it continues running parallel to the first section, after the jump.

Jump and shape: There is a jump at some point in the time trend and, after the jump, the trend changes shape

- **Sector-specific checks**: Several checks were performed tailored to the reporting in the sector agriculture[27,28]. First, the data are checked on consistency in reporting of activity data throughout the tables. Further, several other tests are performed:

Difference between the sum of nitrogen excreted and reported in the different manure management system (MMS) versus the total reported nitrogen excreted.

Difference between the total nitrogen excreted and the product of animal population and nitrogen excretion rate.

Difference of the sum of N handled in MMS over animal type vs. total N handled in each MMS.

Check of the reported IEF per MMS with the total N excreted and the reported emissions.

Calculation and evaluation of the IEF in category 3.B.2 by animal type and in relation to the total N excreted.

Check that the sum of manure allocated to climate regions adds up to 100 % over all MMS and climate regions.

Check that compares the Manure ‘managed’ in Pasture Range and Paddock in category 3.B.2 with AD in 3.D.1.3 (Urine and Dung Deposited by Grazing Animals). The sum of FPRP over all animal types should therefore equal the AD in category 3.D.1.3.

Comparison of the IEF in 3.D.1.3 (N_2O emissions from Urine and Dung Deposited by Grazing Animals) with default IEFs EF3_PRP_CPP for Cattle - Pigs and Poultry (0.02) and, EF3_PRP_SO for Sheep and other animals (0.01) using the shares FracPRP_CPP and FracPRP_SO of manure deposited by the two animal groups.

Comparison of the fraction of N lost in MMS (via volatilization of NH_3+NO_X) versus total managed manure. According to IPCC Table 50.22[29] most of the loss fractions are between 20% and 45% of N in managed manure and N loss ratios are identified that are higher than 45% or lower than 20%.

Comparison of the manure 'managed' and not lost as NH_3+NO_X or leaching in MMS (3B2) with Animal manure applied to soil (3D12a). Manure available for application is obtained from N managed in MMS and not lost (FracLOSSMS) according to IPCC Table 10.23[30] plus any addition of bedding material. The loss fractions in Table 10.23 include also losses of N2, which are not included in the indirect emissions-volatilisation. Therefore, FAM is expected to be smaller than N managed in MMS minus N lost as NH_3+NO_X+leaching unless bedding material has been accounted for. In case of crop residues as bedding material care has to be taken to avoid double counting.

- **Recalculation**: Countries were asked for justifications of recalculations of more than 0.5% of national total emissions (excluding LULUCF) and above or below the mean recalculations across all MS ±1.5 standard deviations.

A slight higher number of issues were identified (118 for 2023) compared to last year (63 issues were identified for 2022):

- 8 completeness issues (related to 'NE'/'empty'/'notation keys')
- 6 country-outlier issues
- 11 agricheck issues
- 39 previous recommendations (ESD and UNFCCC review)
- 27 recalculation issues
- 27 consistency issues in Annexe IX

5.5.2.2 Calculation of EU background data

EU-wide background data were calculated as weighted averages of the parameters provided by the countries, using activity data (animal numbers in category 3A and 3B and N input in category 3D) as weighting factors[31].

Care is being taken to not include in the calculation erroneous values:

- Data which had been identified as being reported with a different unit than the values reported by other countries (see above) were *converted* into the appropriate unit before calculating EU weighted averages
- Data which *obviously* wrong (very large outliers) but for which no clear correction could be identified were *eliminated* from the calculation of the EU weighted averages to avoid biases in the results. Therefore, the EU weighted averages - in some cases - could not represent 100% of EU activity data.

5.5.2.3 Compilation of the chapter agriculture for the EU-GHG inventory report

The agriculture chapter of the EU-GHG inventory report takes advantage of the data base generated by EU-GIRP. All numeric data presented in the chapter are calculated directly using the processed data as described above, thus eliminating the risk of transcription or copy errors. This does not eliminate the possibility of mistakes completely. Therefore, all values are cross-checked.

6 LULUCF (CRF SECTOR 4)

Europe is a fine-grained mosaic of different land uses that conforms a highly fragmented landscape, where almost all its lands are under more or less intensive management. This variety is well recognized as valuable in terms of biodiversity and culture but may represent a challenge when compiling a greenhouse gas (GHG) inventory.

Land use, Land-use change, and Forestry (LULUCF) covers anthropogenic GHG emissions, and CO_2 removals that result from land management practices. The impact of these practices on the carbon stock and on the quantity of non-CO_2 gases emitted depends on several factors. While certain patterns prevent the release of carbon, or enhance the carbon sink, others enhance the release of carbon stored in pools.

With more than three-quarters of the European Union (EU) territory covered by forests and agricultural lands, the EU's environmental and agricultural policies have had a paramount impact on the current landscape for many years.

In particular, over the last years, the Common Agricultural Policy and the rural development programs have stimulated less intensive agricultural practices and have implemented measures towards a more sustainable environmental management. Furthermore, with the aim of protecting ecosystems and enhancing their services, the EU environmental policies have resulted in an increase of the area under conservation and have contributed to preserves biodiversity and landscapes values.

Overall, throughout the reporting period the land use area-trends have shown a decrease of arable lands while the forests, and to a lesser extent, urban areas, have increased. This land use development is itself one of the main drivers of the final carbon balance on the LULUCF sector. However, of utmost importance is also the fact that at the EU level, wood felling continues to be less than the net annual wood increment. This management has led to a build-up of biomass over time in the forests, and to a notable annual net carbon removals by the EU forests. However, although the LULUCF sector results in a carbon sink for most of the MS, at EU level this sink is experiencing a decline since late 2000s that is mainly attributed to forest aging leading to a lower net annual increment and to the increase in harvest rates. The impact of natural disturbances plays also a key role in some cases.

6.1 Overview of the sector

Complying with relevant EU Regulations No 2018/841[47] and 2018/842[48], the LULUCF sector is a compilation of the inventories submitted by individual EU Member States (MS). Individual submissions are used as the primary source of data and information, unless otherwise specified and referenced in the text.

This chapter provides the general trends of GHG emissions and CO_2 removals from LULUCF in the EU. It provides general information on the methods used by the countries, and describes the efforts carried out to harmonize and improve the quality of the inventories. More detailed information can be found in national inventory reports (NIRs) and common reporting format (CRF) tables submitted by each EU MS.

In particular, this chapter includes: an overview of LULUCF sector and overall trends, the contribution of land use changes, the completeness of the sector in the individual inventories, the key categories analysis of the EU GHG inventory, general methodological information used to derive GHG emissions by sources and removals by sinks, the trends of net CO_2 emissions or removals, and activity data for each land use category, specific methodological information for relevant categories; as well as an overview of cross-cutting issues including uncertainties, QA/QC procedures, time series consistency, recalculations and verification.

[47] EUR-Lex - 32018R0841 - EN - EUR-Lex (europa.eu)

[48] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018R0842

6.1.1 Trends by land use categories

Within the EU GHG inventory, the LULUCF sector shows higher removals by sinks than emissions by sources, as a result the sector represents a net carbon sink.

In terms of land use categories, a net carbon sink is reported under Forest land. In addition, Harvested Wood Products also result in a net carbon sink for the EU GHG inventory. Other land use categories are net sources: Cropland is the largest source of emissions, followed by the conversion of lands to Settlements. Grasslands, along with the other categories, represent a smaller source of emissions.

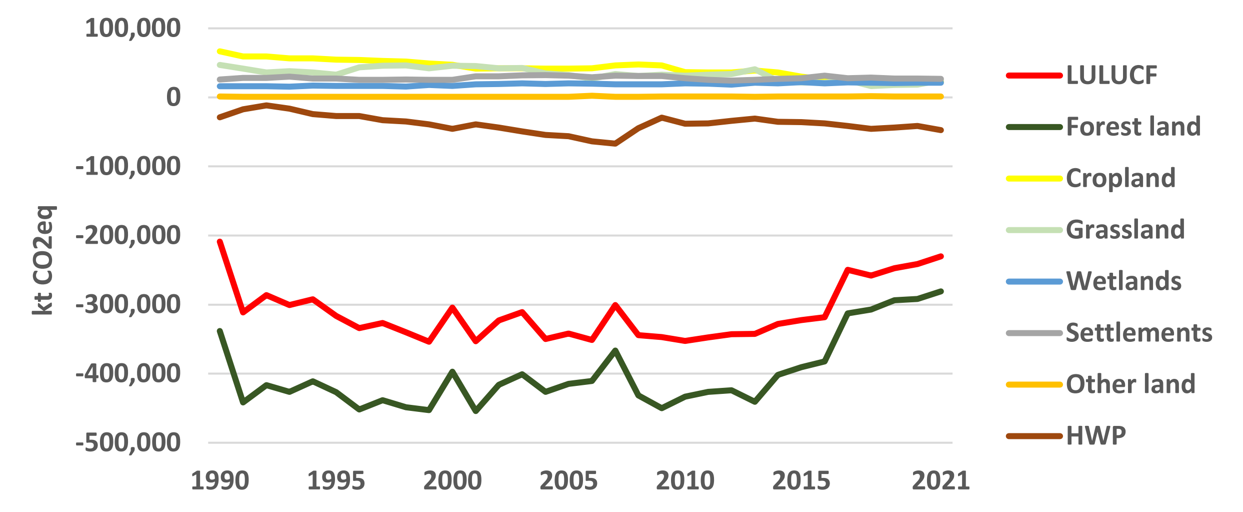
In 2021, the **LULUCF sector** of the **EU** results in a total net sink of **-253 523 kt CO_2**, which represents an increase of 8% as compared to the net sink reported for the year 1990 (Table 6. 1).

Within the LULUCF sector, the carbon pool Harvested Wood Products is in 2021 reported as a net carbon sink of -47 390 kt CO_2. On the other hand, emissions of CH_4 and N_2O in 2021 represent about 9% of annual net carbon sink.

In terms of CO_2 equivalent *LULUCF* results for the year 2021 in **-229 985 kt CO_2 equivalent**.

Moreover, France and Germany have reported GHG emissions in the CRF table 4, under the category “Other”. France reports CO_2 and CH_4 emissions from Reservoir of Petit-Saut in French Guiana, and biogenic NMVOC emissions from managed forest. In addition, Germany reports in CRF table 4 under “Other”, non-CO_2 emissions from drainage and rewetting and other management of soils under Settlements.

Figure 6.1 *Sector 4 LULUCF: EU GHG net emissions (+) / removals (-) for 1990–2021, in CO_2 eq. (kt).*



Source: EU MS submissions 2023, CRF Table10s1

The overall trend of the LULUCF sector is largely driven by the Forest Land category.

An increase of the forest carbon sink took place during the 90s mainly due to forest area expansion and to an increase of net forest increment, which has been followed by a decline resulting from a general increase in harvest rates. In the late 2000s harvest rates decreased, mainly due to the economic crisis, and the sink increased again. The last years of the time series are affected by the maturity of the forests leading to lower increment, and by higher harvest rates.

Inter-annual variations are well assumed in the emission-trend of the LULUCF sector and are mainly related to natural disturbance events. Major wind storms that took place in central-western Europe (e.g,1990, 2000, 2005, 2007 and 2009) and severe wildfires (e.g.,1990, 2003, 2005, 2007, 2016 and 2017) in Mediterranean countries are reflected in Figure 6.1. In the recent years, central Europe suffered the effects of droughts that were followed by bark beetle infestations, which required important salvage logging efforts, these events have also contributed to the trend of GHGs in this sector.

Natural disturbances also explain the sharp change in the sink observed in the base year, which result largely from the reporting of Germany. As explained by the Party, in spring 1990, Germany was impacted by a storm that caused an unprecedented number of windfalls (about 70 million m^3 of wood), and this explains the notably low LULUCF sink in 1990 for Germany that is reflected in the EU trend.

By last, other drivers of the trend of the LULUCF sector of the EU GHG inventory are (i) the economic crisis that EU economies underwent in 2008, which led to lower forest harvesting rates than usual, and is reflected as a short-time increase of the net LULUCF carbon sink, until the rates were gradually getting back to normal values in subsequent years, and (ii) in some specific years, the methods implemented by countries to derive carbon stock changes, for instance when the stock-difference method is applied.

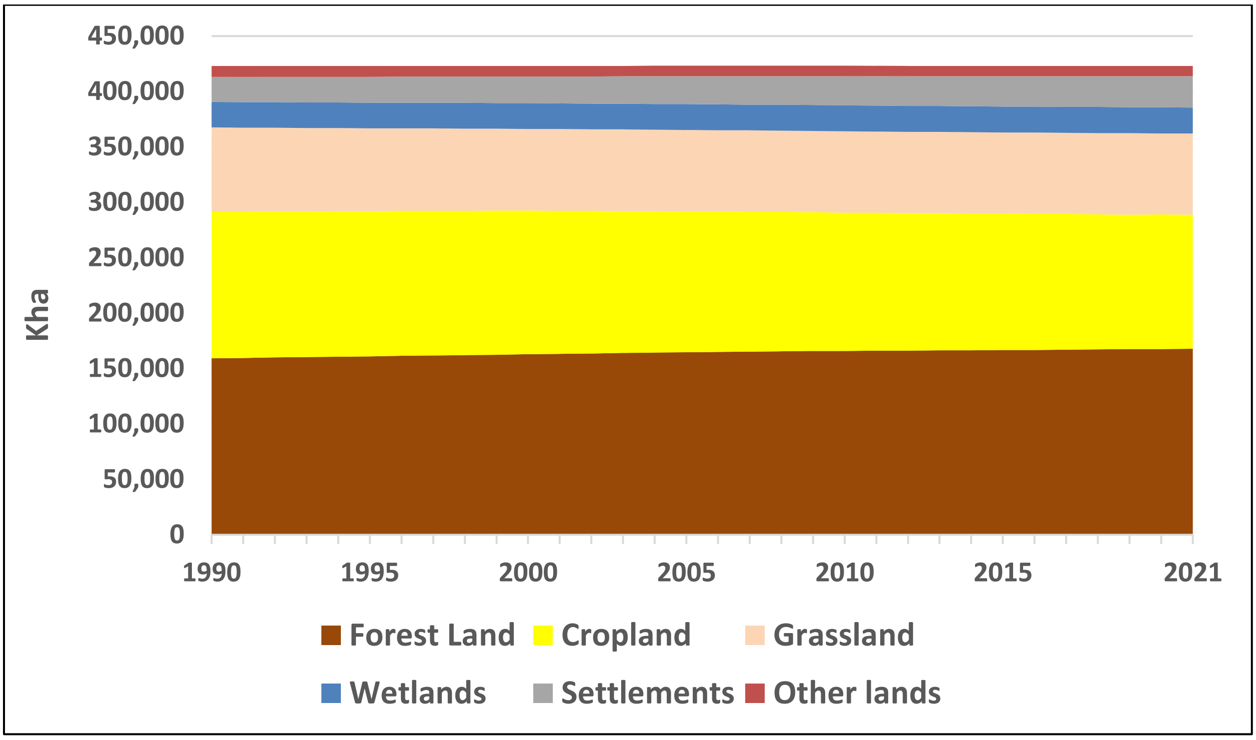
Additional category-specific information on trends and inter-annual variability is provided in the following sections of this chapter.

The total reported area in the EU GHG inventory as the sum of the different land use categories is ca. 423 000 kha. The trends on these categories (

Figure 6. *2*) are in line with the trends known from other EU statistics (e.g., Eurostat). However, absolute numbers may be slightly different due to different definitions used under each dataset.

As compared with the base year, the changes in total area reported in the current inventory for each land use category are Settlements (+25%), Croplands (-8%), Forest land (+5%), Grassland (-4%), Wetlands (1%), Other lands (-5%).

Figure 6. 2 Total area for each of the land use categories (kha), as reported by EU MS in 2023.



Although the LULUCF sector results in a net carbon sink at the level of EU, the sector is reported by countries ranging from a net source to a large net sink. Compared to 1990, individual inventories report this year in some cases a significant increase in the carbon sink, while in other cases there is a substantial reduction. Changes are mainly driven by forest harvest rates and the impact of natural disturbances. More detailed information on drivers of the trend for specific categories is provided in the relevant sections for each land use category of this chapter.

Table 6. 1 **Sector 4 LULUCF: individual contributions to net CO_2 removals (CRF table 4)**

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	-12 347	-5 364	-10 541	4.2%	1 807	15%	-5 177	-97%
Belgium	-2 942	-439	-428	0.2%	2 515	85%	11	3%
Bulgaria	-16 665	-9 659	-9 593	3.8%	7 073	42%	66	1%
Croatia	-6 357	-5 841	-5 924	2.3%	433	7%	-83	-1%
Cyprus	-153	-300	-245	0.1%	-92	-60%	56	19%
Czechia	-8 682	11 214	8 342	-3.3%	17 024	196%	-2 872	-26%
Denmark	6 540	2 773	2 089	-0.8%	-4 451	-68%	-684	-25%
Estonia	-4 007	2 162	2 535	-1.0%	6 542	163%	374	17%
Finland	-28 999	-11 763	-2 149	0.8%	26 850	93%	9 614	82%
France	-20 502	-23 784	-19 256	7.6%	1 247	6%	4 528	19%
Germany	28 760	-3 511	-3 733	1.5%	-32 493	-113%	-222	-6%
Greece	-2 324	-5 451	-5 654	2.2%	-3 330	-143%	-202	-4%
Hungary	-3 417	-7 152	-7 241	2.9%	-3 824	-112%	-89	-1%
Ireland	5 311	6 006	6 279	-2.5%	968	18%	273	5%
Italy	-5 690	-33 381	-28 924	11.4%	-23 233	-408%	4 457	13%
Latvia	-13 399	-606	956	-0.4%	14 355	107%	1 562	258%
Lithuania	-5 464	-6 771	-6 238	2.5%	-774	-14%	533	8%
Luxembourg	-1	-456	-614	0.2%	-613	-53181%	-158	-35%
Malta	-8	8	0	0.0%	8	101%	-8	-99%
Netherlands	5 833	3 816	3 985	-1.6%	-1 847	-32%	169	4%
Poland	-30 168	-20 784	-21 845	8.6%	8 323	28%	-1 061	-5%
Portugal	5 705	-5 412	-6 875	2.7%	-12 580	-220%	-1 462	-27%
Romania	-28 800	-50 486	-49 330	19.5%	-20 530	-71%	1 156	2%
Slovakia	-9 464	-7 760	-7 710	3.0%	1 754	19%	50	1%
Slovenia	-4 464	-3 181	-3 142	1.2%	1 322	30%	38	1%
Spain	-34 731	-44 410	-44 982	17.7%	-10 251	-30%	-572	-1%
Sweden	-47 968	-42 845	-43 290	17.1%	4 678	10%	-445	-1%
EU-27	**-234 403**	**-263 376**	**-253 523**	**100%**	**-19 120**	**-8%**	**9 853**	**4%**

At the EU level, the LULUCF sector offsets about 7% of the total emissions from other sectors ("Total without LULUCF"), with significant differences among MS (Table 6. 2, column a).

Forest Land category is the main driver in the LULUCF sector, offsetting itself on average about 9% of total emissions from other sectors. This year, the category resulted (in terms of CO_2 equivalent) a net sink for all MS with the exception of Czechia and Estonia (Table 6. 2, column b). The most significant contributors to the total net sink reported for the EU under the category 4A are Germany, France, Sweden, Italy, Romania and Spain (Table 6. 2, column c).

Table 6. 2 Sector 4 LULUCF: Contribution of Sector 4 (column a) and category 4A -Total Forest land - (column b) to total EU GHG inventory emissions without LULUCF (CO_2 eq); and individual contribution to total EU-27 category 4A (column c).

Country	**LULUCF over total inventory excluding LULUCF**	**Category 4A over total inventory excluding LULUCF**	**Individual contribution to total EU-27 category 4A**
	(a)	***(b)***	***(c)***
Austria	-13,4%	-13,4%	3,7%
Belgium	-0,3%	-1,8%	0,7%
Bulgaria	-17,0%	-15,1%	2,9%
Croatia	-23,7%	-23,8%	2,1%
Cyprus	-2,7%	-1,3%	0,0%
Czechia	7,1%	9,3%	-3,9%
Denmark	5,5%	-6,7%	1,0%
Estonia	22,9%	11,1%	-0,5%
Finland	1,0%	-17,4%	3,0%
France	-4,1%	-6,7%	9,9%
Germany	0,5%	-5,4%	14,8%
Greece	-7,1%	-2,8%	0,8%
Hungary	-11,2%	-10,4%	2,4%
Ireland	11,8%	-1,4%	0,3%
Italy	-6,6%	-6,6%	9,9%
Latvia	22,3%	-7,1%	0,3%
Lithuania	-30,1%	-32,0%	2,3%
Luxembourg	-6,4%	-6,9%	0,2%
Malta	0,0%	0,0%	0,0%
Netherlands	2,6%	-1,2%	0,7%
Poland	-5,0%	-5,5%	7,9%
Portugal	-10,7%	-4,0%	0,8%
Romania	-42,7%	-25,2%	10,4%
Slovakia	-18,6%	-15,3%	2,2%
Slovenia	-19,3%	-18,3%	1,0%
Spain	-15,4%	-13,8%	14,2%
Sweden	-87,2%	-76,0%	12,9%
EU	-6,6%	-8,1%	100,0%

Source: EU MS submissions 2023, CRF Table10s1

6.1.2 Contribution of land use changes

The conversion of lands in the territory of the EU MS results in net removal of -13 400 kt CO_2 equivalent (Table 6. 3).

Land use changes represent 9% of the total reported land area. The emissions resulting from conversions to Cropland, Wetlands, Settlements and Other in this year is by far counterbalanced by removals from conversions to land Forest Land and Grassland.

Table 6. 3 Contribution of land use changes in 2021 for EU MS, in terms of area (columns a-b) and net CO_2eq. (Columns c-d) (As aggregation of data from CRF Table 4.)

Land use conversions	(a) land area (Kha)	(b) Area % of the corresponding category[1]	(c) Emissions (+) and removals (-) (Kt CO_2eq.)	(d) Net emissions % of the corresponding category[1,2]
4A2. Land converted to Forest Land	7 375	4%	-41 807	14%
4B2. Land converted to Cropland	10 428	9%	14 432	75%
4C2. Land converted to Grassland	14 706	20%	-13 576	30%
4D2. Land converted to Wetlands	845	4%	3 437	25%
4E2. Land converted to Settlements	5 120	18%	23 007	96%
4F2. Land converted to Other Land	247	3%	1 106	100%
Total land use changes	38 720	9%	-13 400	25%

[1] The corresponding category is 4A (4.A1 + 4.A2 for Forest land) for 4A2, 4B (4.B1 + 4.B2 for Cropland) for 4B2, etc.

[2] The contribution of emissions from land use changes to the total of each category was obtained by considering separately the absolute values of each subcategory, i.e. (abs 4A2)/(abs 4A1+ abs 4A2) x 100.

On average for this year, from total area under conversion, 38% is reported as converted to Grassland, 27% as converted to Cropland, 19% as converted to Forest land, 13% as converted to Settlements, 2% as converted to Wetlands, and 1% as converted to Other lands.

6.1.3 Completeness of the sector

Table 6. 4 shows the current status of reporting in terms of quantitative estimates for each of the land use sub-categories. Information is taken from the individual inventories submitted this year.

This table, along with Table 6. 5, aims to provide an overview of the completeness status. Empty cells should not be unequivocally associated with an incomplete reporting because in many cases the carbon stock changes are assumed in balance, in line with the 2006 IPCC guidelines, or no methods exist for their estimation (in these cases, such pools are marked in grey in table 6.4 and 6.5 to facilitate the assessment of the completeness).

It should also be noted that the tables provide information for the main sub-categories “remaining” and “land converted to”. Under the subcategories “land converted to” there are a wide range of methods and status of completeness. For instance, certain carbon pool can be a source in forest converted to grassland, and a sink in cropland converted to grassland. This large variety cannot be displayed given the length that would be required for the tables. However, more information is provided, with a different format, in other sections of this chapter, such as the tables providing information on implied emission factors. Moreover, it is pertinent to highlight here that more detailed explanations can be found in the individual inventories submitted by countries.

For the three main land use categories, Forest Land, Cropland and Grassland, including their sub-categories, the reporting is mostly complete, and quantitative estimates are reported. However, under certain subcategories of other land uses, there are still some gaps that are largely associated with the lack of IPCC methods for estimating GHG emissions (e.g., Flooded land remaining flooded land, under Wetlands), the assumption of equilibrium under Tier 1 methods (e.g., Dead organic matter in Cropland), or the implementation of the *insignificance* provision in accordance with the Decision 24 CP/19 (e.g., for living woody biomass under Grassland remaining Grassland). Finally, in many cases the lack of quantitative estimates is also associated with an actual absence of lands being converted to certain subcategories or the absence of organic soils under certain land uses.

Thus, any judgement on completeness would require a comprehensive case by case assessment. In this inventory, it is not possible to include such a detailed set of information, and therefore we refer to the country-specific information of the individual GHG inventories.

Table 6. 4 Sector 4 LULUCF: Coverage of CO_2 emissions and removals for each of the LULUCF sub-categories for the inventory year, as derived from individual 2023 GHGI submissions.

Country	Reporting category												
	Forest land		Cropland		Grassland		Wetland		Settlements		Other land		HWP
	4. A.1. F-F	4. A.2. L-F	4. B.1. C-C	4. B.2. L-C	4. C.1. G-G	4. C.2. L-G	4. D.1. W-W	4. D.2. L-W	4. E.1. S-S	4. E.2. L-S	4. F.1. O-O	5. F.2. L-O	
Austria	R	R	E	E	E	E		E		E		E	R
Belgium	R	R	E	E	E	E		R		E			E
Bulgaria	R	R	R	E	E	R		E		E			R
Croatia	R	R	E	E	E	R		E		E			R
Cyprus	E	R	R	E	R	E		E		E			E
Czechia	R	R	R	E	R	R		E		E			R
Denmark	R	R	E	E	E	E	E	E		E			R
Estonia	R	R	E	E	E	R	E	E		E		E	R
Finland	R	R	E	E	E	E	E	E		E			R
France	R	R	R	E	R	R	E	E	R	E		E	R
Germany	R	E	E	E	E	R	E	E	E	E			R
Greece	R		R	E	E	R		E		E		E	R
Hungary	R	R	R	E	R	E		R		E			R
Ireland	E	R	R		E	E	E	E		E		E	R
Italy	R	R	R	E	R	R		E		E			R
Latvia	R	R	E	E	E	E	E	E	R	E			R
Lithuania	R	R	R	E		R	E			E		E	R
Luxembourg	R	R	E	E		R		E		E		E	R
Malta	R	R	R	R		R	R			E		E	
Netherlands	R	R	E	E	E	R		R	E	E		E	E
Poland	R	R	E	E	E	R	E	E	R	E			R

Country	Reporting category												
	Forest land		Cropland		Grassland		Wetland		Settlements		Other land		HWP
	4. A.1. F-F	4. A.2. L-F	4. B.1. C-C	4. B.2. L-C	4. C.1. G-G	4. C.2. L-G	4. D.1. W-W	4. D.2. L-W	4. E.1. S-S	4. E.2. L-S	4. F.1. O-O	5. F.2. L-O	
Portugal	R	R	R	E	R	R	E	E		E			R
Romania	R	R	R	R	R	R		R		E		R	R
Slovakia	R	R	R	E		R				E		E	R
Slovenia	R	R	E	E	R	E		E	R	E		E	R
Spain	R	R	R	E	R	R	E	R		E		E	R
Sweden	R	R	E	E	R	E	E		R	E		E	R

R = Carbon stock changes in the pool result in net Removals.
E = Carbon stocks change in the pool results in net Emissions.
Empty cells = Quantitative estimates were included elsewhere, or no quantitative estimates are provided in line with Tier 1 assumption, the provision of insignificance, because no land use changes took place, or due to the lack of IPCC methods.

Overall, the reporting of Wetlands, Settlements and Other lands categories is associated with lower Tier methods, in comparison to the main land use categories. This is especially the case when looking at their subcategories “land remaining in”. On the contrary, carbon stock changes are typically estimated and reported for land use changes involving such categories.

Table 6. 5 shows with more detail the completeness of the reporting on carbon stock changes by carbon pools, for the three most important land use categories as reported this year in individual submissions. Compared to the previous years, several MS have increased the number of carbon pools estimated and reported.

As for table 6. 4, empty cells in table 6. 5 represent carbon pools which are not reported with quantitative estimates (e.g., based on the Tier 1 assumptions, demonstrating the insignificance of the resulting carbon stock changes, because of the lack of 2006 IPCC methods, because of the absence of organic soils, or because the pool is included elsewhere).

Table 6. 5 **Sector 4 LULUCF: Quantitative estimates of carbon stock changes on carbon pools for the most important land use subcategories for the current inventory year.**

COUNTRY	Reporting category																									
	Forest land										Cropland								Grassland							
	4.A.1. F-F					4.A.2. L-F					4.B.1. C-C				4.B.2. L-C				4.C.1. G-G				4.C.2. L-G			
	LB	DW	LT	SOC min	SOC org	LB	DW	LT	SOC min	SOC org	LB	DOM	SOC min	SOC org	LB	DOM	SOC min	SOC org	LB	DOM	SOC min	SOC org	LB	DOM	SOC min	SOC org
AUT	R	R	E	R		R	R	R	R		E		E		E	E	E				R	E	E	E	R	
BEL	R					R	R	R	R		R		E	E	E	E	E				E	E	E	E	R	
BGR	R	R				R	R	R	E		E		R	E	E		E		R		E	E	R		R	
HRV	R					R	R	R	E		R		E	E	R		E					E	E		R	
CYP	R					R	R	R	R		R		R		E	E	E		R				E	E	R	
CZE	E	R	R	R		R	R	R	R		R		R		E	E	E				R		R	E	R	
DNM	R	R	R		E	R	R	R	R	E	E		R	E	E	E	E		E			E	E	E	R	E
EST	E	R		R	E	R	R	R	R	E	E		R	E	E	E	E	E				E	E	E	R	E
FIN	R			R	E	R			R	E	R		E	E	E	E	E	E	R			E	E		R	E
FRA	R	E	R	R		R	E	R	R		E	R	R		E	E	E		E	E	R		E	E	R	
DEU	R	R		R	E	E	R	E	R	E	E		E	E	E	E	E	E	E		R	E	R	E	R	E
GRC	R										R		R	E	E	E	E		E				E	E	R	
HUN	R	R			E	R	R	R	R		E		R		E	E	E				R		E	E	R	
IRL	E	R	R	E	E	R	R	R	E	E	R		R								R	E			E	E
ITA	R	R	R			R	R	R	R		E		R	E			E		R	R	R	R	R		R	
LVA	R	R			E	R	R	R		E	R	E		E	E	E	E	E	E	R		E	E	E		E
LTU	R	R				R	R	R	R		E		R		E	E	E						R	R	R	
LUX	R	R				R	R	R	R		E		R		E	E	E						R	E	R	
MLT	R					R		R			R		E		R		R						R		E	
NLD	R	R	R		E	R	R	R	E	E			E	E	E	E	E	E	R		R	E	R	E	R	E
POL	R	R		R	E	R	R		R	E	R		E	E			E	E			R	E	R		R	E
PRT	R		E	E		R		R	R		R		R		R	E	E		R	R	R		R	E	R	
ROU	R	R	R	R	E	R	R	R	R		R		R	E	R	E	R		R		R	E	E	E	R	

COUNTRY	Reporting category																									
	Forest land										Cropland								Grassland							
	4.A.1. F-F					4.A.2. L-F					4.B.1. C-C				4.B.2. L-C				4.C.1. G-G				4.C.2. L-G			
	LB	DW	LT	SOC min	SOC org	LB	DW	LT	SOC min	SOC org	LB	DOM	SOC min	SOC org	LB	DOM	SOC min	SOC org	LB	DOM	SOC min	SOC org	LB	DOM	SOC min	SOC org
SVK	R	R				R	R	R	R		R		R		E		E						E	E	R	
SLV	R	R				R	R	R	R		E	E	R	E	E	R	E		R	R	E		E	E	R	
ESP	R					R	R	R	R		R		R		E	E	E				R		E	R	R	
SWE	R	R	E	R	E	R	R	E	R	E	R	R	R	E	R	E	E	E	R	R	R	E	E	E	R	E

Pools: DW-Dead Wood, LT- Litter, LB – Living Biomass, SOCmin – Soil Organic Carbon in mineral soils, SOCorg – Soil Organic Carbon in organic soils.
R: net Removal;
E: net Emission;
Empty cells: Quantitative estimates were included elsewhere, or no quantitative estimates are provided in line with Tier 1 assumption (grey cells indicate carbon pools for which the IPCC tier 1 methods assume the net carbon stock changes in equilibrium), the provision of insignificance, or because the pool is not present (i.e., absence of organic soils under certain land use categories). Only in a few cases the lack of quantitative estimates could be associated with incompleteness. See more details in following sections.

Source: EU MS submissions 2023, CRF tables 4A-4C

6.1.4 Data and methods

This section provides an overview of the information on methods and data used by the EU MS for reporting on emissions by sources and removals by sinks from the three main land use categories. More detailed information regarding methodological issues is included as an annex to this report, and a complete description can be found in individual national inventory reports, which are considered also part of this submission.

Given the heterogeneity among countries in terms of ecological and socio-economic conditions, there is no common definition of land use categories. Methods used to estimate GHG emissions and CO_2 removals from the LULUCF sector also differ among countries and land use categories. The underlying assumption of the EU GHG inventory is that the implementation of country-specific definitions and methods that reflect and capture specific national circumstances (as long as they are in accordance with IPCC guidelines) is likely to result in more accurate estimates than the implementation of a single EU wide approach.

Table 6. 6 is a summary of relevant information on methodologies applied for each individual carbon pool under the three main land use categories of the LULUCF sector as included in individual GHG inventories.

Usually, for reporting carbon stock changes in "lands remaining in the same category", a single data source is used, which facilitate the categorization of the methodologies under a single Tier method. By contrast, multiple data sources are often used to derive emissions from “land converted to” which prevents an easy categorization of the methods under a single Tier. For instance, for estimating carbon stock changes in living biomass from forest land converted to cropland, MS may implement country-specific values for forest land and default factors for cropland.

Furthermore, because the categorization of methods under a single tier for “land converted to” depends also on the categories involved in the conversion (e.g., different approaches and data sources are often used for forest converted to grassland compared to those used for cropland converted to grassland), Table 6. 6 shows a summary of the main information on methods and carbon stock change factors used by individual inventories.

Finally, because of different underlying methods applied by each country, and due to their own national circumstances, the comparison of absolute levels, or trends, of emissions across them should be done carefully to avoid erroneous interpretations. Indeed, in some cases, large differences may be attributable to the different estimating methodologies. For example, (i) the gain-loss and stock-difference methods may lead to different trends in the short term, or (ii) the resulting implied carbon stock change factors may be significantly affected by new areas entering in a given category, or the inclusion of areas subjects to different management practices.

Table 6. 6 Summary of methods and carbon stock change factors used by the EU MS to calculate CO_2 emissions and removals of different carbon pools in the LULUCF sector, as reported in this year GHGI submissions.

COUNTRY	Forest land								Cropland								Grassland							
	FL-FL				L-FL				CL-CL				L-CL				GL-GL				L-GL			
	LB	DOM (1)	SOC Min	SOC Org (2)	LB	DOM	SOC Min	SOC Org (2)	LB (3)	DOM	SOC Min (4)	SOC Org (2)	LB (5)	DOM	SOC Min	SOC Org (2)	LB	DOM	SOC Min (4)	SOC Org (2)	LB	DOM	SOC Min	SOC Org (2)
AT	CS	CS,CS	CS	NO	CS	CS	CS	NO	CS	D	CS	NO	CS,CS	CS	CS	NO	D	D	CS	CS	CS	CS	CS	NO
BE	CS	CS,CS	D	NO	CS	D	CS	NO	CS	D	CS	D	CS,NO	CS	CS	NO	D	D	CS	D	CS	CS	CS	NO
BG	CS	D,D	D	NO	CS	CS	CS	NO	D	D	CS	NO	CS,CS	NO	CS	NO	D	D	NO	NO	CS	NO	CS	NO
CY	D	D,D	D	NO	CS	CS	CS	NO	D	NE	NE	NE	CS, D	NE	CS	NE	D	NE	NE	NE	CS	CS	CS	NE
CZ	CS	D,D	D	NO	CS	D	CS	NO	D	D	CS,D	NO	CS,D	CS	CS	NO	D	D	CS,D	NO	CS	CS	CS	NO
DE	CS	CS,CS	CS	CS	CS	CS	CS	CS	NO	D	NO	CS	CS,CS	CS	CS	CS	CS	D	CS	CS	CS	CS	CS	CS
DK	CS	CS,CS	D	CS	CS	CS	CS	CS	CS	D	CS	CS	CS,CS	CS	CS	CS	CS	D	NO	CS	CS	CS	CS	CS
EE	CS	CS,D	CS	CS	CS	CS	CS	CS	CS	D	CS,D	D	CS,CS	CS	CS	CS	CS	CS	CS,D	CS	CS	CS	CS	CS
ES	CS	D,D	D	NO	CS	CS	CS	NO	CS	D	CS,D	NO	CS,CS	CS	CS	NO	D	D	NE	NO	CS	CS	CS	NO
FI	CS	CS,CS	CS	CS	CS	CS	CS	CS	CS	D	CS	CS	CS,CS	CS	CS	CS	CS	D	NO	CS	CS	CS	CS	CS
FR	CS	CS,D	D	NO	CS	CS	CS	NO	CS	CS	CS	CS	CS	CS	CS	CS	D	D	NO	NO	CS	CS	CS	CS
GR	CS	D,D	D	NO	CS	D	NO	NO	CS	D	NE	D	CS,CS	CS	CS	NO	D	D	NO	NO	NO	NO	CS	NO
HR	CS	D,D	D	NO	CS	D	CS	NO	D	D	CS,D	CS	CS,CS	NO	CS	NO	D	D	NO	CS	CS	NO	CS	NO
HU	CS	D,D	D	CS	CS	CS	CS	NO	CS	D	CD,D	NO	CS,D	CS	CS	NO	D	D	CS,D	NO	CS	CS	CS	NO
IE	CS	CS,CS	D	CS	CS	CS	NO	CS	CS	D	CS,D	NO	NO,NO	NO	NO	NO	D	D	CS,D	CS	CS	CS	NO	CS
IT	CS	CS,CS	D	NO	CS	CS	CS	NO	CS	NO	NO	D	NO,D	NO	CS	NO	CS	CS	NO	NO	CS	NO	CS	NO
LT	CS	CS,D	D	D	CS	D	NO	D	D	D	CS,D	D	NO,CS	D	CS	D	NO	NO	NO	D	NO	NO	CS	D
LU	CS	D,D	D	NO	CS	D	CS	NO	CS	D	CS,D	NO	CS,CS	CS	CS	NO	D	D	NO	NO	CS	CS	CS	NO
LV	CS	CS,D	D	D	CS	CS	NO	CS	CS	CS	NO	D	NO,NO	NO	CS	D	CS	CS	NO	D	NO	NO	CS	D
MT	CS	D,D	D	NO	NO	NO	NO	NO	D	D	NO	NO	NO,NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NL	CS	CS,D	D	NE	CS	D	CS	CS	NE	D	NO	CS	CS,CS	CS	CS	CS	D	D	NO	CS	CS	CS	CS	CS

COUNTRY	Forest land								Cropland								Grassland							
	FL-FL				L-FL				CL-CL				L-CL				GL-GL				L-GL			
	LB	DOM (1)	SOC Min	SOC Org (2)	LB	DOM	SOC Min	SOC Org (2)	LB (3)	DOM	SOC Min (4)	SOC Org (2)	LB (5)	DOM	SOC Min	SOC Org (2)	LB	DOM	SOC Min (4)	SOC Org (2)	LB	DOM	SOC Min	SOC Org (2)
PL	CS	D,D	D	D	CS	D	D	D	D	D	D,D	D	NO	NO	D	NO	D	D	D,D	D	CS	NO	D	NO
PT	CS	CS,CS	CS	NO	CS	CS	CS	NO	CS	D	CS	NO	CS,CS	CS	CS	NO	D	D	CS	NO	CS	CS	CS	NO
RO	CS	CS,CS	CS	D	CS	CS	CS	NO	CS	CS	CS	CS	CS,CS	CS	CS	NO	CS	D	NO	D	CS	CS	CS	NO
SE	CS	CS,CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS,CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
SK	CS	D,D	D	NO	CS	CS	CS	NO	D	D	CS,D	NO	CS,CS,	CS	CS	NO	D	D	NO	NO	CS	CS	CS	NO
SV	CS	CS,D	D	NO	CS	D	CS	NO	D	D	CS,D	D	CS,CS	CS	CS	NO	D	D	NO	NO	CS	CS	CS	NO

Source: submissions 2023, CRF table 4A-4C

(D: default; CS: country-specific; NA: not applicable; NE: not estimated; NO: not occurring). Grey field means that for these carbon pools IPCC TIER 1 allows to assume no net change in C stock.

"CS" country-specific data associated either with IPCC method tier 2 or country-specific method tier 3 if data are highly disaggregated or derived using models. Note that sometimes not all parameters involved in the estimation are truly "CS" (e.g., root/shoot ratio and BEF are often taken from IPCC guidelines). However, it is expected that if "CS" is reported in table 6.6, the most important parameters are truly "CS."

"D" means that the default IPCC emission factors are used in the estimation. D is typically associated with IPCC default method (tier 1).

"NE" means either country assumes insignificant emission/removal or not enough data is available for the estimation.

"NO" means emissions or removals "not occurring" in a country (it includes also "NA" - not applicable)

(1) For DOM under "FL r FL" the two notation keys separated by a comma mean: dead wood and litter respectively.

(2) For SOCorg any notation key used under carbon stock changes, if areas of organic soils are reported, should, in principle, be seen as NE. D refers to the use of IPCC default emissions factors

(3) For LB carbon stock change in CL-CL, estimates generally refer only to perennial woody crops. Biomass of annual crops is generally assumed in balance.

(4) For SOCmin on CL and GL, the two notation keys separated by a comma mean that the country uses IPCC default method (which is tier 1 if associated with D data or tier 2 if associated with CS data). In this case, the first notation key refers to "reference C stock", and second to "C stock change factors" (see 2006 IPCC GL for details). A cell with a single "CS" indicates a country-specific method and data (i.e. tier 3 if data are highly disaggregated)

(5) For LB under L – CL, "conversion to cropland", the two notation keys used mean: the first one refers to FL-CL and the second one to GL-CL.

6.1.5 Key categories

The following LULUCF subcategories of the EU GHG inventory were identified to be key categories (Table 6. 7) for the trend (T) and the level assessment (L).

Table 6. 7 Key category analysis for the EU (LULUCF sector excerpt)

Source category gas	kt CO_2 eq.		Trend	Level	
	1990	2021		1990	2021
4.A.1 Forest Land: Land Use (CO_2)	-299886	-247793	T	L	L
4.A.2 Forest Land: Land Use (CO_2)	-47685	-41715	T	L	L
4.B.1 Cropland: Land Use (CO_2)	28487	5018	T	L	L
4.B.2 Cropland: Land Use (CO_2)	33463	14450	T	L	L
4.C.1 Grassland: Land Use (CO_2)	50918	34688	0	L	L
4.C.2 Grassland: Land Use (CO_2)	-8560	-13438	0	L	L
4.D Wetlands: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CH_4)	5481	5962	0	0	L
4.D.1 Wetlands: Land Use (CO_2)	8320	10217	T	L	L
4.D.2 Wetlands: Land Use (CO_2)	1004	3437	T	0	0
4.E.2 Settlements: Land Use (CO_2)	21635	23007	T	L	L
4.G Harvested Wood Products: Wood product (CO_2)	-28666	-47390	T	L	L

6.2 Categories and methodological issues

6.2.1 Forest land (CRF 4A)

6.2.1.1 Overview of the Forest land category

Forest land category is by large the main driver in the LULUCF sector. In terms of area, it represents about 40% of the entire territory. Based on individual submissions reported this year, total forest area reached 167 846 kha in 2021, which represents an increase of 5% as compared with 1990.

About 4% of the total forest area is represented by lands under conversion to forest land. This trend of increasing forest land area, which is also reflected in different official statistics of the EU, is a result of the expansion of forests due to less grazing pressure and the abandonment of agricultural activities, which promote natural forest expansion. But an important driver behind the forest area increase has been also the promotion of national afforestation programs, including grant-aid.

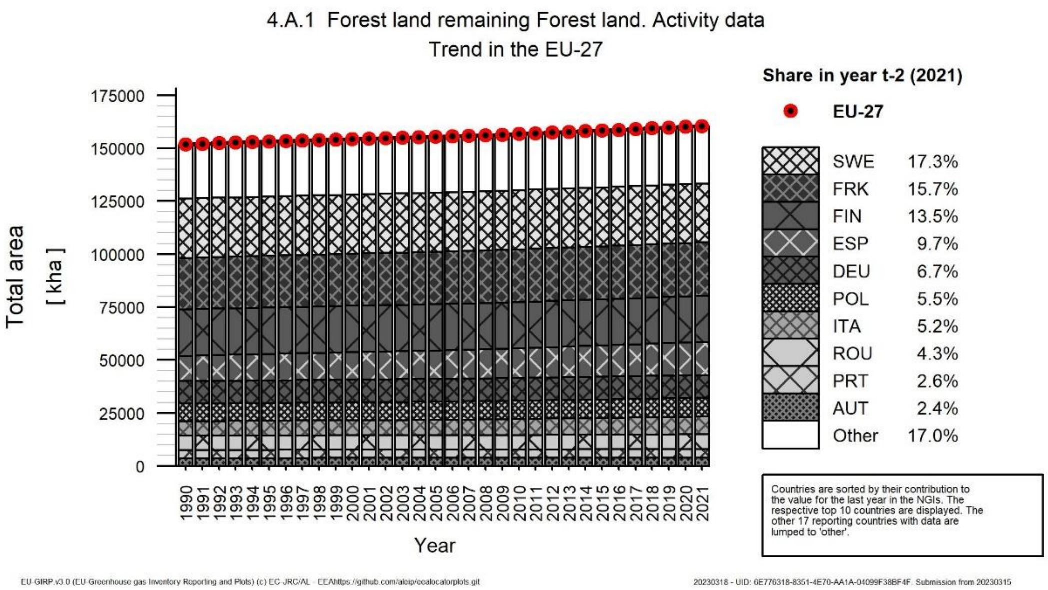
The largest forest areas are reported by Sweden, France and Finland, which together report about 46% of the total forest area at EU level (Figure 6.3). Deforestation does not appear to be a major issue in Europe. Moreover, the absolute area under conversion from forest is by far compensated by new afforested areas and natural forest expansion.

6.2.1.2 Forest Land remaining Forest Land (CRF 4A1)

Overview of Forest Land remaining Forest Land category

As with the main category, the area of Forest Land remaining Forest Land reported for the inventory year increased by 6% as compared with 1990. However, at the level of individual submissions there are significant differences. For instance, Spain reports an increase of about 30%, while Malta reports a decrease of 6% in forest area in 2021 compared to the year 1990.

Figure 6. 3 Trend of activity data in subcategory 4A1 "Forest land remaining Forest Land" in EU-27



For this inventory year, the total land area reported under the sub-category 4.A1 by EU MS reached 160 472 kha, out of which about 83% is attributed to the 10 MS with the higher contribution.

In terms of GHG emissions the category 4.A1 resulted in a net sink of -247 793 kt CO_2, decreasing by 17% as compared to 1990. The largest contributors are Germany, Sweden, and Romania (Table 6. 8).

Table 6. 8 **4A1 Forest Land remaining Forest Land: EU-27 contributions to net CO_2 emissions (+)/removals (-) (CRF table 4)**

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	-8 122	-5 493	-8 938	3.6%	-817	-10%	-3 445	-63%
Belgium	-1 903	-1 697	-1 699	0.7%	205	11%	-2	0%
Bulgaria	-13 584	-8 191	-8 203	3.3%	5 381	40%	-13	0%
Croatia	-6 430	-5 580	-5 572	2.2%	857	13%	8	0%
Cyprus	2	-162	-104	0.0%	-106	-6800%	58	36%
Czechia	-7 072	14 769	11 570	-4.7%	18 642	264%	-3 199	-22%
Denmark	-224	-1 024	-1 793	0.7%	-1 569	-701%	-770	-75%
Estonia	-4 760	1 397	1 407	-0.6%	6 167	130%	10	1%
Finland	-34 669	-22 748	-10 595	4.3%	24 074	69%	12 154	53%
France	-22 365	-22 037	-18 094	7.3%	4 272	19%	3 943	18%
Germany	-18 470	-39 255	-42 024	17.0%	-23 554	-128%	-2 769	-7%
Greece	-1 289	-2 200	-2 346	0.9%	-1 057	-82%	-146	-7%
Hungary	-3 021	-5 470	-5 526	2.2%	-2 505	-83%	-56	-1%
Ireland	-2 403	1 131	1 694	-0.7%	4 097	171%	563	50%
Italy	-15 002	-25 243	-23 893	9.6%	-8 891	-59%	1 351	5%
Latvia	-17 548	-3 341	-1 512	0.6%	16 036	91%	1 829	55%
Lithuania	-7 365	-6 592	-5 710	2.3%	1 654	22%	882	13%
Luxembourg	-10	-479	-634	0.3%	-624	-6174%	-155	-32%
Malta	0	0	0	0.0%	0	60%	0	2%
Netherlands	-1 876	-1 748	-1 566	0.6%	310	17%	181	10%
Poland	-32 607	-19 793	-20 438	8.2%	12 169	37%	-644	-3%
Portugal	4 986	909	-877	0.4%	-5 864	-118%	-1 787	-196%
Romania	-27 165	-27 906	-27 554	11.1%	-389	-1%	351	1%
Slovakia	-5 999	-6 149	-5 986	2.4%	13	0%	163	3%
Slovenia	-4 587	-2 727	-2 765	1.1%	1 822	40%	-38	-1%
Spain	-20 187	-29 916	-30 112	12.2%	-9 925	-49%	-196	-1%
Sweden	-48 216	-37 051	-36 521	14.7%	11 695	24%	530	1%
EU-27	**-299 886**	**-256 595**	**-247 793**	**100%**	**52 093**	**17%**	**8 802**	**3%**

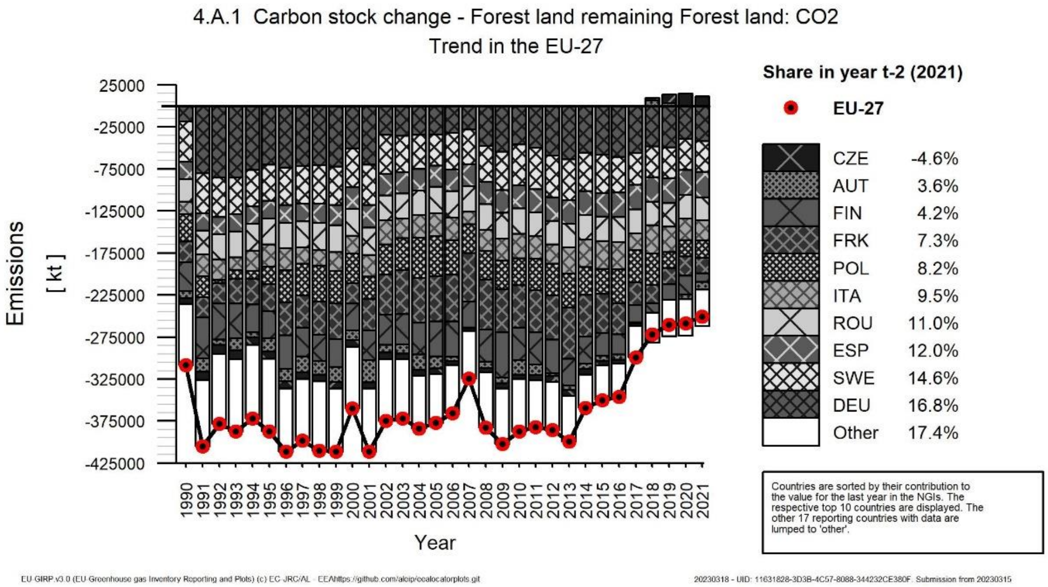
For the year 2021, with the exception of Czechia, Estonia and Ireland, individual submissions report a net carbon sink under Forest Land remaining Forest Land.

Important changes in terms of reported amounts, as compared with 1990, are mainly due to the increase in harvesting rates as reported by Czechia, which apply significant salvage logging practices after recent bark beetle infestation). But also, the impact of natural disturbances in forest, as in 1990 as reported by Germany, can explain the changes. By contrast, Italy and Spain report a significant increase of the carbon sink driven by a steady increase of the forest area that results in a net carbon accumulation on Forest Land remaining Forest Land.

In some cases, this category has shifted throughout the years from a net sink to a net source of carbon. This is explained by the impact of natural disturbances and by the age-class distribution of the forests which both also tend to result in more harvesting. Increased demand for woody biomass also impacts harvesting levels.

The 10 MS with the largest contribution to the total net carbon sink account for about 83% of the EU removals (Figure 6. 4).

Figure 6. 4 Trend of emissions (+)/removals (-) in subcategory 4A1 "Forest land remaining Forest Land" in EU-27 (kt CO_2)



Inter-annual variations in this subcategory are closely related to natural disturbances. In this respect, wildfires, in southern European countries, and windstorms and insect infestations, in several central European countries, resulted in a significant source of GHG emissions directly emitted to the atmosphere, or lagged emissions, via the transfer of carbon to other pools that are reflected in the trend at EU level.

Portugal and Italy report for the year 2017 enormous areas of forests and grasslands affected by wildfires. The impact of these events is about 25.000 kt CO_{2eq} emitted to the atmosphere. Noteworthy is also the significant impact that Germany reports from the massive storm "Vivian" that caused an estimated loss, due to windfalls, of about 70 Mm^3 of wood in 1990.

The emissions of CO_2 from biomass burning are, in many cases, implicitly reported in CRF table 4.A, as part of the "stock-change" approach used to report carbon stock changes, while related non-CO_2 emissions are reported in CRF table 4(V).

Estimation of emissions from forest fires is made with default methods in case of small emissions or with higher Tiers, involving country-specific information, where such emissions have a significant share within the overall carbon budget of the country (e.g., Portugal, Spain).

In general, emissions from natural disturbances that do not necessarily result in instantaneous carbon oxidation (e.g., insect outbreaks) are not easy to quantify as an annual biomass loss, and therefore they are practically not explicitly mentioned in the individual national inventory reports but reflected in the long-term estimation through the national forest inventories.

An exception is given by Czechia that due to exceptionally high sanitation harvest following an unprecedented drought and a bark-beetle outbreak experienced in its forests in recent years, reports a source of emissions from forests that result from this circumstance.

Among individual inventories with the largest inter-annual variability in GHG estimates that affect the EU trend of this category are:

- Forest fires (e.g., Portugal in 1990, 2003, 2005 and 2017; Italy in 1990, 1993, 2007, 2017 and 2021; Greece 2021).
- Windstorms (e.g., Germany 1990, France in 1999 and 2009, and Denmark in 2000, Sweden in 2005, Italy in 2018).

In addition, Finland, Portugal, and Germany reported this year significant recalculations in this category, which are well reflected in the EU inventory, overall, these recalculations are the result of implementing new methods and updated parameters than are consistently applied across the time series. For Finland this impacted in particular emissions from organic soils, for Germany emissions from mineral soils, while in the case of Portugal, after the submission of the NIR in April 2022, Portugal made a re-submission of the CRF tables and NIR in July 2022. And that submission introduced a comprehensive recalculation of the LULUCF sector.

Methodological issues for Forest Land remaining Forest Land category

The definition of forest land is reported by all individual submissions (Table 6. 9; Table 6. 10). The consistency of these definitions with the land representation system is ensured within the national inventory systems in terms of time and space. The forest definitions among countries slightly differ in terms of the quantitative parameters (i.e., crown cover, tree height and minimum area) used to define a land as forest.

In general, these forest definitions are consistent with definitions used by countries under other international reporting frameworks (e.g., Global Forest Resources Assessments FRA (FAO)). For forest administrative purposes, forest lands without tree coverage may be included or not in the forest area, and thus, additional qualitative criteria complement the forest definition. As an example, the definitions may include a reference to forest roads, un-stocked forest areas, nurseries, willow crops, etc.

Few countries have changed their forest definition since 1990, but recalculations of the entire time-series ensured the consistency on activity data. For example, Denmark changed from a questionnaire-based forestry information system to national forest inventory system to collect forest information but implemented methods for ensuring the consistency of the time series in line with the new approach (i.e., reassessment of base year data based on earth observation information).

The overall effect of different forest definitions on carbon stock changes at EU level is difficult to assess because it depends on several factors (e.g., land fragmentation, land use change frequency, transition period, land registry systems, GHG estimation methodology, etc.), but is considered small. Ultimately the implementation of country-specific forest definitions contributes to ensure that the large variety of forest ecosystems, and their management practices, that are in Europe are all considered in the GHG inventories.

Table 6. 9 **Quantitative thresholds used to define forests as selected by individual EU MS**

Country	Crown cover (%)	Height (m)	Area (ha)	Minimal width (m)
Austria	30	2	0.05	10
Belgium	20	5	0.5	-
Bulgaria	10	5	0.1	10
Croatia	10	2	0.1	-
Cyprus	10	5	0,3	-
Czechia	30	2	0.05	-
Denmark	10	5	0.5	20
Estonia	30	2	0.5	-
Finland	10	5	0.25	20
France	10	5	0.5	20
Germany	10	5	0.1	-
Greece	25	2	0.3	-
Hungary	30	5	0,5	-
Ireland	20	5	0.1	20

Country	Crown cover (%)	Height (m)	Area (ha)	Minimal width (m)
Italy	10	5	0.5	-
Latvia	20	5	0.1	20
Lithuania	30	5	0.1	10
Luxembourg	10	5	0.5	-
Malta	30	5	1	-
Netherlands	20	5	0.5	30
Poland	10	2	0.1	10
Portugal	10	5	1	20
Romania	10	5	0.25	20
Slovakia	20	5	0.3	20
Slovenia	10	5	0.25	-
Spain	20	3	1.0	25
Sweden	10	5	0.5	-

Additional information used by the countries to define the area of forests is provided in the table below:

Table 6. 10 **Additional qualitative criteria used to define forests complementing quantitative thresholds.**

Country	Forest land definition
Austria	Permanently unstocked basal areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forestall hauling systems, wood storage places, forest glades, forest roads) also represent forests. Areas which are used in short rotation with a rotation period of up to thirty years as well as forest arboretums, forest seed orchards. Christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut do not account as forests. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not forest land.
Belgium	This category includes all land with woody vegetation consistent with thresholds used to define forest land as described in paragraph 6.1 of the NIR. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.
Bulgaria	Areas of natural forest regeneration outside urban areas with a size of more than 0.1 ha also represent “forest”. Forests are also: areas which are in a process of recovering and are still under the parameters, but it is expected to reach forest crown cover over 10% and tree height 5 meters; areas, which as the result of anthropogenic factors or natural reasons are temporarily deforested, but will be reforested; protective forest belts, as well as tree lines with an area over 0.1 ha and width over 10 meters; cork oak stands. City parks with trees, forest shelter belts, and single row trees do not fall under the category “forests.
Croatia	Forest includes land under forest management (forest land without tree cover): Productive Forest land without tree cover, non-productive forest land without tree cover, barren wooded land (e.g., forest roads wider than 3 meters, quarries)
Cyprus	Forests include forest roads, cleared tracts, firebreaks and other small open areas within the forest as well as reforested areas or burnt areas or other areas that temporarily have low plant cover due to human intervention or natural causes, but does not include municipal parks and gardens.
Czechia	Forests excludes the areas of permanently unstocked cadastral forest land, such as forest roads, forest nurseries and land under power transmission lines.

Country	Forest land definition
Denmark	Temporarily non-wooded areas, fire breaks and other small open areas, that are an integrated part of the forest, are also included. Christmas trees are also included.
Estonia	All temporarily unstocked forest areas and regeneration areas which have yet to reach a crown density of 30 per cent and a tree height of 2 meters are also included as forest, as are areas which are temporarily unstocked as a result of human intervention such as harvesting, or natural causes (fires, etc.) but which are expected to revert to forest.
Finland	Parks and yards are excluded regardless of whether they meet the forest definition.
France	Forest roads, forest openings less than 20 m wide (e.g., for fire control), windbreaks and forest belts, as well as the poplar plantations and short rotations woody crops, if the criteria for Forest land are met. 5% of France's European forests are unmanaged on lands such as strong slopes or used for loisir, esthétique, cultural or military. Also, 40% of France's dependencies Forest land is considered as unmanaged.
Germany	Any area of ground covered by forest vegetation, irrespective of the information in the relevant cadastral survey or similar records. "Forest" also refers to cutover or thinned areas, forest tracks, firebreaks, openings and clearings, forest glades, feeding grounds for game, landings, rides located in the forest, further areas linked to and serving the forest including areas with recreation facilities, overgrown heaths and moorland, overgrown former pastures, alpine pastures, and rough pastures, as well as areas of dwarf pines and green alders. Heaths, moorland, pastures, alpine pastures, and rough pastures are considered to be overgrown if the natural forest cover has reached an average age of five years and if at least 50% of the area is covered by forest. Forested areas of less than 1,000 m2 located in farmland or in developed regions, narrow thickets less than 10 m wide, watercourses up to 5 m wide do not break the continuity of a forest area.
Greece	No additional criteria are used.
Hungary	Forest land (includes FL-FL, L-FL sub-categories) includes areas covered by trees, as well as roads and other areas that are under forest management but that are not covered by trees.
Ireland	All public and private plantation forests. Includes recently clear-felled areas. Tree grown for fruits or flowers, and shrub species (furze, rhododendron) are excluded. Includes open areas within forest boundaries.
Italy	Forest roads, cleared tracts, firebreaks and other open areas within the forest as well as protected forest areas are included in forest. Plantations, mainly poplars, characterized by short rotation coppice system and used for energy crops are included and also other plantation as chestnut and cork oak, have been included in forest land.
Latvia	Young natural stands and all plantations established for the forestry purposes, which have to reach a crown density of 20 % or tree height of 5 m are considered under forest land; as well as the areas normally forming part of the forest area, which are temporarily unstocked as a result of human intervention or natural causes, but which are expected to revert to forest.
Lithuania	Tree lines up to 10 meters of width in fields, at roadsides, water bodies, in living areas and cemeteries or planted at the railways protection zones as well as single trees and bushes, parks planted and grown by man in urban and rural areas are not defined as forests.
Malta	No additional criteria are used.
Luxembourg	Permanently unstocked basal areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forestal hauling systems, wood storage places, forest glades, forest roads) also represent forests. Areas which are used in short rotation with a rotation period of up to thirty years as well as forest arboretums, forest seed orchards, Christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut do not account as forests but represent cropland. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not forest land.
Netherlands	The Netherlands has chosen to define the land-use category "Forest Land" as all land with woody vegetation, now or expected in the near future (e.g., clear-cut areas to be replanted, young afforestation areas)
Poland	Young stands and all plantations that have yet to reach a crown density of 10 percent, or a tree height of 2 m 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.
Portugal	Forests (areas occupied by forests and woodlands which can be used for the production of timber or other forest products) and agro-forestry areas (annual crops or grazing land under the wooded cover of forestry species). The forest trees are under normal climatic conditions higher than 5 m with at least 30% canopy closure.
Romania	It comprises deciduous forest, coniferous forest, mixt forests, clear-cut areas and nurseries, as defined by presence of deciduous trees, coniferous trees, deciduous and resinous trees, dead trees, clear-cuts and forest nursery.
Slovakia	This category includes the land covered by all tree species serving for the fulfilment of forest functions and the lands on which the forest stands were temporarily removed with aim of their regeneration or establishment of forest nurseries or forest seed plantation.
Slovenia	It includes abandoned agricultural land with natural expansion of forest. Abandoned agricultural land on area more than 0.5 ha, which have been abandoned for more than 20 years, with minimal tree height 5.00 m and have a tree crown cover between up to 75 % are defined as forests.
Spain	Any land having woody vegetation with no agricultural use/activities fulfilling the threshold of forest and any other land which is expected achieve these parameters (including for "dehesa" where tree cover meets the thresholds)

Country	Forest land definition
Sweden	Land which hosts a potential yield of stem-wood exceeding one cubic meter per hectare and year. Meanwhile, the Land which hosts a potential yield of stem-wood lower than one cubic metre per hectare and year are classified as mire (under Wetlands). Permanent forest roads (width>5m) are not considered as forest land. All country forests are considered managed.

National forest inventories provide fundamental data inputs for both the estimation of areas, and the estimation of forest carbon stocks, and their changes. In very few cases, this information is also taken, or complemented, from data from forest management plan databases (especially when countries experience difficulties to get information for the first years of the time series).

Data collection approach of national forest inventories is typically based on repeated measurements of parameters on permanent sampling plots, but the sampling design differs among MS in terms of sample size, and frequency of the field surveys (e.g., Austria 3 years, Spain 10 years, Lithuania 5 years).

Given that the availability of annual data is barely available for this sector. Partly because it is not cost-efficient to increase the sampling frequency of some parameters since some changes are not captured in an annual basis. Countries have devoted efforts to meet reporting requirements and to ensure the consistency of the time series. Annual values are usually obtained by interpolation and extrapolation of available data sets. The main data source for forest area, the national forest inventories are in many instances complemented with auxiliary information in the form of national statistics (i.e. surveys) or remotely sensed products (i.e. satellite images, aerial photographs).

In this sense, not only for forest, but with a wider focus on acquiring data to monitoring lands and information for a better management, the result of some EU programs is already used by countries to improve their LULUCF reporting information (e.g., Copernicus products or Corine Land Cover data)

Furthermore, countries usually have disaggregated forest areas in various subdivisions according to available datasets. The breakdown criteria differ across countries, although they are consistent across time series. The aim is to differentiate and stratify the forest to capture the impact that specific strata features have on the GHG estimates. Main strata are based on forest types (e.g. broadleaved/coniferous; evergreen/deciduous; species based classification – beech, oak, pine, spruce, etc.); climate conditions (e.g. temperate moist or temperate dry,); soil and site type (e.g. lowlands, mountains), administrative or geographical boundaries (e.g. northern, southern territories), and management type (e.g. coppice, high forest).

For Forest land, definitions of carbon pools are reported by most of the MS (Table 6. 11). Among them, there are slight variations. The impact on the estimates of such variability, even if difficult to assess in quantitative terms, is considered small.

For instance, forest inventories define above-ground biomass carbon pool according to the threshold of minimal diameter of the vegetation that is measured (i.e. DBH– diameter at breast height) up to 7,5 cm. Concerning the below-ground biomass, the information on what exactly is included on this carbon pool is sparse. Dead wood mostly differs in terms of decay time and thresholds of diameters and height/length of wood pieces included in the pool. Litter is either independently assessed or included with soils. In soil organic carbon, carbon stock changes are computed according to various methods and transition periods. Usually, carbon stock in understory biomass is only accounted in principle for estimating forest fires emissions.

Table 6. 11 Explicit information on forest carbon pools definitions as reported by EU MS.

Country	Description
Above-ground biomass	
Austria	All living biomass (DBH > 5cm) above the soil including stem, stump, branches, seeds, bark and foliage (foliage only of evergreen trees). At ARD sites and LUC from and to forests all forest biomass (shrubs, forest understory) with a DBH > 0 cm to 5 cm is also taken under consideration.
Belgium	Tree and shrub species with circumference exceeding 20/22 cm at 1.50 m height (i.e., 7 cm in diameter), while in coppices the stems under 7 cm diameter are also included.
Denmark	Living trees with a height over 1.3 m, under different recording schemes (i.e., trees larger than 40 cm are measured only within a 15 m circle). Smaller trees, shrubs and other non woody are not counted. Aboveground biomass is defined as living biomass above stump height (1% of tree height).
Finland	Biomass of living trees with a height over 1.35 m, i.e., those trees that are measured in NFIs, including the stem wood, stem bark, living and dead branches, cones, needles/foliage. Understory is counted only to estimate the emission from forest fire.
France	Trees with DBH over 7.5 cm.
Germany	Trees with DBH over 7 cm.
Greece	Trees with DBH over 10 cm, but in cases of degraded forests (e.g., oak) and coppices (e.g., Castanea) the threshold is 4.6 cm. The trees in the sample area under the minimum diameter are not considered. Understory biomass is considered for GHG emissions from wildfires.
Hungary	The total biomass above the stump, including all branches and bark, of trees taller than two meters.
Lithuania	Above ground biomass refers to all living biomass above the soil including stem, stump, bark, branches, seeds and foliage.
Ireland	Modelled individual cycle of living biomass (but not the understory and annual/perennial non woody vegetation).
Italy	Trees with DBH over 3 cm.
Lithuania	Above ground biomass refers to all living biomass above the soil including stem, stump, bark, branches, seeds and foliage.
Luxemburg	Diameter of 4 cm at 3.5 m of the total height (average value)
Portugal	Living biomass above the soil, including stems, stumps, branches, bark and foliage, and forest understory (only for estimation of emissions from forest fires).
Slovakia	Merchantable volume, defined as tree stem and branch volume under bark with a minimum diameter threshold of 7 cm.
Slovenia	Volume over bark of all living trees more than 9.99 cm in diameter at breast height (1.3 m). Includes the stem from ground to a top diameter of 6.99 cm, and also branches to a minimum diameter of 6.99 cm.
Spain	Trees with DBH over 7.5 cm at the ground level are measured, while those under 7.5 cm are only counted.
Sweden	Biomass of living trees with a height over 1.3 m. Small trees, shrubs and other vegetation (i.e., herbs) are not counted. Aboveground biomass is defined as tree part above stump height (1% of tree height).
Below-ground biomass	
Austria	All living biomass of live roots with a diameter > 2 mm.
Ireland	Fine roots pool is simulated within integrates models.
Belgium	Diameter of estimated roots > 5 mm.
Denmark	Stumps from harvested trees within a year from the measurement are measured.
France	Fine roots are included with the soil organic matter.
Finland	Stumps and roots down to a minimum diameter of 1cm.
Hungary	The total biomass of the above trees minus their above-ground biomass.
Czechia, Italy, Poland, Spain	Applies a country specific “root- to-shoot” factor.
Lithuania	Below-ground biomass refers to all living biomass of live roots.
Portugal	Living biomass of belowground biomass (the lower limit of root diameter, if any, is not explicitly defined).
Sweden	Biomass of living trees below stump height (1% of tree height) down to a root diameter of 2 mm.
Dead wood	
Austria	All non-living woody b

Country	Description
	biomass not contained in the litter or soil, standing on the ground, without roots, as they are already considered as part of the litter or soil.
Belgium	Dead wood as measured by NFI, namely standing dead trees and fallen logs and branches. A dead tree is considered as fallen when it tilts at a vertical angle equal or superior to 45°. Dead trees above 20 cm of circumference are measured, under 20 cm are estimated visually.
Denmark	Standing deadwood with a DBH larger than 4 cm. Lying dead wood with a diameter of more than 10 cm, whose length is recorded. The degree of decay is recorded on an ordinal scale.
Finland	Non-living biomass which is not contained in litter (described by model as coarse woody litter input, larger than 10 cm in diameter, from natural mortality of trees and harvesting residues).
France	Standing trees, dead for less than 5 years, plus 10% from the wood which is annually harvested.
Germany	Fallen dead wood with a thicker-end diameter of at least 20 cm; standing dead wood with a diameter of at least 20 cm at breast height and trunks with either a height of at least 50 cm or a cut surface diameter of at least 60 cm. NFI 2008 collected data on all dead-wood objects with a thicker-end diameter of at least 10 cm. Data collection was for both NFIs on 3 species groups and 4 decomposition class.
Ireland	Pool is simulated by models.
Italy	The amount of carbon in dead wood is estimated from the aboveground carbon amount with an expansion factor.
Greece	Dead wood that remains on site after fire is assumed to fully decompose in 10 years.
Lithuania	Dead wood includes total standing and lying volume of dead tree stems.
Slovakia	The dead wood carbon pool contains dead trees from standing, stumps, coarse lying dead wood and small-sized lying dead wood not included in litter or soil carbon pools.
Slovenia	Dead wood content is all non-living woody biomass not contained in the litter, either standing, lying on the ground. According to definition from NFI 2007, dead wood in Slovenia includes: dead trees (DBH > 10 cm); stumps (D > 10 cm and H > 20 cm); snags (D > 10 cm and H > 50 cm); coarse woody debris (D > 10 cm and L > 50 cm).
Sweden	Dead wood is defined as fallen dead wood, snags or stumps including coarse and smaller roots down to a minimum "root diameter" of 2 mm. Dead wood of fallen dead wood or snags should have a minimum "stem diameter" of 100 mm and a length of at least 1.3 m.
	Litter
Austria	All non-living biomass lying dead in various states of decomposition above the mineral or organic soil.
Austria, Ireland	Litter is simulated by models.
Denmark	Non-living biomass, which is not included in other classes, under various status of decomposition on top of mineral or organic soil. It includes the litter, fumic and humic layers.
Finland	Non-living biomass with a diameter less than 10 cm in various status of decomposition (allocated by model in compartments: fine woody litter, coarse woody litter, extractives, celluloses and lignin-like compound). Biomass of ground vegetation (e.g., moss-, lichen-shrub- and twig vegetation) is not included in the living biomass, but it is included when the litter input to the soil is estimated.
France	Non-living dead wood lying on soil with maximum 7.5 cm diameter, dead leaves, humic and fumic layers, fine roots.
Germany	Dead organic cover with a fraction < 20 mm.
Italy	The amount of carbon in litter is estimated from the aboveground carbon amount with linear relations.
Portugal	Non-living biomass on top of mineral soil, in various stages of decomposition (include fumic, humic) (considered only in forest fires).
Slovakia	The litter pool definition used in the inventory includes all non-living biomass with a size less than the minimum diameter defined for dead wood (1 cm). The small-sized lying dead wood (diameter between 1 and 7 cm), in various states of decomposition above the mineral soil are not a part of litter, because they are included in dead wood. The litter includes the surface organic layer (L, F, H horizons) as usually defined in soil profile description and classification. Live fine roots above the mineral or organic soil (of less than the minimum diameter limit chosen for below-ground biomass) are included in litter.
Slovenia	The carbon stock in Ol, Of and Oh sub horizon. Volume of roots and coarse fragments (soil skeleton > 2 mm) is not included.
Sweden	Non-living biomass not classified in other classes, under various stages of decomposition, on top of mineral or organic soil: litter, fumic and humic layers. Litter includes, as well: a) live fine roots (<2 mm) from O horizon and b) coarse litter with "wood stem diameter" between 10-100 mm.
	Soil Organic Carbon
Austria	All organic matter in mineral and organic soils (including peat) to a soil depth of 50 cm (forests, LUC from

Country	Description
	and to forests) or to a soil depth of 30 cm (all other land uses and LUC).
Austria, Finland, Ireland	Pool is simulated by models (undefined depth or dimensions).
Belgium, France, Germany, Italy, Luxemburg, Portugal	Organic carbon in 0-30 cm topsoil.
Bulgaria	Organic carbon in 0-40 cm topsoil, also includes the C stock of the litter layer (humus layer).
Croatia	Organic carbon in 0-40 cm topsoil.
Czechia	Soil organic carbon in 0-30 cm, including the upper organic horizon.
Denmark	Organic carbon in the mineral soils below the litter, fumic and humic layers and all organic carbon in soils classified as Histosols. It is for 30 cm depth between top of the mineral soil or, alternatively, from the soil surface (if Histosols).
Hungary	The soil carbon stocks were determined from humus content (Hu) values (Filep, 1999) that were measured for the uppermost 30 cm of the soil.
Slovakia	Organic carbon in the mineral soils 0-20 cm.
Slovenia	Carbon stock in mineral part of soil (SOM) in 0–40 cm soil depth.
Spain	Organic carbon in the mineral soils down to 30 cm.
Estonia, Sweden	Organic carbon in the mineral soils below the litter, fumic and humic layers and all organic carbon in soils classified as Histosols, down to a depth of 50 cm.

When assessing inventory completeness, it should be noted that what is not reported under a pool, is reported under another one (e.g., fine roots are reported either as litter or as soil organic matter), so that no bias in the overall estimation is expected to occur.

Individual submissions of GHG inventories follow 2006 IPCC guidelines for estimating the carbon stock changes in forest carbon pools. For living biomass, methodologies are based either on the “stock difference” or “gain-loss” methods (

Table 6. 12).

Table 6. 12 **IPCC Method used for estimating carbon stock changes in forest aboveground biomass.**

Country	IPCC method
Austria	*Gain-loss*
Belgium	*Stock-difference*
Bulgaria	*Stock-difference*
Croatia	*Gain-loss*
Cyprus	*Gain-loss*
Czechia	*Gain-loss*
Denmark	*Stock-difference*
Estonia	*Stock-difference*
Finland	*Gain-loss*
France	*Gain-loss*
Germany	*Stock-difference*
Greece	*Stock-difference*
Hungary	*Stock-difference*
Ireland	*Gain-loss*
Italy	*Gain-loss*
Latvia	*Gain-loss*
Lithuania	*Stock-difference*
Luxemburg	*Gain-loss*
Malta	*Gain-loss*
Netherlands	*Gain-loss*
Poland	*Stock-difference*
Portugal	*Gain-loss*
Romania	*Gain-loss*
Slovakia	*Gain-loss*
Slovenia	*Stock-difference*
Spain	*Stock-difference*
Sweden	*Stock-difference*

Data sources for the estimation of carbon stock changes in living biomass also differ among countries, upon data availability. Nowadays, NFIs represent the primary source of information for most of MS, while others rely on other forestry statistics and yield tables. In addition, forest fire statistics complement both data sources. Data collection and data analysis programs are ongoing in most of the countries to further improve the completeness and accuracy of the estimates, primarily of carbon stock changes.

The implied carbon stock change factors reported for net carbon stock changes in living biomass for this inventory year range from -1.48 to 1.76 t C ha^{-1} (Table 6. 13). Generally, low values of IEFs are shown by countries with high harvesting rates or with less favorable climatic conditions (i.e., lower growth and also more losses by natural disturbances); while higher values are reported by countries where planting combined with relatively short forest rotation times is the main instrument to ensure forest regrowth.

Table 6. 13 **Implied carbon stock change factors for living biomass pool in 4A1 (t C ha-1 year-1) reported in individual GHGI 2023.**

Country	Net carbon stock change factor in living biomass (t C/ha)	
	1990	2021
AUT	0,76	0,21
BEL	0,74	0,68
BGR	1,07	0,50
HRV	0,75	0,66
CYP	0,00	0,18
CZE	0,54	-1,48
DNM	0,16	0,65
EST	0,46	-0,21
FIN	0,33	0,18
FRK	0,27	0,21
DEU	0,15	0,71
GRC	0,10	0,19
HUN	0,43	0,73
IRL	3,79	-0,22
ITA	0,55	0,76
LVA	1,54	0,14
LTU	0,96	0,61
LUX	-0,06	1,76
MLT	0,00	0,00
NLD	1,37	1,17
POL	1,04	0,43
PRT	0,05	0,24
ROU	0,96	0,88
SVK	0,83	0,74
SVN	1,18	0,63
ESP	0,46	0,53
SWE	0,37	0,23

Changes of organic carbon stored in mineral soils and dead organic matter are mostly reported by applying Tier 1 method, which assumes for this land use subcategory that these carbon pools are in equilibrium, and therefore no net carbon stock changes occur in long term. In these cases, notation keys are used in the corresponding CRF table 4.A (see also Table 6. 5 and Table 6. 6).

When they are estimated, countries mainly rely on data collected in the course of the national forest inventories. However, it should be noted that the widespread use of the Tier 1 assumption is due to the lack of appropriate data, and the high costs associated with systems that would allow a proper collection of this information, in other cases also to the very high uncertainty of the existing data.

Nevertheless, an increasing number of countries document ongoing efforts to estimate emissions and removals from dead organic matter and mineral soils in forest. This has resulted in more countries reporting for first time carbon stock changes in these pools using country-specific data.

When data on soil organic carbon content is available from two measurement cycles, they are often directly used for estimating carbon stock changes using stock difference approaches. In few cases, data is also integrated in models. Moreover, depending on the availability of datasets in individual countries, carbon stock changes in dead organic matter are often disaggregated between dead wood and litter or some countries include their estimates within soil organic carbon pool (e.g., Finland).

Table 6. 14 Implied carbon stock change factors in DOM carbon pool in 4A1 (t C ha-1 yr-1) reported in individual *GHGI 2023.*

Country	Net carbon stock change in dead wood per area (t C/ha)		Net carbon stock change in litter per area (t C/ha)	
	1990	2021	1990	2021
AUT	0,02	0,02	IE,NA	IE,NA
BEL	NA	NA	NA	NA
BGR	0,03	0,08	NA	NA
HRV	NA	NA	NA	NA
CYP	NA	NA	NA	NA
CZE	0,06	0,08	0,16	0,19
DNM	0,01	0,05	0,07	0,27
EST	0,05	0,02	NA	NA
FIN	IE	IE	IE	IE
FRK	NA	-0,01	NA	0,00
DEU	0,04	0,09	-0,01	-0,01
GRC	NA,NO	NO,NA	NA,NO	NA,NO
HUN	0,02	0,03	NE	NE
IRL	IE	0,05	-0,26	0,28
ITA	0,02	0,01	0,03	0,01
LVA	0,05	0,06	NA	NA
LTU	0,07	0,13	NA	NA
LUX	0,09	0,11	NE	NE
MLT	NA	NA	NA	NA
NLD	0,08	0,07	0,29	0,14
POL	NO	0,14	NO	NO
PRT	IE	IE	0,00	0,00
ROU	0,08	0,11	0,03	0,04
SVK	0,08	0,08	NO	NO
SVN	0,10	0,01	NA	NA
ESP	NA	NA	NA	NA
SWE	0,05	0,07	-0,06	-0,04

Carbon stock changes in mineral soils under forest land remaining forest land in this submission are quantitatively estimated generally as a small net sink of carbon. (Table 6. 15).

Most of the countries report absence or insignificant areas of organic soils under this land use subcategory. However, when organic soils are present, they are reported in most cases as a net source of emissions.

CO_2 emissions from organic soils are associated with managed forests (e.g., drainage of soils to establish plantations)

Table 6. 15 Implied carbon stock change factors in mineral and organic soils in 4A1 (t C ha-1 yr-1) reported in individuals GHGI 2023.

Country	Net carbon stock change in mineral soils per area (t C/ha)		Net carbon stock change in organic soils per area (t C/ha)	
	1990	2021	1990	2021
AUT	-0,16	0,39	NO	NO
BEL	NA	NA	NO	NO
BGR	NA	NA	NO	NO
HRV	NA	NA	NO	NO
CYP	NA	NA	NO	NO
CZE	-0,02	0,02	NO	NO
DNM	NA	NA	-1,95	-1,30
EST	0,15	0,15	-0,32	-0,33
FIN	0,17	0,07	-0,07	-0,37
FRK	NA	0,00	NO	NO
DEU	0,38	0,35	-2,90	-2,90
GRC	NA,NO	NO,NA	NO,NA	NO,NA
HUN	NE	NE	-2,60	-2,60
IRL	-0,04	-0,05	-1,40	-1,60
ITA	NO,NA	NO,NA	NO	NO
LVA	NA	NA	-0,52	-0,52
LTU	NE	NE	IE	IE
LUX	NO	NO	NO	NO
MLT	NA	NA	NO	NO
NLD	NA	NA	-0,98	-0,99
POL	0,05	0,09	-0,68	-0,68
PRT	0,05	-0,03	NO	NO
ROU	0,05	0,06	-2,60	-2,60
SVK	NO	NO	NO	NO
SVN	NA	NA	NO	NO
ESP	NA	NA	NO	NO
SWE	0,21	0,18	-0,37	-0,35

6.2.1.3 Land converted to Forest Land (CRF 4A2)

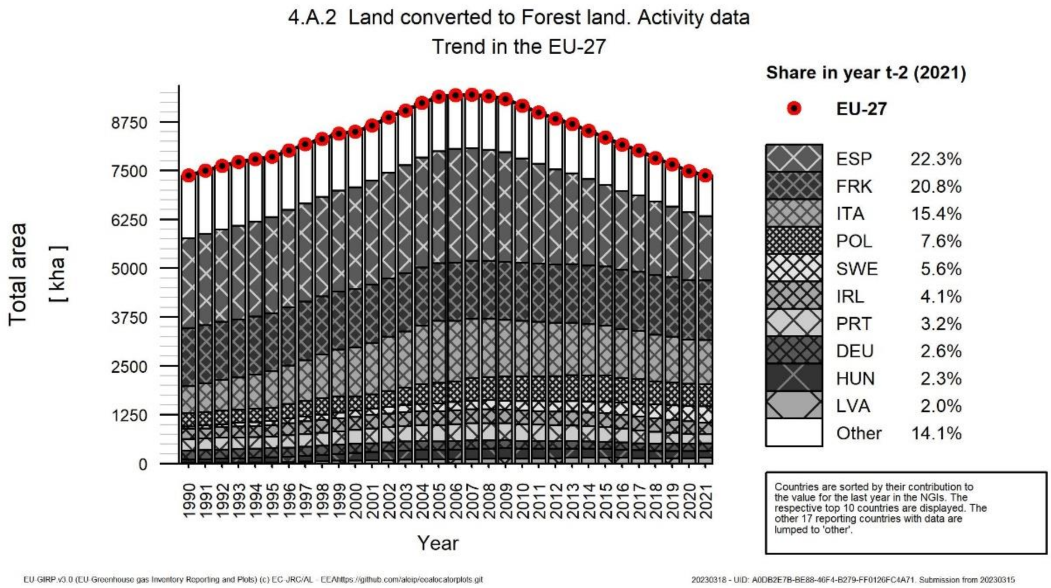
Overview of Land converted to Forest Land category

In this submission, the area reported under this subcategory represents 4% of the total Forest Land area. This subcategory has first increased up to the year 2007 and then decreased so it is now almost the same as in 1990 (Figure 6. 5), from 7 383 kha in 1990 to 7 375 kha in 2021.

Most of the new forest lands are converted from Grassland and Cropland areas, and although within the overall category they have a low share in terms of areas, they contribute by 11% to the total carbon sink of the European forests.

In term of areas, Spain, France, Italy, Poland and Sweden together contribute with about 72% of the total areas being converted to forest land.

Figure 6. 5 Trend of activity data in subcategory 4A2 "Land converted to Forest Land" in EU-27 (kha)



This subcategory has been always reported as a net carbon sink at the EU level. In this submission, it reaches -41 715 kt CO_2, which represents a decrease of the sink by 13% as compared with 1990. (Figure 6. 6; Table 6. 16).

Nevertheless, some MS (e.g., Germany for 2021) reports this subcategory as a net source of emissions. This fact is explained by the emissions caused during the preparatory practices that preceded the afforestation or reforestation activities. The absence of such emissions is often associated with natural expansion of forest areas.

Table 6. 16 4A2 Land converted to Forest Land: EU-27 contributions to net CO_2 emissions (+)/removals (-) (CRF table 4)

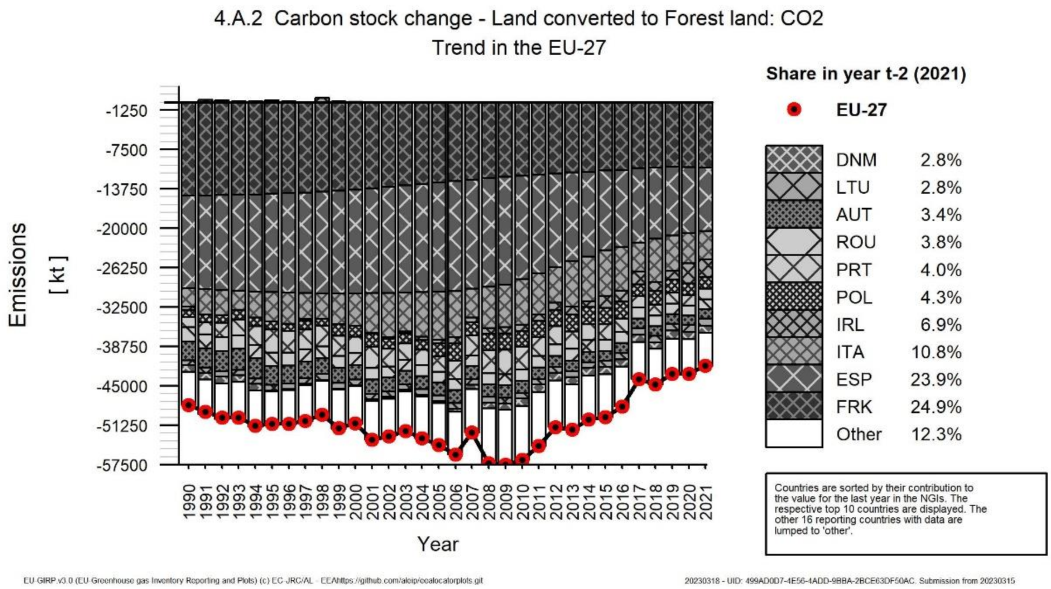
Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	-2 957	-1 461	-1 437	3.4%	1 520	51%	24	2%
Belgium	-11	-296	-302	0.7%	-291	-2613%	-6	-2%
Bulgaria	-1 310	-130	-173	0.4%	1 137	87%	-43	-33%
Croatia	-29	-261	-261	0.6%	-232	-802%	1	0%
Cyprus	0	-16	-17	0.0%	-17	-17805%	-1	-6%
Czechia	-237	-581	-586	1.4%	-349	-147%	-5	-1%
Denmark	-1 037	-1 177	-1 174	2.8%	-137	-13%	4	0%
Estonia	-11	-347	-324	0.8%	-313	-2939%	24	7%
Finland	2	-190	-180	0.4%	-182	-9558%	11	6%
France	-14 829	-10 318	-10 418	25.0%	4 412	30%	-99	-1%
Germany	-226	11	153	-0.4%	379	168%	142	1253%
Greece	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Hungary	-394	-1 260	-1 148	2.8%	-754	-191%	112	9%
Ireland	-522	-3 172	-2 871	6.9%	-2 349	-450%	301	9%
Italy	-2 849	-4 799	-4 505	10.8%	-1 656	-58%	294	6%
Latvia	-10	-175	-182	0.4%	-172	-1691%	-7	-4%
Lithuania	-801	-1 117	-1 183	2.8%	-382	-48%	-66	-6%
Luxembourg	-33	-14	-12	0.0%	20	62%	1	9%
Malta	NO	0	0	0.0%	0	-∞	0	-3%
Netherlands	-577	-495	-493	1.2%	83	14%	2	0%
Poland	-1 187	-1 870	-1 803	4.3%	-616	-52%	67	4%
Portugal	-1 584	-1 634	-1 663	4.0%	-79	-5%	-29	-2%
Romania	-2 291	-1 639	-1 582	3.8%	708	31%	57	3%
Slovakia	-2 263	-351	-344	0.8%	1 919	85%	7	2%
Slovenia	-233	-277	-177	0.4%	56	24%	100	36%
Spain	-14 359	-10 415	-9 935	23.8%	4 424	31%	480	5%
Sweden	63	-1 066	-1 099	2.6%	-1 162	-1847%	-33	-3%
EU-27	**-47 685**	**-43 051**	**-41 715**	**100%**	**5 970**	**13%**	**1 336**	**3%**

As shown in Table 6. 16, some MS reported significant changes in this subcategory as compared with 1990, for instance, France, Ireland, and Spain.

In the case of Ireland, the increase on removals by the post-1990 forest is due to an increase in forest area, and their productivity as new established forests mature. The slight decrease in the slope of the change in removals from 2007 onward is due to thinning harvests in productive forests at age 17 years old and onwards.

Finally, the changes in the carbon sink reported by Sweden and Spain are driven by the trend of the area in this category. While Sweden reports a constant increase of land converted to forests, Spain reports a constant decrease that is well reflected in a lower the sink at the end of the time series as compared with the base year.

Figure 6. 6 Trend of emissions (+)/removals (-) in subcategory 4A2 "Land converted to Forest Land" in EU-27 (kt CO_2)



For this year, about 49% of total carbon sink reported in the subcategory 4A.2 was reported by France and Spain while the 10 MS with the larger contribution represent about the 88% of the total sink of the new forest areas.

Methodological issues for Land converted to Forest Land category

Methods used to identify and represent the areas converted to forests, as well as to report the associated GHG emissions and CO_2 removals from these areas, are generally the same as the ones used for the subcategory 4.A.1. Nevertheless, different parameters are involved under each subcategory due to differences among other in growth rates and management practices of these young forests.

Most of the countries have developed land identification systems that are able to identify and track land use conversions to, and from, forests. Mainly, as already mentioned, these methods are based on information collected by the national forest inventories on systematic sampling grids, and that, in many cases, is complemented by auxiliary information on the form of satellites images, remote sensing analysis, aerial photography, or national registries.

Estimates of GHG emissions and CO_2 removals from this subcategory are usually reported using tier 2 methods involving country-specific data collected during the national forest inventories. Under this subcategory, living biomass and dead organic matter carbon pools are in most of the cases reported as a net carbon sink. Mineral soils are reported either as a net source or a net sink of emissions depending on whether there is presence or absence of disturbed soils on new forest areas (i.e., natural regeneration or, soils management practices that enhance carbon oxidation).

Concerning organic soils, countries have reported this carbon pool as a net source of emissions whenever new forest areas were established in this type of soils.

Nevertheless, it should be noted that the heterogeneity in approaches used by the countries under 4A.2 suggests caution in interpreting differences in the implied carbon stock change factors among carbon pools. For instance, possible reasons of differences may include the length of the time series on activity data and their starting point, the use of time-averaged annual biomass growth, or the quantity of CO_2 emissions estimated from the land that is converted to forests, including lagged emissions.

6.2.2 Cropland (CRF 4B)

6.2.2.1 Overview of the Cropland category

Subject to intensive agriculture practices, Cropland category is an important contributor to the EU GHG budget. This category, which includes arable lands for annual crops, permanent crops, set aside lands and rice-fields, represents the largest source of emissions among the six land use categories.

Based on individual submissions reported this year, Cropland areas covered in 2021 a total of 121 005 kha, which represent 29% of the lands reported by EU MS. However, the category shows a steady decreasing trend. For this inventory year the area is about 8% less than in the year 1990.

6.2.2.2 Cropland remaining Cropland (CRF 4B1)

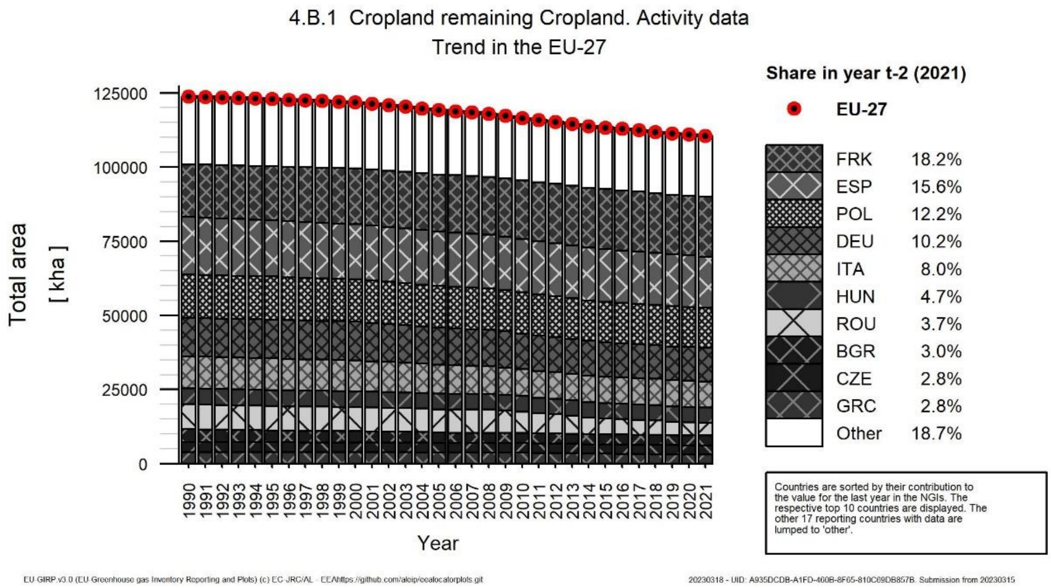
Overview of Cropland remaining Cropland category

In line with the overall category, this subcategory has constantly decreased since 1990 (Figure 6. 7) from 123 827 kha in 1990 to 110 577 kha in 2021. This represents a decrease of 11%.

With the exception of France, Luxembourg and Slovakia, countries report a decrease of Cropland area as compared with 1990.

The overall trend of this subcategory is driven by 10 MS which together contribute to about 81% of the total area, and more specifically, Spain, France, Poland, and Germany which represent more than half of the area reported under this subcategory.

Figure 6. 7 Trend of activity data in subcategory 4B1 "Cropland remaining Cropland" in EU-27 (kha)



In terms of emissions, at the EU level this subcategory has been always reported as a net source of GHG emissions.

For the year 2021, based on individual submissions, GHG emissions from Cropland remaining Cropland reached 5 018 kt CO_2 which represents a decrease of 82% as compared to 1990 (Table 6. 17).

This trend is mainly driven by Germany and Denmark that reports less emissions, France that reports removals in 2021 and emissions in 1990 and Romania and Spain that reports more removals from this subcategory in 2021 (Figure 6. 8). In general, emissions are the result of the oxidation of soils organic matter, which are particularly important in those MS with presence of cultivated areas on organic soils.

Nevertheless, some MS report a considerable carbon sink in Cropland remaining Cropland. For instance, France Romania, and Spain report a substantial net carbon sink in mineral soils and, in some cases, also in the living biomass carbon pool. This is generally justified by the implementation of IPCC methodologies (i.e. tier 1 and tier 2) that result in a net sink when current management practices of soils are less intensive than those implemented 20 years before. In addition, net carbon sink may occur in countries with significant areas of woody crops (i.e., orchards, vineyards, Christmas trees, fruits, bushes, and olive trees) that provide a net sink resulting from carbon accumulation in the living biomass pool.

A particular case is Romania, which on top of the role of perennial crops, reports a significant sink in this subcategory because, as explained in its NIR, Cropland includes tree plantations, other wooded land and trees outside forests with act a net carbon sink over time.

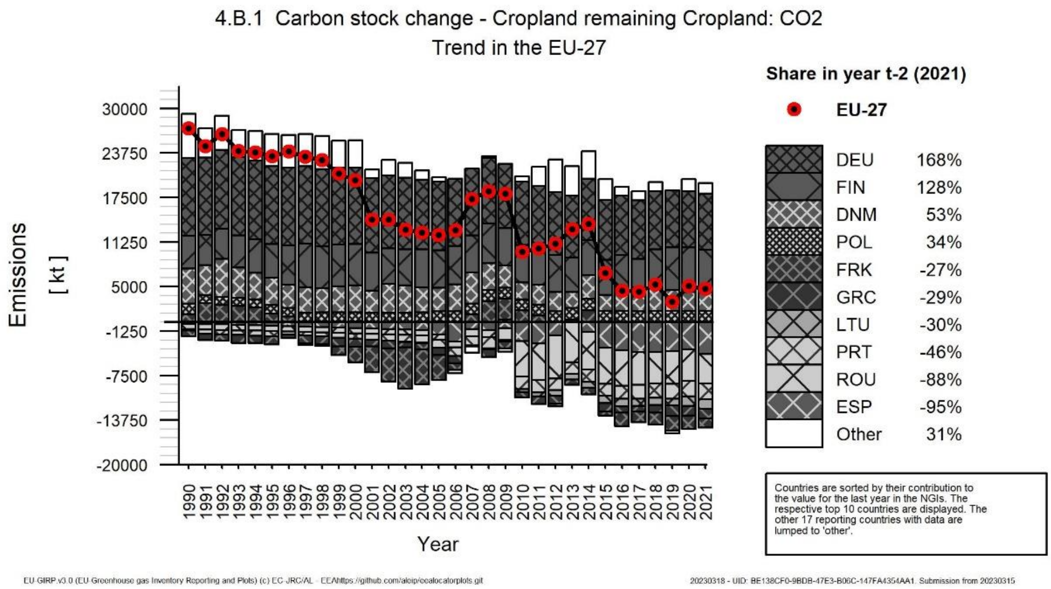
Table 6. 17 4B1 Cropland remaining Cropland: EU-27 contributions to net CO_2 emissions (+)/removals (-) (CRF table 4)

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	-18	-40	48	1.0%	66	366%	88	220%
Belgium	213	115	113	2.3%	-100	-47%	-2	-2%
Bulgaria	-851	-496	-533	-10.6%	319	37%	-36	-7%
Croatia	89	138	138	2.8%	49	55%	0	0%
Cyprus	-134	-134	-134	-2.7%	0	0%	0	0%
Czechia	-13	-12	-17	-0.3%	-4	-29%	-4	-32%
Denmark	4 966	2 565	2 514	50.1%	-2 452	-49%	-51	-2%
Estonia	604	277	456	9.1%	-147	-24%	179	65%
Finland	4 551	6 332	6 029	120.1%	1 478	32%	-303	-5%
France	1 041	-1 884	-1 253	-25.0%	-2 294	-220%	631	33%
Germany	10 914	7 873	7 926	157.9%	-2 988	-27%	53	1%
Greece	-808	-1 346	-1 362	-27.1%	-554	-69%	-16	-1%
Hungary	40	-57	-38	-0.8%	-78	-195%	19	33%
Ireland	-135	-312	-270	-5.4%	-135	-100%	42	13%
Italy	865	-242	-162	-3.2%	-1 027	-119%	80	33%
Latvia	2 364	1 200	1 239	24.7%	-1 125	-48%	39	3%
Lithuania	78	-1 351	-1 399	-27.9%	-1 477	-1905%	-48	-4%
Luxembourg	0	2	2	0.0%	2	158011%	0	-1%
Malta	0	-1	-1	0.0%	-1	-301%	0	29%
Netherlands	1 912	861	830	16.5%	-1 082	-57%	-31	-4%
Poland	1 458	1 617	1 606	32.0%	148	10%	-11	-1%
Portugal	952	-2 071	-1 914	-38.1%	-2 866	-301%	157	8%
Romania	-748	-4 444	-4 124	-82.2%	-3 376	-452%	321	7%
Slovakia	-1 391	-1 147	-1 217	-24.3%	174	13%	-70	-6%
Slovenia	65	88	85	1.7%	20	30%	-3	-3%
Spain	-207	-3 824	-4 491	-89.5%	-4 284	-2071%	-667	-17%
Sweden	2 682	1 482	945	18.8%	-1 736	-65%	-536	-36%
EU-27	**28 487**	**5 187**	**5 018**	**100%**	**-23 469**	**-82%**	**-169**	**-3%**

Information above shows that as compared with the year 1990, France and Spain have reported in this submission a significant increase of removals in Cropland remaining cropland. This results mainly from an increase in soil organic carbon in mineral soils which is driven by changes in management practices. However, larger sink in living biomass of woody crops at the end of the time series also contributes to the overall trend.

Germany reports a significant decrease of emissions from Cropland that is mainly driven by a constant decrease of cropland areas after 2000, and by agricultural practices that result in lower emissions, for instance lower area of cultivation of histosoils.

Figure 6. 8 Trend of emissions (+)/removals (-) in subcategory 4B1 “Cropland remaining Cropland” in EU KP (kt CO_2)



Methodological issues for Cropland remaining Cropland category

Lands included under this category generally are in line with the IPCC definition (Table 6. 18). However, there could be national particularities (e.g., treatment of some woody crops) that result in small differences among countries.

In some cases, because of the absence of annual information on activity data, coupled with the fact that management practices include crops-rotation cycles and fallow lands, some cropland areas may not be clearly separated from grassland areas. In these cases, countries have defined the number of years before a land is shifted from/to cropland and grassland.

Table 6. 18 Definitions of lands included under the category 4B: Cropland.

Country	*Definition*
Austria	Arable land, including annual and perennial crops (rotation period of up to thirty years), as well as forest arboretums, forest seed orchards, Christmas tree plantations and orchards (e.g., walnut, or sweet chestnut) and rows of trees and areas with woody plants in parks and green areas, and house garden.
Belgium	Tillage land and agroforestry systems with vegetation falling below the thresholds for forests.
Bulgaria	Cropland consists of annual crops (cornfields and kitchen gardens) and perennials (vineyards, fruit and berry plantation and nurseries). Arable land is the land worked regularly, generally under a system of crop rotation - area with annual crops, set - aside area as well as area with seeds and seedlings. Perennial crops include fruit and berry plantation, vineyards and other permanent crops, nurseries for wine, fruits, ornamental plants, forest trees etc. The orchard is a uniformly kept plantation (by annual pruning and regular treatment for protection from diseases and insects) of fruit trees (pip- trees, stone-trees and nut-trees).
Croatia	Cropland category includes non-irrigated arable land, permanently irrigated arable land, vineyards, fruit trees and berry plantations, olive groves, annual crops associated with permanent crops (Complex cultivation patterns).
Cyprus	This category contains cropped land, including lands with woody vegetation (i.e., fruit trees) where the vegetation does not meet the definition of forest. In particular, this category includes land principally occupied by agriculture, including arable land, annual and permanent crops as well as vineyards, fruit trees and berry plantations, olive groves and other similar types of cultivation.
Czechia	Cropland is predominantly represented by arable land (92.6%), while the remaining area includes hop-fields, vineyards, gardens and orchards.
Denmark	Annual crops, wooden perennial crops, hedgerows and “other agricultural area” (i.e., small undefined areas lying inside the cropland area). It includes farmlands, commercial plantations with perennial crops (fruit trees, orchards and willow), house gardens, hedgerows (perennial trees/bushes not meeting the forest definition) in the agricultural landscape, as well as willow plantations on agricultural land for bioenergy purposes.

Country	*Definition*
Estonia	Cropland is arable land, area where annual or perennial crops are growing (incl. fallow, orchards, short-term and long-term cultural grasslands and temporary greenhouses). It does not include built garden land under 0.3 ha (that is included in Settlements). Abandoned cropland is classified as cropland until it has not lost arable land features – changes in soil and vegetation have not taken place and the land is still usable as cropland without the implementation of specific treatments.
Finland	Arable crops, grass covered (for less than 5 years), set-aside, permanent horticultural crops, greenhouses, and kitchen gardens.
France	Annual crops, temporary pastures (which last for maximum 6 annual harvests) and permanent crops (orchards, vineyards, olives, etc.).
Germany	Annual crops and cropland with perennial crops (long-lived crops: fruit crops, osiers, poplars, Christmas tree farms, nurseries) and lands for cultivation of vegetables, fruit and flowers.
Greece	Annual and perennial crops, temporary fallow land and perennial woody crops, i.e., tree crops and vineyards.
Hungary	Cropland contains arable lands, vegetable gardens, orchards and the vineyard areas, as well as set-aside croplands. Arable lands are any land area under regular cultivation irrespective of the rate or method of soil cultivation and whether the area is under crop production or not due to any reason, such as temporary inland waters or fallow. Areas under tree nurseries (including ornamental and orchard tree nurseries, vineyard nurseries, forest tree nurseries excluding those for the own requirements of forestry companies grown in the forest), permanent crops (e.g., alfalfa and strawberries), herbs and aromatic crops are included. Vegetable gardens are areas around residential houses where, in addition to meeting the owners' demand may produce some surplus of low amount which is usually traded. Orchards are land under fruit trees and bushes that may include several fruit species (e.g.: apples, pears, cherries, etc.). Included are non-productive orchards and orchards of systematic layout in vegetable gardens if the area is 200 m^2 or above in case of berries and 400 m^2 or above in case of fruit trees. Vineyards are areas where grapes are planted in equal row width and planting space and include non-productive areas and vineyards in vegetable gardens (e.g., trellises) if grapes are planted in equal row width and planting space, and the size of the area is at least 200 m^2. Set-aside cropland is land that is abandoned but not converted to any other land use.
Ireland	Permanent crops and tillage land, including set-aside, as recorded by annual statistics.
Italy	Annual crops and perennial woody crops (e.g., woody plantations, that don't meet national forest definition, olive groves or vineyards).
Latvia	The cropland refers to the area of arable land, including orchards and extensively managed arable lands. Cropland also includes animal feeding glades, which according to national land use classification belong to forest land.
Lithuania	The area of cropland comprises of the area under arable crops as well as orchards and berry plantations. Arable land is continuously managed or temporary unmanaged land, used and suitable to use for cultivation of agricultural crops, also fallows, inspects, plastic cover greenhouses, strawberry and raspberry plantations, areas for production of flowers and decorative plants. Arable land set aside to rest for one or several years (<5 years) before being cultivated again as part of an annual crop-pasture rotation is still included under cropland. Orchards and berry plantations are areas planted with fruit trees and fruit bushes (apple-trees, pear-trees, plum-trees, cherry-trees, currants, gooseberry, quince and others).
Luxemburg	Agro-forestry systems where tree cover falls below the forest thresholds, respectively covered by permanent crops, annual crops, artificial meadows (not permanent) and lands temporarily set aside.
Malta	In Malta cropland can be split into three types: arable area which is cultivated under a system of crop rotation; kitchen gardens that include small plots of cultivated land, in which most of the products are intended for consumption by the farmer; land under permanent crops where the crop occupies the same land for a period of time, normally 5 years or more. For inventory purposes, local cropland was split into two: annual crops and perennial woody crops. The main perennial crops considered for this inventory are vines, being the most cultivated crop.
Netherlands	Arable and tillage land, including rice-fields, and agro-forestry systems where the vegetation structure falls below the thresholds for forest and nurseries (including tree nurseries).
Poland	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 1000 m^2, 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 1000 m^2, planted with fruit trees and bushes.
Portugal	Rain-fed annual crops (without irrigation and fallow-land integrated into crop-rotations), irrigated annual crops (under irrigation, greenhouses), rice cultivation lands, wine yards, olives and other species of woody crops
Romania	Cropland includes agricultural lands, i.e., lands covered or temporary uncovered by agricultural crops (major crops and horticultural plants cultures). It includes 3 groups (non-woody crops, woody crops and other wooded land and trees outside forests (which do not meet the forest definition parameters, e.g., forest belts which are narrower than 20m) with 9 categories: orchard, vineyard, shrubs, cultivated land agricultural, temporary fallow land, deciduous tree, coniferous tree, deciduous and resinous trees and dead trees.
Slovakia	Cropland includes lands for growing cereals, root-crops, industrial crops, vegetables and other kinds of agricultural crops; perennial woody crops; lands temporary overgrown with grass or used for growing of fodder lasting several years; hotbeds and greenhouses if they are built up on the arable land; fallow land which is

Country	***Definition***
	arable land left for regeneration for one growing season during which were not sow specific crops or just crops for green manure, eventually it is covered by spontaneous vegetation, which would be ploughed in.
Slovenia	Annual: arable land breeds more than 2 meters and grows the non-woody vegetation (cereals, potatoes, forage crops, vegetable crops, oilseed, ornamental plants, herbs, strawberries, hop fields) and agricultural fallow ground. Also, temporary meadows and greenhouses. Perennial: permanent crops on arable land such as vineyards, extensive and intensive orchards, olive groves, nursery (for grapevines, fruit and forest trees), forest plantations and forest trees on agricultural land.
Spain	Annual crops and fallow land, perennial crops (olive groves, wines and other woody crops) and mix of annual and permanent crops (except when they qualify as forest land, i.e., in “dehesa”).
Sweden	Regularly tilled agricultural land.

Overall, following the IPCC approach, the carbon pool living biomass is assumed in balance for annual crops, while carbon stock changes are reported for conversions among annual and woody crops (e.g., Austria, Croatia, and Bulgaria). Concerning carbon stock changes in woody crops, countries often implement the IPCC approach, either by using country-specific data on biomass accumulation from growth and maturity cycles, or by using default data. However, what is not always transparently provided is how the lands in which woody crops have reached maturity are identified and excluded from those that are still accumulating carbon.

Carbon stock changes in dead organic matter are in most of the cases reported following the IPCC assumption that the dead organic matter stocks are not present in croplands, or they are in equilibrium. In some cases, however, some MS have reported this pool as a net sink (e.g., Sweden) or as a net source (e.g., Latvia).

A particular case is given by Finland which reports the notation key IE since the net carbon stock change in dead organic matter is included in losses in living biomass, explaining that the number of dead branches of currants and apple trees in modern orchards is very low and they are usually chipped and left to decay in the orchards.

With regard to carbon stock change in soils, these have been reported under mineral soils as either a net source or a net sink of carbon. The final net result is typically associated with an increase or decrease of the intensity in the soil management practices along the time series. By contrary, as reported by all countries, for cultivated organic soils the net result of carbon stock changes is associated with a source of CO_2 emissions. Methodologies for reporting this carbon pool follow, in most of the cases, IPCC tier 1 or tier 2 approaches, where carbon stock changes are estimated as the difference on the carbon stock in soils at two moments in time. In a few cases, carbon stock changes have been estimated by using models (e.g., C-tool by Denmark and ICBM by Sweden).

Applied Tier 2 methods rely often on the use of country-specific soil organic carbon reference values along with IPCC default values for relative change factors (i.e., for Fmg, Flu, Fi). In some cases, IPCC default relative change factors have been slightly modified to adapt them to national circumstances, but changes rely more on expert judgment than on a statistical analysis or systematic measurements. An exception is given by Austria, who derived own factors by close comparison with IPCC similar strata.

Parameters to estimate carbon stock change for living biomass of permanent crops vary depending on the types of crops and management practices across Europe, from North (i.e., bush-type currant crops) to South (i.e., olives trees and agroforestry systems).

Table 6. 19 Implied net carbon stock change factor for carbon pools in 4B1 (t C ha-1 yr-1) reported by individual submissions GHGI 2023.

Country	Net carbon stock change in living biomass per area (t C/ha)		Net carbon stock change in dead organic matter per area (t C/ha)		Net carbon stock change in mineral soils per area (t C/ha)		Net carbon stock change in organic soils per area (t C/ha)	
	1990	2021	1990	2021	1990	2021	1990	2021
AUT	0,002	-0,007	NO	NO	0,001	-0,003	NO	NO
BEL	NO	0,000	NO	NO	-0,041	-0,014	-10,000	-10,000
BGR	0,000	-0,006	NA	NA	0,058	0,052	-7,900	-7,900
HRV	0,000	0,002	NO	NO	0,000	-0,011	-10,000	-10,000
CYP	0,142	0,147	NA	NA	0,000	0,001	NO	NO
CZE	0,001	0,001	NO	NO	0,000	0,001	NO	NO
DNM	-0,007	-0,054	NA	NA	-0,091	0,057	-8,076	-7,521
EST	0,000	-0,001	NE	NE	NO	0,024	-5,000	-5,000
FIN	0,000	0,000	IE	IE	0,003	-0,133	-6,468	-6,530
FRK	0,000	-0,005	NA	0,000	-0,016	0,022	IE	IE
DEU	0,001	-0,001	NO,IE,NA	NO,IE,NA	-0,003	-0,001	-9,510	-9,682
GRC	0,073	0,074	NO	NO	NO	0,070	-10,000	-10,000
HUN	-0,002	-0,002	NO	NO	0,000	0,004	NO	NO
IRL	0,052	0,070	NO	NO	-0,002	0,029	NO	NO
ITA	-0,030	-0,047	NO	NO	0,031	0,080	-10,000	-10,000
LVA	0,001	0,003	0,000	-0,001	NA	NA	-4,800	-4,800
LTU	-0,015	-0,006	NA	NA	NO	0,293	IE	IE
LUX	0,000	-0,015	NO	NO	0,000	0,001	NO	NO
MLT	0,012	0,035	NE,NA	NE,NA	-0,006	-0,006	NO	NO
NLD	NA	NA	NA	NA	-0,368	-0,174	-3,994	-3,789
POL	0,030	0,034	NA	NA	-0,002	-0,008	-5,000	-5,000
PRT	0,022	0,263	NO	NO	0,005	0,011	NO	NO
ROU	0,008	0,036	NA	NA	0,022	0,247	-10,000	-10,000
SVK	0,245	0,205	NA	NA	0,009	0,015	NO,NE	NO.NE
SVN	0,013	-0,002	0,001	0,000	-0,002	0,002	-10,000	-10,000
ESP	0,003	0,040	NA	NA	NO	0,031	NO	NO
SWE	0,002	0,023	0,002	0,002	0,093	0,139	-6,220	-6,220

Whenever the Tier 1 assumption of “equilibrium” for carbon stock changes in living biomass of annual crops or dead organic matter was implemented, countries used the notation key NO, NE, or NA. Efforts have been devoted, and are ongoing to follow the recommendation from the UN ERT on the use of NA when the assumption of equilibrium is applied. As a result, more MS are now using the notation key NA. Nevertheless, it should be noted a full harmonization on the use of the notation key NA across MS is not possible since some countries have received from their UN ERT a different recommendation on which notation key should be used in this case.

6.2.2.3 Land converted to Cropland (CRF 4B2)

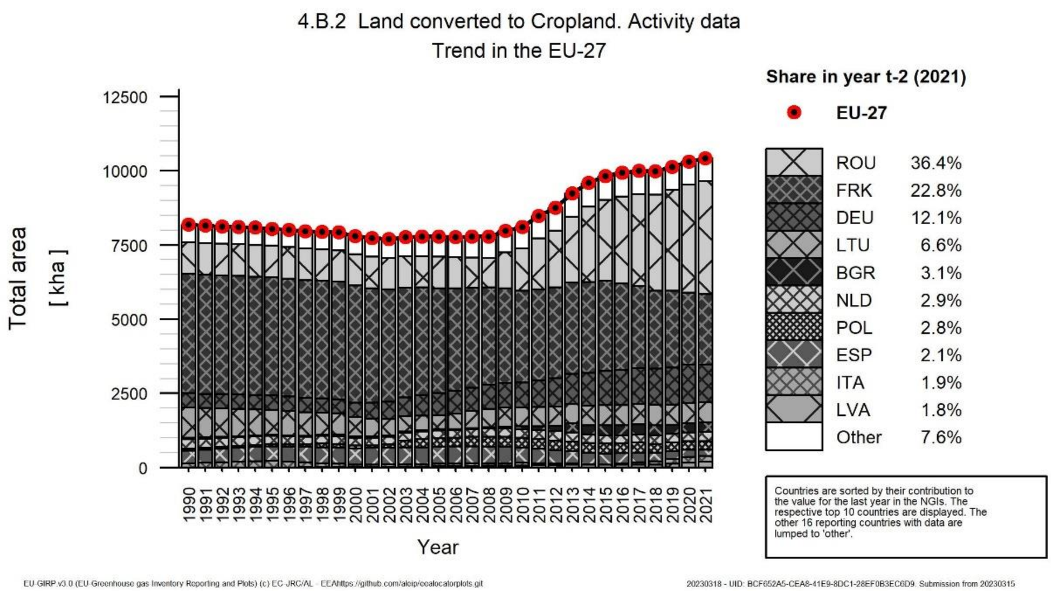
Overview of Land converted to Cropland category.

In terms of area, this subcategory represents 9% of the total cropland areas reported at the level of EU MS. However, it accounts for 75% of the net CO_2 emissions that are reported in Cropland.

In overall, for this inventory year the area increased by 23% as compared with 1990, from 8 181 kha reported for the year 1990, to 10 428 Kha in 2021 (Figure 6. 9).

Main conversions of lands to Cropland take place from areas of Grassland and Forest land. The trend in this subcategory is mainly driven by Romania, France and Germany, which report more than 60% of total area of new Croplands, often associated with rotation of crops and grasses on the same land.

Figure 6. 9 Trend of activity data in subcategory 4B2 "Land converted to Cropland" in EU KP (kha)



In terms of emissions, this subcategory is reported as a net source of emissions that for the current inventory year reaches 14 450 Kt CO_2. This represents a decrease of 10% as compared to 1990 (Table 6. 20). The largest emissions are reported by France, which reports about 48 % of the total emissions in this subcategory; followed by Germany (Figure 6.10).

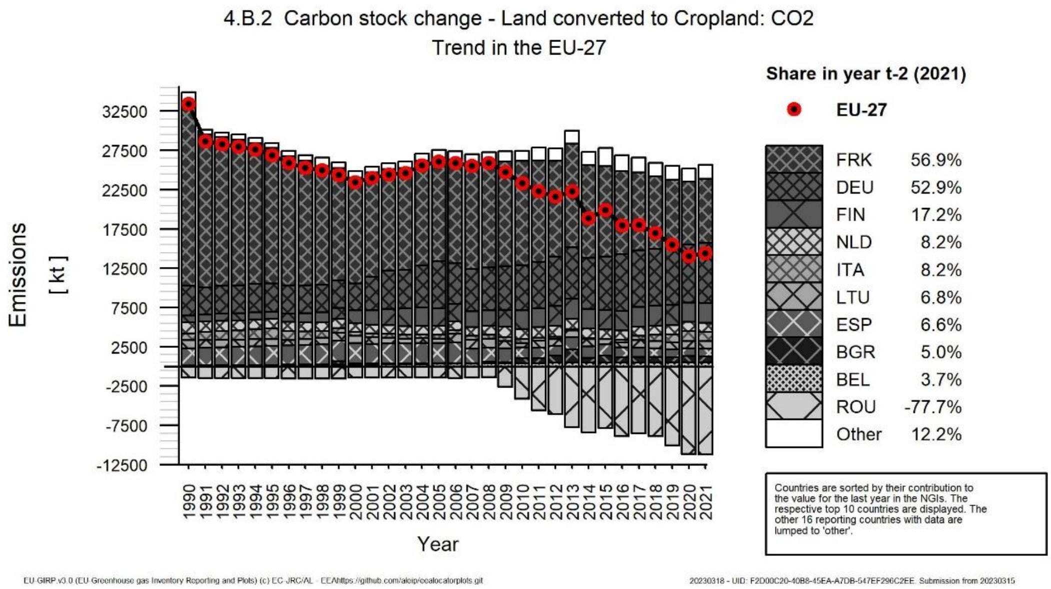
Nevertheless, some individual inventories report this subcategory as a carbon sink, as a result of removals from the living biomass carbon pool when lands are converted to Croplands with woody vegetation (e.g., Malta and Romania). With some few exceptions, all the other carbon pools are reported by the countries as a net source of emissions.

Table 6. 20 4B2 Land converted to Cropland: EU-27 contributions to net CO_2 emissions (+)/ removals (-) (CRF table 4)

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	190	207	211	1.5%	22	11%	4	2%
Belgium	41	519	531	3.7%	489	1184%	11	2%
Bulgaria	75	779	729	5.0%	654	870%	-50	-6%
Croatia	26	127	123	0.9%	98	378%	-4	-3%
Cyprus	0	6	6	0.0%	6	2405%	0	-1%
Czechia	121	60	62	0.4%	-59	-49%	2	4%
Denmark	89	88	70	0.5%	-18	-21%	-18	-20%
Estonia	NO,NE	126	123	0.9%	123	∞	-2	-2%
Finland	858	2 476	2 482	17.2%	1 624	189%	6	0%
France	22 770	8 032	8 210	56.8%	-14 560	-64%	178	2%
Germany	3 808	7 366	7 631	52.8%	3 823	100%	265	4%
Greece	52	17	17	0.1%	-35	-67%	1	4%
Hungary	30	146	153	1.1%	123	409%	7	5%
Ireland	NO	NO	NO	-	-	-	-	-
Italy	857	1 289	1 180	8.2%	323	38%	-109	-8%
Latvia	7	376	412	2.9%	405	5923%	36	10%
Lithuania	1 062	914	979	6.8%	-83	-8%	65	7%
Luxembourg	45	25	25	0.2%	-20	-44%	0	0%
Malta	-2	-1	-1	0.0%	1	42%	0	0%
Netherlands	1 394	1 163	1 187	8.2%	-207	-15%	24	2%
Poland	272	119	94	0.7%	-178	-65%	-25	-21%
Portugal	372	264	248	1.7%	-125	-34%	-17	-6%
Romania	-1 453	-11 137	-11 215	-77.6%	-9 762	-672%	-78	-1%
Slovakia	467	53	44	0.3%	-423	-91%	-9	-17%
Slovenia	200	58	60	0.4%	-140	-70%	2	3%
Spain	2 179	1 003	959	6.6%	-1 221	-56%	-44	-4%
Sweden	5	-27	131	0.9%	126	2793%	158	585%
EU-27	**33 463**	**14 046**	**14 450**	**100%**	**-19 013**	**-57%**	**403**	**3%**

As in other land use subcategories that involve the conversion of areas, the trends in the time series of emissions from Land converted to Cropland have been driven by the activity data. As for instance, in the case of Belgium, Bulgaria and Latvia that report an increase of the area converted to cropland under the subcategory 4B.2, which associate with a constant increase of the emissions in this subcategory. The opposite scenario is given by Portugal and France, which report significant reduction of emissions in this category driven by the trend in areas.

Figure 6. 10   Trend of emissions (+)/ removals (-) in subcategory 4B2 "Land converted to Cropland" in EU KP (kt CO_2)



Methodological issues for Land converted to Cropland.

For estimating and reporting carbon stock changes in this subcategory, the countries generally use the IPCC default methodology. However, implementation of country-specific or default emissions factors depends on which type of lands is being converted to Cropland, and the estimated carbon pool. For instance, concerning the living biomass carbon pool, some countries consider the carbon stocks from one year of growth in Cropland following conversion, while others only consider the oxidation of the carbon stock in the land that is converted to cropland.

Usually, it is assumed that the carbon stored in living biomass and dead organic matter is lost in the year of the conversion, while for soil organic carbon in mineral soils, following IPCC methodology, countries often apply a 20-year transition period before the carbon stock of the soils converted to cropland reach the equilibrium.

In recent years, improvements have been implemented also in this subcategory, including the use of higher methods (as requested by the ERT), which have resulted in an overall increase of accuracy and completeness of the sector.

For instance, Latvia also used country-specific data and Biosoil Project's results to report carbon stock changes from DOM following the conversion from Forest land to Cropland. Also, Poland improved the completeness of this category's reporting with the inclusion of carbon stock changes in living biomass following the conversion from Grassland to Cropland.

6.2.3 Grassland (CRF 4C)

6.2.3.1 Overview of Grassland category (CRF 4C)

Under this category are included lands covered by natural and artificial meadows, range lands, moors and forage crops. They can be subject to economic activities (e.g., grazing lands), or be considered unmanaged lands. In several instances, Grassland areas cover also woody lands (i.e., trees and shrub lands) when they do not fall into the thresholds used to define forest lands.

In overall, Grassland is reported as net source of emissions.

Based on individual submissions, for the current inventory year total Grassland covers 73 249 kha. This represents 17% of the total territory of EU. However, as for Cropland, these areas have constantly decreased, and nowadays these ecosystems cover 4% less area than in the base year.

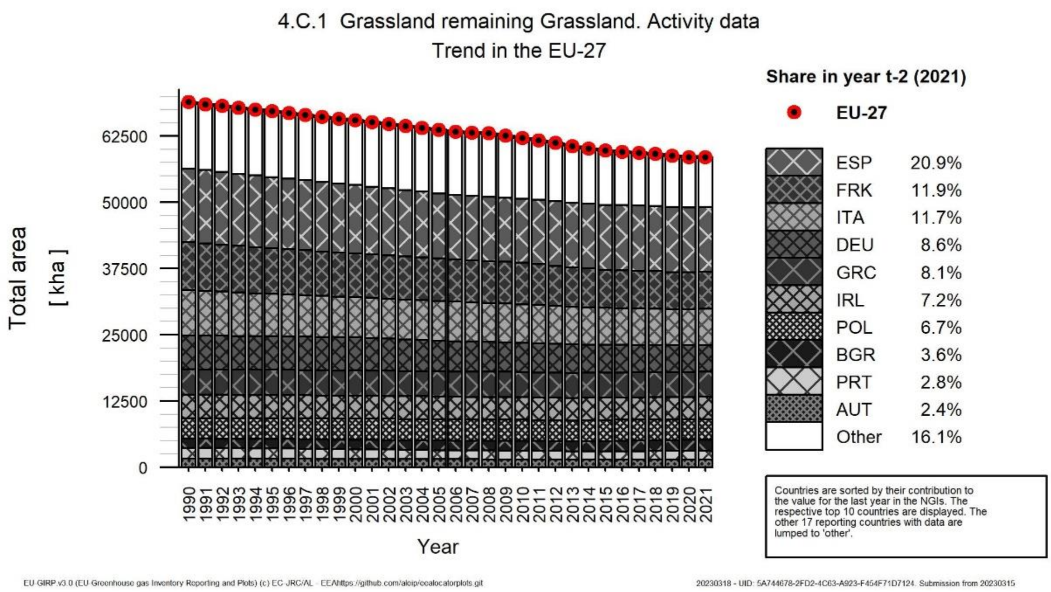
6.2.3.2 Grassland remaining Grassland (CRF 4C1)

Overview of Grassland remaining Grassland category

For the year 2021, total area reported under this subcategory reaches 58 543 kha. Following the general trend of these lands, this subcategory has also constantly decreased since 1990, and in 2021 it represents 15% less than in 1990 (Figure 6. 11).

Spain, France and Italy report together about 45% of the total area of Grassland remaining Grassland, while the 10 MS with the larger contribution account for about 85% of the total area.

Figure 6. 11 Trend of activity data in subcategory 4C1 "Grassland remaining Grassland" in EU-27 (kha)



In terms of emissions, this subcategory has always resulted in a net source at the level of EU. In the current inventory year, the reported emissions reached 34 688 kt CO_2, which represents a decrease of 32% as compared with the year 1990 (Table 6. 21).

Nevertheless, individual inventories have reported this subcategory either as a net source or as a net sink of carbon.

As in the case of cropland areas, the net result of the carbon stock change in grassland depends on the one hand on whether these areas are subject to agricultural activities, and particularly if they occur in organic soil areas, but also on the presence or absence of significant woody biomass and the intensity and variation of management practices over the years.

Table 6. 21 4C1 Grassland remaining Grassland: EU-27 contributions to net CO_2 emissions (+)/removals (-) (CRF table 4)

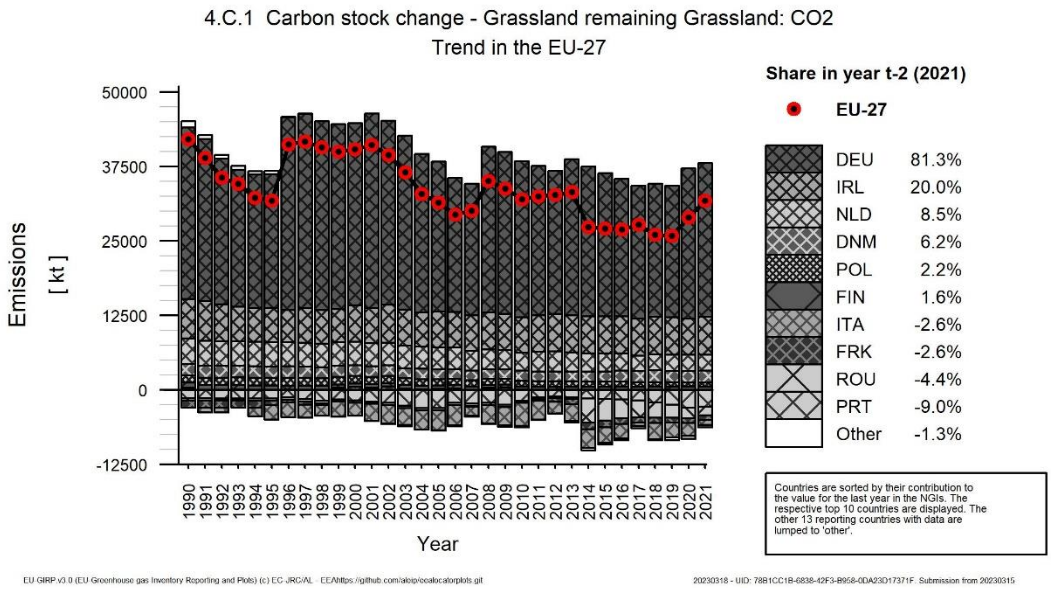
Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	294	296	296	0.9%	2	1%	0	0%
Belgium	29	212	218	0.6%	188	643%	5	2%
Bulgaria	201	96	93	0.3%	-108	-54%	-4	-4%
Croatia	2	2	2	0.0%	0	0%	0	0%
Cyprus	-23	-22	-22	-0.1%	2	7%	0	0%
Czechia	0	-309	-311	-0.9%	-311	-100%	-1	0%
Denmark	1 982	1 951	1 980	5.7%	-2	0%	28	1%
Estonia	8	8	8	0.0%	0	-1%	0	1%
Finland	852	521	523	1.5%	-329	-39%	2	0%
France	-1 218	-822	-822	-2.4%	396	33%	1	0%
Germany	28 769	25 223	25 833	74.5%	-2 937	-10%	610	2%
Greece	0	0	0	0.0%	0	105%	0	110%
Hungary	-30	-171	-146	-0.4%	-116	-392%	25	14%
Ireland	6 595	6 041	6 342	18.3%	-252	-4%	302	5%
Italy	5 367	-1 509	1 429	4.1%	-3 938	-73%	2 938	195%
Latvia	935	303	273	0.8%	-662	-71%	-31	-10%
Lithuania	O,NE,IE,NA	O,NE,IE,NA	O,NE,IE,NA	-	-	-	-	-
Luxembourg	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Malta	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Netherlands	4 259	2 703	2 698	7.8%	-1 562	-37%	-6	0%
Poland	1 309	712	702	2.0%	-606	-46%	-10	-1%
Portugal	2 334	-2 669	-2 203	-6.4%	-4 537	-194%	465	17%
Romania	-381	-1 724	-1 399	-4.0%	-1 018	-267%	324	19%
Slovakia	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Slovenia	195	-432	-405	-1.2%	-600	-308%	27	6%
Spain	-19	-41	-38	-0.1%	-18	-94%	4	9%
Sweden	-542	-368	-363	-1.0%	179	33%	5	1%
EU-27	**50 918**	**30 004**	**34 688**	**100%**	**-16 230**	**-32%**	**4 685**	**16%**

The EU trend in emissions from this subcategory is largely affected by Germany, Ireland, and Netherlands (Figure 6. 12). While for some of these countries, the overall share in areas of grassland remaining grassland is not significant at EU level, all of them report important areas of grasslands managed on organic soils that generate significant emissions.

By contrary some other MS have reported this subcategory as a net carbon sink. Examples are Portugal that reports a significant carbon sink from woody vegetation and Romania that reports a carbon sink from mineral soils on grassland areas.

In Mediterranean countries, this subcategory shows significant inter-annual variability driven by wildfires affecting woody biomass in grassland areas. These episodes, at present occurring erratically, are expected to increase because of the climate change.

Figure 6. 12 Trend of emissions (+)/removals (-) in subcategory 4C1 "Grassland remaining Grassland" in EU-27 (kt CO_2)



Methodological issues for Grassland remaining Grassland category

Despite of different eco-regions and management approaches among the countries, Grassland definitions show a good match with the IPCC land use definition (Table 6. 22). One of the most significant differences that should be considered when comparing implied emissions factors is the presence or absence of reported unmanaged grassland and the presence or absence of woody vegetation.

In general, there is a wide-spread use of the Tier 1 method for reporting carbon stock changes in living biomass and dead organic matter, which assumes no net carbon stock changes for these pools. However, some countries have developed country-specific data and (or) methodologies to assess the changes in these pools (e.g., Italy, Latvia, and Sweden). When this is the case, these pools are generally reported as a net sink that is associated with the presence of woody biomass on grassland areas.

Under mineral soils, a significant number of individual submissions have demonstrated that there are no changes over the time in the type of management practices that impact the carbon storage in the soils. In few cases also the absence of managed soils was argued. In these cases, quantitative estimates were not provided, and the notation keys were used instead. However, some other countries report this carbon pool using IPCC methodology, with country-specific or default data.

For those countries that report presence of organic soils areas under managed grassland, this carbon pool is reported as a net source of emissions that result from the oxidation of the soil organic matter (Table 6. 23).

Table 6. 22 Definitions of lands included under the category 4C: Grasslands.

Country	*Definition*
Austria	Meadows cut once/twice/several times, cultivated pastures, litter meadows, rough pastures, alpine meadows and pastures and abandoned grassland.
Belgium	Rangelands and pastureland that is not considered under cropland. It also includes systems with vegetation that fall below the threshold of forest land category and are not expected to exceed it, without human intervention.
Bulgaria	Grassland includes the permanent grasslands – natural meadows, low productive grasslands, permanent lawns and grassland which are not used for production purposes.
Croatia	Grassland includes pastures, land principally occupied by agriculture, with significant areas of natural vegetation, natural grasslands, moors and heathland, sclerophyllous vegetation.
Cyprus	This category includes rangelands and pastureland that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as bushes and sclerophyllous vegetation that fall

Country	*Definition*
	below the threshold values used in the Forest Land category. The category also includes all pastures, natural grassland and scarcely vegetated areas.
Czechia	Grassland as defined in this inventory is mostly used as pastures for cattle and meadows for growing feed. Additionally, the fraction of permanently unstocked cadastral FL is also included under Grassland. This is because it predominantly has the attributes of Grassland (such as land under power transmission lines).
Denmark	Land defined as grazing land under LPIS, heath land which may or may not be used for sheep grazing, as well as all other areas not meeting the definitions of forest land. The area of grassland is divided in “grazing land” and “other grassland”.
Estonia	Grassland includes rangelands and pasture, land that is not considered cropland nor forest land: land with perennial grasses that is proper for mow and pasture, smaller fallows and former cultural grasslands that have lost arable land features and grassland from wild lands (natural grassland). Overgrown wooded pasture with canopy cover between 30 and 50% is classified as grassland or forest, depending on the mainland-use purpose. The national land cover class ‘bushes’ (area covered with natural or wildered cultivated bush and shrub species where canopy cover is over 50%) is included into GL.
Finland	Grassland includes areas of extensive grass, ditches associated with agricultural land, areas of bioenergy plants and abandoned arable land. In this context, abandoned arable land refers to fields that are no longer used for agricultural production and where natural reforestation is possible or is already taking place.
France	Land covered by natural and seeded herbaceous for more than 5 years. Includes areas covered trees and bushes being under the forest definition or not included under land category.
Germany	Meadow and pasture areas that cannot be considered cropland. Includes land covered with trees and shrubs that does not fall within the definition of "forest", as well as natural grassland and recreational areas.
Greece	Rangeland and pasture with vegetation that falls below the threshold of national forest definition and are not expected to exceed that without human intervention. Pastures that have been fertilized or sown are considered as cropland.
Hungary	Grassland includes meadows, i.e., land under grass (artificial planting included) where the production is utilized by cutting, irrespective of whether it is used for grazing sometimes, and pasture, i.e., land under grass (artificial planting included) that is utilized for grazing irrespective of whether it is used for cutting sometimes. Grassland includes areas with trees which are utilized for grazing and unmanaged grasslands which are not in use for agricultural purposes.
Ireland	Improved grassland (pasture and areas used for the harvesting of hay and silage) and unimproved grassland (rough grazing) in use as recorded by annual statistics.
Italy	Grazing lands, forage crops, permanent pastures, and set-aside lands since 1970, all shrub lands (data derived from NFI) and other woodlands that do not fulfil forest definition.
Latvia	The grassland category consists of lands used as pastures, as well as glades and bushland which do not fit to forest definition, vegetated areas on non-forest lands complying to forest definition where land use type can be easily switched back to grassland without legal requirement of transformation of the land use, but except grassland used in forage production and extensively managed cropland.
Lithuania	Grassland includes meadows and natural pastures planted with perennial grasses or naturally developed, on a regular basis used for moving and grazing. Grasslands cultivated for less than 5 years, in order to increase ground vegetation, still remain grasslands.
Luxemburg	All grasslands that are not considered as cropland including systems with vegetation or tree cover below forest threshold, natural grassland, recreational areas as well as agricultural systems. It includes one cut meadows; two and more cut meadows, cultivated pastures, litter meadows, rough pastures and pastures and abandoned grassland.
Malta	This category is split into other grassland and maquis. On the basis of expert judgement, it was decided that maquis will be included in this category. The data of this category was derived from the Corine Land Cover 1996, 2000, 2006 under the sclerophyllous vegetation and Grassland.
Netherlands	Under Grassland (non-TOF) any type of terrain which is predominantly covered by grass vegetation is reported. It also includes vegetation that falls below the threshold used in the forest land category and is not expected to exceed the threshold used in the forest land category. It is further stratified in: 'Grassland vegetation', 'Nature', ‘Orchards’. Trees outside forests (TOF) are wooded areas that comply with the forest definition except for their surface area (< 0.5 ha or less than 30 m width). These represent fragmented forest plots as well as groups of trees in parks and nature terrains and most woody vegetation lining roads and fields.
Poland	Grassland consists of permanent meadow and pastures include land permanently covered with grass, but does not include arable land sown with grass as part of crop rotation; permanent meadow is understood as the land permanently covered with grass and mown in principle in mountain area; also, the area permanent pastures are understood as the land permanently covered with grass not mown but grazed in principle in mountain area; also the area of grazed pastures and meadows.
Portugal	Lands covered by permanent herbaceous cover.
Romania	Grassland includes land whose destination is grazing or mowing hay for livestock production, as well as other wooded land and trees outside forests (which do not meet forest definition parameters, e.g., forest belts which are narrower than 20m). It includes pastures, hayfields in hilly and mountainous areas and meadows in lowlands.
Slovakia	This category includes permanent grasslands and meadows used for the pasture or hay production, which is not considered as cropland.

Country	*Definition*
Slovenia	Agricultural areas grown by grass and other herbs that are regularly cut or grazed. These areas are not in tillage or fallow ground. Included are areas covered with some of forest trees (less than 50 trees/ha) and the alpine pastures too. In this class there are swamp pastures and meadows on organic or mineral-organic soils, where the groundwater rises few times in the year. It includes also uncultivated agriculture land.
Spain	Pastureland, including grazing land not included in cropland. It includes also pastures and meadows in the dehesa (forested pasture) that do not comply with the definition of forest.
Sweden	Agricultural land that is not regularly tilled. This corresponds to natural grazing land. All grasslands are assumed managed.

Table 6. 23 Implied net carbon stock change factors for carbon pools in 4C1 (t C ha-1 yr-1) reported by individual submissions in the GHGI 2023.

Country	Net carbon stock change in living biomass per area (t C/ha)		Net carbon stock change in dead organic matter per area (t C/ha)		Net carbon stock change in mineral soils per area (t C/ha)		Net carbon stock change in organic soils per area (t C/ha)	
	1990	2021	1990	2021	1990	2021	1990	2021
AUT	NA	NA	NO	NO	0,002	0,001	-6,402	-6,402
BEL	NO	NO	NO	NO	-0,008	-0,103	-1,521	-1,891
BGR	0,003	0,000	NE,NA	NE,NA	-0,028	-0,007	-6,100	-6,100
HRV	NO	NO	NO	NO	NO	NO	-2,500	-2,500
CYP	0,049	0,046	NA	NA	NA	NA	NO	NO
CZE	NO	NO	NO	NO	0,000	0,092	NO	NO
DNM	-0,015	-0,134	NA	NA	IE	IE	-6,602	-6,411
EST	NO	NO	NO	NO	NA	NA	-0,043	-0,045
FIN	0,119	0,183	NE	NE	NA	NA	-3,500	-3,500
FRK	0,000	-0,002	NA	0,000	0,037	0,034	IE	IE
DEU	-0,058	-0,130	NO,IE	NO,IE	NO,NA	0,007	-7,733	-7,648
GRC	0,000	0,000	NO	NO	NO	NO	NO	NO
HUN	NA	NA	NA	NA	0,007	0,033	NO	NO
IRL	NO	NO	NO	NO	-0,009	0,115	-4,672	-6,416
ITA	-0,011	0,019	0,004	0,004	-0,004	0,009	2,500	2,500
LVA	0,010	-0,033	0,002	0,174	NA	NA	-4,400	-4,400
LTU	NA	NA	NA	NA	NE	NE	IE	IE
LUX	NA	NA	NA	NA	NO	NO	NO	NO
MLT	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO	NO
NLD	0,009	0,007	NA	NA	0,122	0,293	-4,340	-4,378
POL	NO	NO	NO	NO	-0,043	0,001	-0,250	-0,250
PRT	0,191	0,470	NO	0,000	NO	0,000	NO	NO
ROU	0,008	0,013	NA	NA	0,024	0,346	-2,500	-2,500
SVK	NA	NO	NA	NO	NA	NA	NO	NO
SVN	-0,082	0,268	-0,018	0,058	-0,012	-0,002	NO	NO
ESP	NE	NE	NA	NA	0,000	0,001	NO	NO
SWE	0,155	0,158	0,233	0,069	0,092	0,187	-1,488	-1,387

6.2.3.3 Land converted to Grassland (CRF 4C2)

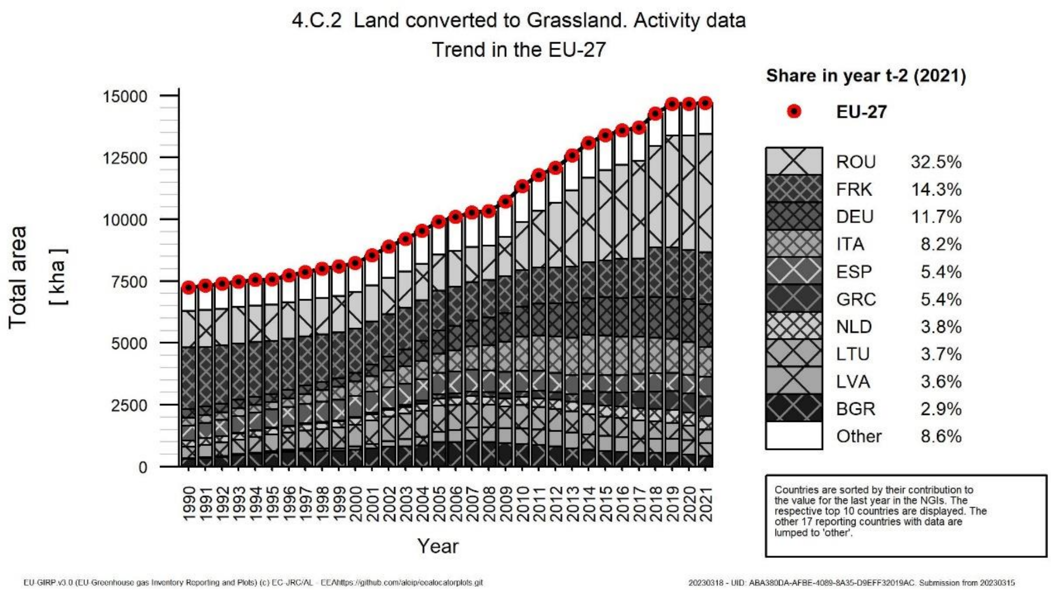
Overview of Land converted to Grassland category.

In terms of area, this subcategory represents 20% of the total grassland areas; however, the carbon sink reported offsets about 75% of the emissions resulting from grassland remaining grassland.

The area reported under this subcategory for this inventory year reached 14 706 kha, which is about two times the area reported in 1990 under this category (Figure 6. 13). Main conversions to grassland areas have origin in former croplands and, to a lesser extent, on forests land.

The main drivers of the EU trend on new grassland areas originate from the reporting of Romania, France and Germany, which together report about 60% of the total area converted to Grassland.

Figure 6. 13 Trend of activity data in subcategory 4C2 "Land converted to Grassland" in EU-27 (kha)



In terms of emissions, lands converted to Grassland represent in the current inventory year a total net sink of -13 438 kt CO_2, which corresponds to an increase of about 57% compared to the year 1990 (Table 6. 24).

The trend in GHG emissions for this subcategory is by far driven by Italy, and followed by Greece and Spain, in all cases, the net sink reported under this category is the result of carbon sequestration in mineral soils. By contrary, final net emissions, as reported for several countries, as for instance Sweden, are associated with emissions from the conversion of Forest land, and to a lesser extent, from woody crops to Grassland.

Table 6. 24 4C2 Land converted to Grassland: EU-27 contributions to the net CO_2 emissions (+)/removals (-) (CRF table 4)

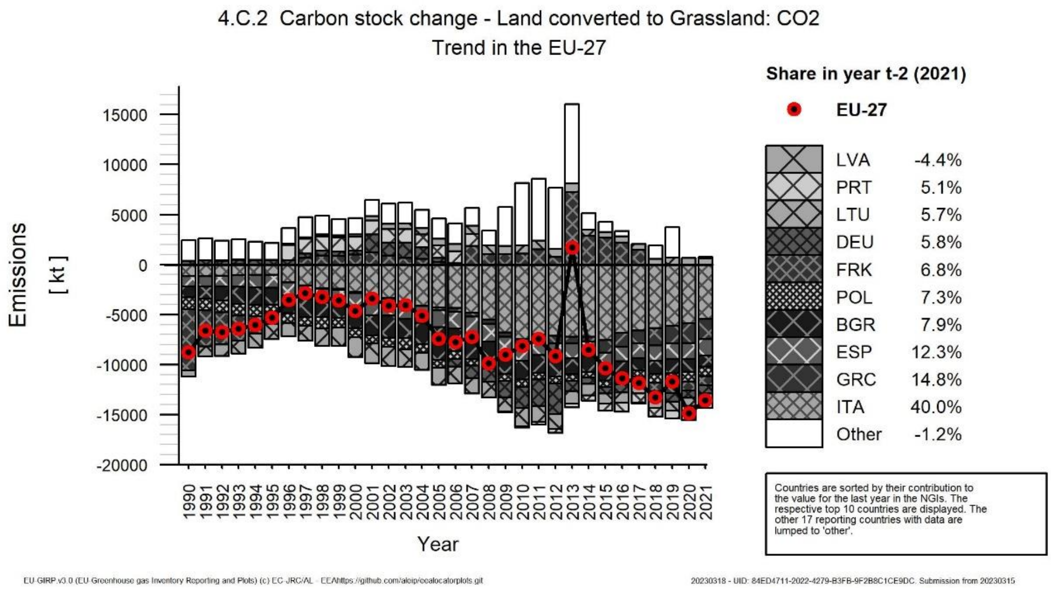
Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	391	147	138	-1.0%	-253	-65%	-9	-6%
Belgium	52	81	83	-0.6%	31	60%	2	2%
Bulgaria	-1 142	-1 301	-1 076	8.0%	67	6%	225	17%
Croatia	-10	-320	-311	2.3%	-301	-3023%	9	3%
Cyprus	0	2	2	0.0%	2	460%	0	0%
Czechia	-144	-168	-186	1.4%	-42	-29%	-18	-11%
Denmark	56	45	137	-1.0%	81	145%	92	206%
Estonia	0	-38	-36	0.3%	-35	-9187%	2	6%
Finland	168	186	179	-1.3%	11	7%	-7	-4%
France	-6 081	-911	-918	6.8%	5 163	85%	-7	-1%
Germany	352	-752	-787	5.9%	-1 139	-323%	-35	-5%
Greece	0	-1 944	-2 012	15.0%	-2 012	-7171701%	-67	-3%
Hungary	-4	62	204	-1.5%	209	4657%	143	232%
Ireland	3	14	10	-0.1%	7	243%	-4	-27%
Italy	-1 180	-5 885	-5 429	40.4%	-4 250	-360%	455	8%
Latvia	8	675	603	-4.5%	594	7158%	-72	-11%
Lithuania	-619	-811	-778	5.8%	-160	-26%	33	4%
Luxembourg	-35	-28	-28	0.2%	7	19%	0	0%
Malta	-9	-3	-3	0.0%	6	68%	0	10%
Netherlands	-313	-112	-93	0.7%	220	70%	19	17%
Poland	-1 207	-972	-985	7.3%	222	18%	-13	-1%
Portugal	NO	-744	-677	5.0%	-677	-∞	67	9%
Romania	2 188	-896	-519	3.9%	-2 707	-124%	377	42%
Slovakia	-196	-93	-55	0.4%	141	72%	38	40%
Slovenia	-472	34	48	-0.4%	520	110%	13	39%
Spain	-786	-1 502	-1 546	11.5%	-760	-97%	-44	-3%
Sweden	419	462	597	-4.4%	179	43%	136	29%
EU-27	**-8 560**	**-14 773**	**-13 438**	**100%**	**-4 877**	**-57%**	**1 335**	**9%**

Major changes in the time series of emissions from Land converted to Grassland have been reported by France, Portugal Italy, and Spain, mainly driven by the activity data.

New grassland areas are associated with the abandonment of cropland areas that result in a larger carbon sink reported in mineral soils at the end of the time series as compared with the base year. This is for instance reported by Germany. By contrary, some countries report a significant decrease of the carbon sink in these lands driven by the decrease of these areas but also when they are affected by wildfires in specific years.

The EU trend for this category reflects in the year 2013 the impact of the reporting of France that in 2021 has introduced a complete update of the methodology for land use change monitoring and for calculating carbon fluxes using a spatially explicit approach. This new method led to various recalculations, among others the area of deforestation, which is the main driver of the increase in the emissions for that year.

Figure 6. 14 Trend of emissions (+)/removals (-) in subcategory 4C2 "Land converted to Grassland" in EU 27 (kt CO_2)



Methodological issues for Land converted to Grassland category.

For estimating and reporting carbon stock changes in this subcategory, IPCC default methodology is generally used. The implementation of country-specific emission factors or default factors depends on which type of lands are being converted to Grassland, and on the estimated carbon pool. For instance, while some countries only consider a gross quantity of carbon loss from the conversion of forest lands to grassland, some others provide a net estimate on this carbon pool, by also considering one year of growth after the establishment of the grassland.

Usually, it is assumed that the carbon stored in living biomass and dead organic matter is lost in the year of the conversion, while for soil organic carbon in mineral soils, following IPCC methodology, countries often apply a 20-year transition period before the carbon stock of the soils converted to Grassland reach equilibrium.

During the las years, the efforts devoted by the countries to assess soils organic carbon contents in these areas, have resulted in more accurate quantification of the carbon stock change that occur in managed grassland and as a result of the conversion to and from grasslands.

6.2.4 Wetlands, Settlements and Other land (CRF Tables 4D, 4E, 4F)

6.2.4.1 Wetlands (CRF 4D)

In terms of area, Wetlands represents 23 866 kha, which represents 6% of the total EU area. The category has shown a constant slight increase, resulting in about 2% more area in the reporting year, as compared to the base year.

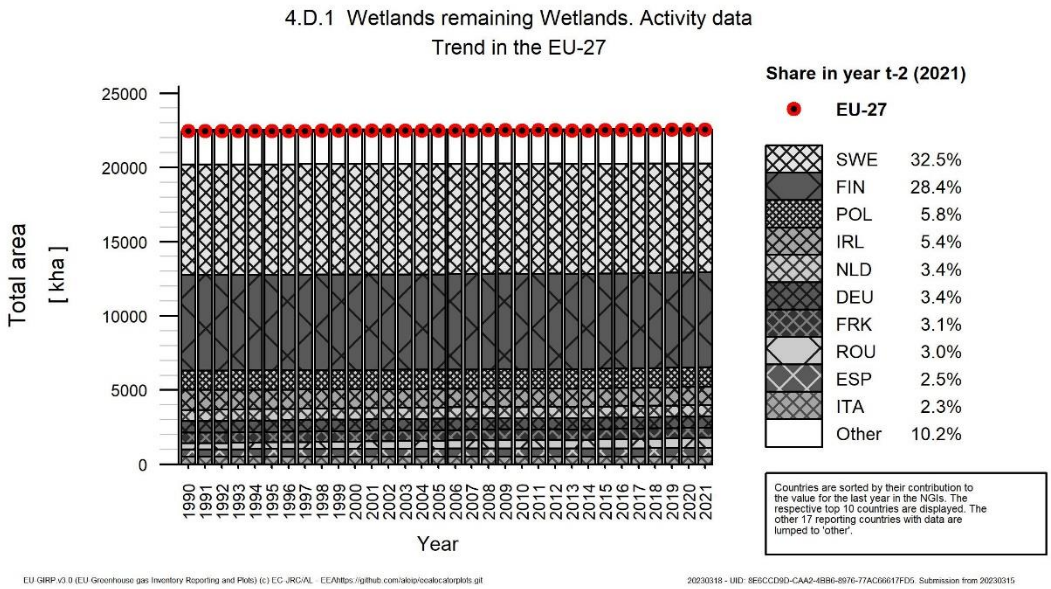
The trend in areas show a fairly constant area of Wetlands dominated by Sweden and Finland, and mainly for the dominant subcategory of Wetlands remaining Wetlands (

Figure 6. *15*).

In terms of emissions, Wetlands remaining Wetlands reaches for this inventory year about 10 217 ktCO_2. Subcategories, 4D1 and 4D2, have been in overall reported as a net source of emissions, resulting mostly from countries reporting the productive management activities of peatland areas. On the other hand, in some countries these subcategories have been also reported as a net carbon sink.

The main driver of emissions in this category is indeed the occurrence of peat extraction areas, which even if affecting relatively small areas at country level has a big impact on the overall emissions from LULUCF. Within the EU, Germany, Ireland, Finland, and Estonia are the main contributors of the emissions from Wetlands remaining wetlands.

Figure 6. 15 Trend of activity data and emissions (+)/removals (-) in subcategory 4D1 "Wetlands remaining Wetlands" in EU-27 (kha, Kt CO_2)



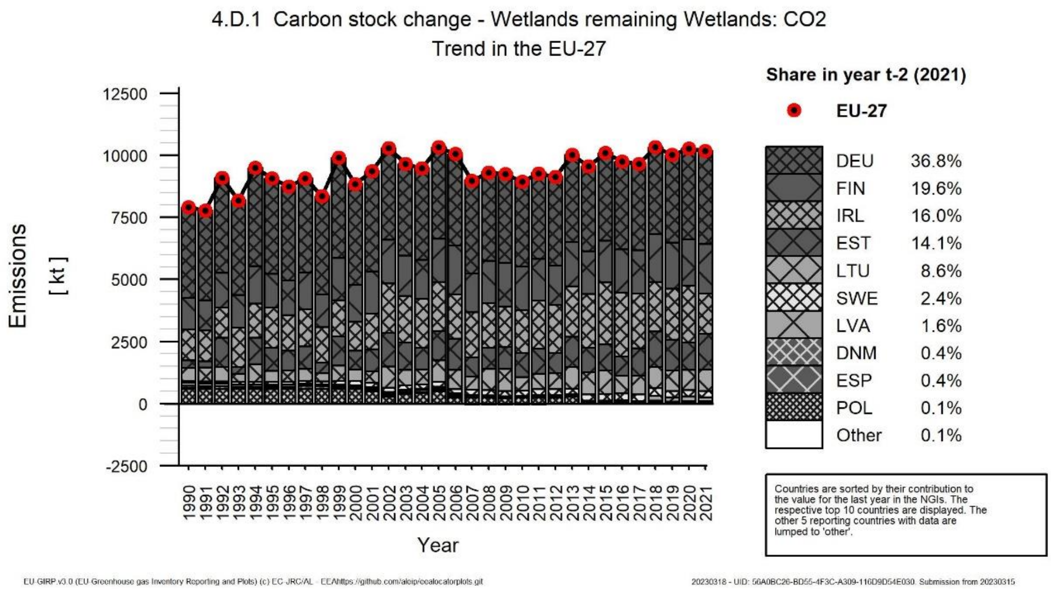


Table 6. 25 CO_2 Emissions and removals from 4.D.1 wetlands remaining wetlands contributions to the net CO_2 emissions (+)/removals (-) (CRF table 4)

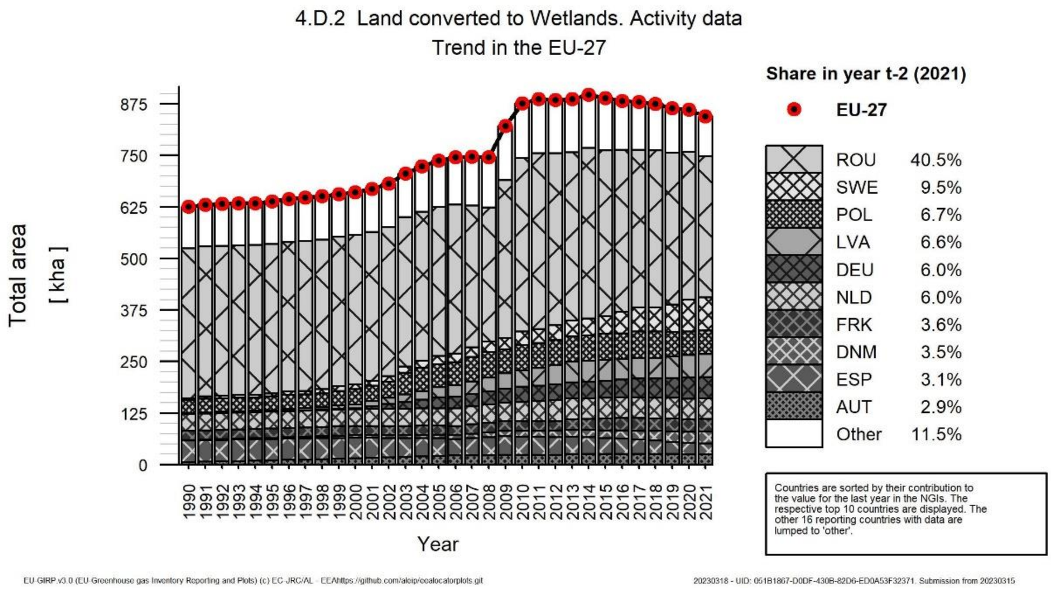
Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	NE,NO	2	NO,NE	-	-	-	-2	-100%
Belgium	NO	NO	NO	-	-	-	-	-
Bulgaria	NE,NO	NO,NE	NO,NE	-	-	-	-	-
Croatia	NO	NO	NO	-	-	-	-	-
Cyprus	NE,NO	NO,NE	NO,NE	-	-	-	-	-
Czechia	NA	NA	NA	-	-	-	-	-
Denmark	100	43	43	0.4%	-57	-57%	0	0%
Estonia	299	1 104	1 438	14.1%	1 139	382%	334	30%
Finland	1 269	1 873	1 991	19.5%	722	57%	118	6%
France	O,NE,IE,NA	10	11	0.1%	11	∞	1	13%
Germany	3 677	3 650	3 740	36.6%	63	2%	91	2%
Greece	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Hungary	NO,IE	0	NO,IE	-	-	-	0	-100%
Ireland	1 648	2 403	1 672	16.4%	24	1%	-731	-30%
Italy	NE,NO	NO,NE	NO,NE	-	-	-	-	-
Latvia	131	199	161	1.6%	31	24%	-38	-19%
Lithuania	517	810	872	8.5%	354	69%	62	8%
Luxembourg	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Malta	0	0	0	0.0%	0	-310%	0	0%
Netherlands	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
Poland	578	14	12	0.1%	-566	-98%	-2	-15%
Portugal	NO	0	0	0.0%	0	∞	0	-8%
Romania	-3	NO,NA	NO,NA	-	3	100%	-	-
Slovakia	NO	NO	NO	-	-	-	-	-
Slovenia	NO,NE,NA	NO,NE,NA	NO,NE,NA	-	-	-	-	-
Spain	31	38	38	0.4%	7	23%	0	0%
Sweden	75	251	239	2.3%	164	218%	-12	-5%
EU-27	**8 320**	**10 397**	**10 217**	**100%**	**1 896**	**23%**	**-181**	**-2%**

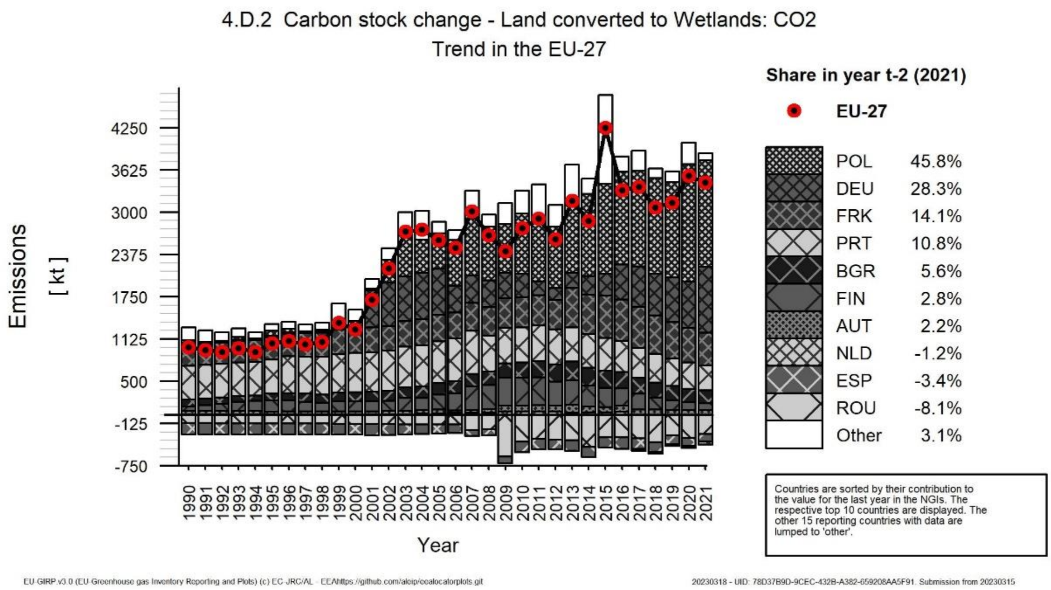
The other subcategory, Land converted to wetlands, represents only 4% of the wetlands area but results in about 25% of the final net emissions reported within the category. For the current inventory year, this subcategory category has reached respectively 845 kha, and 3 437 kt CO_2. In terms of emissions this represents almost three times more than the reported emissions in the base year. The main driver is Poland that reports since 2001 a significant increase of land area in conversion to wetlands which, in particular, is done by clearing grassland.

The area of land converted to wetlands is dominated by Romania and France. Overall, this area has increased by 56% as compared with 1990, mainly driven by new areas reported by Sweden, Germany and Italy in the second half of the time series (Figure 6.16).

Nevertheless, these new areas are not always linked to carbon stock changes, as in some cases new wetlands areas are the result of the conversion of lands with insignificant carbon stocks to Other wetlands (i.e. mires and areas saturated by fresh water).

Figure 6. 16 Trend of activity data and emissions (+) / removals (-) in subcategory 4D2 "Lands converted to Wetlands" in EU-27 (kha, Kt CO_2)





Emissions in this subcategory are mainly reported by Poland and Germany as a result of the loss of carbon from the living biomass existing in the lands that are converted to wetlands.

Table 6. 26 CO_2 Emissions and removals from 4.D.2 land converted to wetlands contributions to the net CO_2 emissions (+)/removals (-) (CRF table 4)

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	47	74	76	2.2%	28	60%	2	3%
Belgium	11	-4	-4	-0.1%	-15	-137%	0	-8%
Bulgaria	104	201	191	5.6%	87	84%	-10	-5%
Croatia	77	11	12	0.3%	-65	-85%	1	5%
Cyprus	NO	0	0	0.0%	0	∞	0	0%
Czechia	24	36	27	0.8%	3	11%	-10	-27%
Denmark	3	35	12	0.3%	9	265%	-24	-67%
Estonia	9	24	6	0.2%	-3	-31%	-17	-73%
Finland	65	114	97	2.8%	31	48%	-17	-15%
France	288	510	484	14.1%	195	68%	-27	-5%
Germany	15	680	974	28.3%	958	6211%	294	43%
Greece	NO	1	2	0.1%	2	∞	1	136%
Hungary	3	-3	-3	-0.1%	-6	-192%	0	-7%
Ireland	NO,IE	10	10	0.3%	10	∞	0	-2%
Italy	NO	32	NO	-	-	-	-32	-100%
Latvia	0	22	23	0.7%	23	18091%	1	4%
Lithuania	63	131	NO,NE	-	-63	-100%	-131	-100%
Luxembourg	0	2	2	0.1%	2	1311%	0	0%
Malta	0	NO	NO	-	0	100%	-	-
Netherlands	11	-31	-41	-1.2%	-52	-475%	-10	-32%
Poland	68	1 741	1 574	45.8%	1 506	2211%	-167	-10%
Portugal	501	389	370	10.8%	-131	-26%	-19	-5%
Romania	-121	-337	-279	-8.1%	-158	-130%	58	17%
Slovakia	NO	NO	NO	-	-	-	-	-
Slovenia	2	20	20	0.6%	18	773%	0	0%
Spain	-169	-120	-116	-3.4%	52	31%	4	3%
Sweden	NO,NA	NO,NA	NO,NA	-	-	-	-	-
EU-27	**1 004**	**3 539**	**3 437**	**100%**	**2 433**	**242%**	**-102**	**-3%**

Under this category, countries include different lands that are not always subject to management practices. This explains why countries with the largest share on areas not always report the largest emissions. For instance, this happens when areas within wetlands include flooded lands, or other wetlands that are not subject to management activities. Carbon fluxes are not reported in these areas, mainly due to lack of IPCC methods and the absence of country specific data.

Table 6. 26 Definitions of lands included under the category 4D: Wetlands.

Country	***Definition***
Austria	Rivers, lakes, mires and peat areas (protected areas, in general) as classified by national statistical system.
Belgium	Land covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the other land category. It includes reservoirs as a managed subdivision and natural rivers and lakes as unmanaged subdivisions.
Bulgaria	Wetlands category - wetlands surface water areas are included (wetlands) – covered with water or water saturated lands (throughout the year or partially in the year) which does not fall in the other categories. These are natural or artificial watercourses serving as water drainage channels, natural or artificial stretches of water, coastal lagoons, wetlands areas and peatbogs.
Croatia	Inland marshes, salt marshes, salines, intertidal flats, water courses, water bodies, coastal lagoons
Cyprus	This category contains areas of land that is covered or saturated by water for all or part of the year and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. In particular, it contains inland and salt marshes, water courses and water bodies.
Czechia	Category Wetlands includes riverbeds, and water reservoirs such as lakes and ponds, wetlands and swamps.
Denmark	Permanent wetlands, wetlands for peat extraction and re-established anthropogenic wetlands. Several subdivisions may be distinguished: unmanaged fully water covered wetlands (lakes and rivers); unmanaged

Country	*Definition*
	partly water covered wetlands (fens and bogs); managed drained land for peat extraction; managed partly water covered wetlands (re-established wetlands on primarily former cropland and grassland).
Estonia	Land permanently saturated by water and/or areas where the peat layer is at least 30 cm, and the minimum potential tree height does not conform to the forest land definition. It does include smaller bog holes.
Finland	Inland waters (reservoirs, natural lakes and rivers), peat extraction areas and peatlands which do not fulfil the definition of other land uses.
Germany	Reporting in the wetlands category primarily covers emissions from organic soils that are released during peat extraction, covering: CO_2 losses from extraction areas, and during extraction and spreading of peat. Also, it includes (but they are not estimated) the few non-drained semi-natural bogs that have been largely free of anthropogenic impacts, flooded lands, water-storage facilities (dams, reservoirs, etc.) and settling basins that are used for energy production, irrigation, shipping and recreation, and that are flooded or drained, or that otherwise have large water-level fluctuations.
Greece	Land that is covered or saturated by water for all or the greatest part of the year (e.g., lakes, reservoirs, marshes), riverbed (including torrent beds) and that does not fall into the forest land, cropland, grassland or settlements categories.
France	Lands covered or saturated by water all year long or part of it.
Hungary	Wetland includes the wetlands and water bodies as defined by the CORINE land-cover databases and contain inland marshes (low-lying land usually flooded in winter, and more or less saturated by water all year round), peat bogs (peat land consisting mainly decomposed moss and vegetable matter), water courses (natural or artificial watercourses including those serving as water drainage) and water bodies (natural or artificial lakes, ponds etc.).
Ireland	Natural unexploited wetlands and areas commercially exploited for public and private extraction of peat and areas used for domestic harvesting of peat.
Italy	Lands covered or saturated by water, for all or part of the year, have been included in this category (MAMB, 1992). Reservoirs or water bodies regulated by human activities have not been considered.
Latvia	Wetlands category includes all inland water bodies (rivers, ponds, and lakes), swamps (constantly wet areas where height of trees cannot reach more than 5 m in height and ground vegetation consists mostly of sphagnum and different sword grasses), flood-lands (small areas) and alluvial lands (larger flood-lands).
Lithuania	Wetlands include peat extraction areas and peat lands which do not fulfil the definition of other categories. Water bodies and swamps (bogs) are also included under this category. Peat extraction areas are considered as managed land.
Luxemburg	Land that is covered or saturated by water for all or part of the year (e.g., peat land, reservoirs) and that does not fall into other categories.
Malta	In the Maltese islands wetlands are mostly saline.
Netherlands	Land covered or saturated with water for all or part of the year and does not fall into the other land category. It includes reservoirs as a managed sub-division and natural lakes and rivers as unmanaged, including natural open water in rivers, but also man-made open water in channels, ditches and artificial lakes.
Poland	Wetland consists of 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, land under ponds including water reservoirs (excluding lakes and dam reservoirs for water level adjustment) including ditches and areas adjacent and related to ponds; land under ditches including open ditches acting as land improvement facilities for land used.
Portugal	Inland wetlands, coastal wetlands, salt marshes, saline and intertidal flats.
Romania	Wetlands includes all lands covered by water (rivers, ponds, dams, swimming pools, etc.) and land affected by humidity (caused by water stagnation, marshy areas, etc.), with the exception of agricultural land. It contains two sections (waters and wetlands) and 11 categories (permanent streams, temporary streams, lakes, dams, floating vegetation, hydrophilic vegetation (stubble etc.), harbours, temporarily flooded areas, bogs, channels and piers.
Slovakia	The wetlands include artificial reservoirs and dam lakes, natural lakes, rivers and swamps.
Slovenia	Wetlands are defined as land that is temporarily or permanently saturated by water. Wetlands include lands such as fens, marshes, bogs and reeds and are not under agricultural use. Inland water bodies (major rivers, lakes and water reservoirs) are also part of Wetlands. Although there are small areas of raised bogs, all Wetlands are assumed managed.
Spain	Includes the lands covered or saturated by water all year long or part of it.
Sweden	Wetlands is assumed unmanaged (mires and areas saturated by fresh water) and managed (cca 10 000 ha used for peat extraction).

6.2.4.2 Settlements (CRF 4E)

In terms of area, this land use category represents 28 181 kha, which is 7% of the total reported area. For the year 2021, Settlements areas have resulted in an increase of 25% as compared with 1990.

The expansion of these areas, which generally include urban areas, either paved or unpaved, transport infrastructures, and industrial and commercial units, has been mainly driven by the urban expansion on abandonment of agricultural lands.

In terms of emissions, this land use category is reported as a net source that reaches 24 079 kt CO_2 in 2021. Out of this, 95% are due to emissions resulting from Land converted to Settlement, which although in terms of area represents only 18% of the total category, results in significant emissions when forest, other woody lands, or high-carbon content soils are converted to urban areas.

Definitions of lands included under this category vary across individual inventories (Table 6.).

Table 6. 27 Definitions of lands included under the category 4E: Settlements.

Country	*Definition*
Austria	Includes buildings land: sealed, partly sealed and unsealed areas; parks and gardens; roads and railway tracks; excavation areas, and other not further differentiated settlement area.
Belgium	All developed land, including transportation infrastructure and human settlements of any size (i.e., including roadsides) unless they are already included under other categories.
Bulgaria	The Settlements refer to all classes of urban formation. These are areas that are functionally or administratively associated with public or private land in cities, villages or other settlement types.
Croatia	Continuous and discontinuous urban fabric area, industrial or commercial units, road and rail networks and associated land, port areas, airports, mineral extraction sites, dump sites, construction sites, green urban areas, sport and leisure facilities.
Cyprus	All developed land, including transportation infrastructure and human settlements of any size. It contains industrial and commercial units, urban areas, port areas, airports, construction, mineral extraction and waste dump sites.
Czechia	Settlements include two categories built-up areas and courtyards and other lands. Other lands include all types of land-use were included with the exception of “unproductive land”, which corresponds to category 4.F Other Land. Hence, the Settlements category also includes all land used for infrastructure, as well as that of industrial zones and city parks.
Denmark	Urban cores, industrial areas, roads, high and low build-up areas. Low build-up areas are characterized as single-family houses surrounded by gardens, graveyards, sports facilities, etc. (estimates are reported only for low build-up areas).
Estonia	Built-up areas, with roads, streets and squares, traffic and power lines, urban parks, industrial and manufacturing land, sports facilities, airports, legal waste down points, construction sites and buildings with up to 0.3 ha of garden yard (including permanent greenhouses), and open cast areas (except peat extraction areas) are included into this land-use category
Finland	Combined area of NFI built-up land, traffic lines and power lines. Includes parks, yards, farm roads and barns.
France	Artificialized land (settlements, parks, roads and infrastructure, etc.).
Germany	Open settlement and transport areas.
Greece	Developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other land-use categories.
Hungary	Settlements comprises the urban areas, industrial, commercial and transport units, as well as mines, dump and construction sites and artificial non-agricultural vegetated areas.
Ireland	Urban areas, roads, airports and the footprint of industrial commercial/institutional and residential buildings.
Italy	Artificial surfaces, transportation infrastructures (urban and rural), power lines and human settlements of any size, comprising also parks.
Latvia	According to national definitions settlements include land under buildings including yards and gardens as well as land necessary to maintain and to access those buildings; land under roads including buffer zones; forest infrastructure excluding ditches and other wetlands, but including seed orchards, forest nurseries and firebreaks; other infrastructure – buffer zones of industrial networks, quarries etc.
Lithuania	All urban territories, power lines, traffic lines and roads are included under this category as well as orchards and berry plantations planted in small size household areas and only used for householders’ meanings.
Luxemburg	Developed land, including transportation and any size of human settlement unless already included under other category.
Malta	The land-use category Settlements includes all classes of urban tree formations, namely trees grown along roads and streets, in public and private gardens, and in cemeteries, airports, construction sites, dumpsites, industrial or commercial units, port areas and sport and leisure facilities.
Netherlands	Developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories.
Poland	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

Country	Definition
	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; 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: roads; stopping 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; railway grounds; other transport grounds.
Portugal	Includes all artificial territories, including cities and villages, industry, roads and railway, ports and airports.
Romania	Settlements has 3 groups (urban/rural, buildings and infrastructure) and includes: fenced and constructed areas, sealed lands (e.g., car parks, roundabouts, platforms), urban/rural lawns, playgrounds in green areas, beach lawn and other areas with lawn, dwellings, industrial and administration buildings (e.g., banks, churches, railway stations, restaurants), warehouses, huts, ruins, greenhouses, graveyards, dirt roads, trails, rail roads and roads (street, sidewalk, square), bridges and dams.
Slovakia	The settlements include all developed land, including transportation infrastructure and human settlements of any size.
Slovenia	Settlements are all piece of land where the buildings, roads, parking places, mines, stone pits and all other infrastructure are in human use.
Spain	All developed land, transport infrastructure and establishments of any size, unless they are included in other categories.
Sweden	Infrastructure such as roads and railways, power lines, municipality areas, gardens and gravel pits.

As regards the methods used for reporting carbon stock changes in these areas, often countries used the Tier 1 assumption of equilibrium under the subcategory 4E1, therefore no carbon stock changes are reported, and notation keys are accordingly included in the CRF tables.

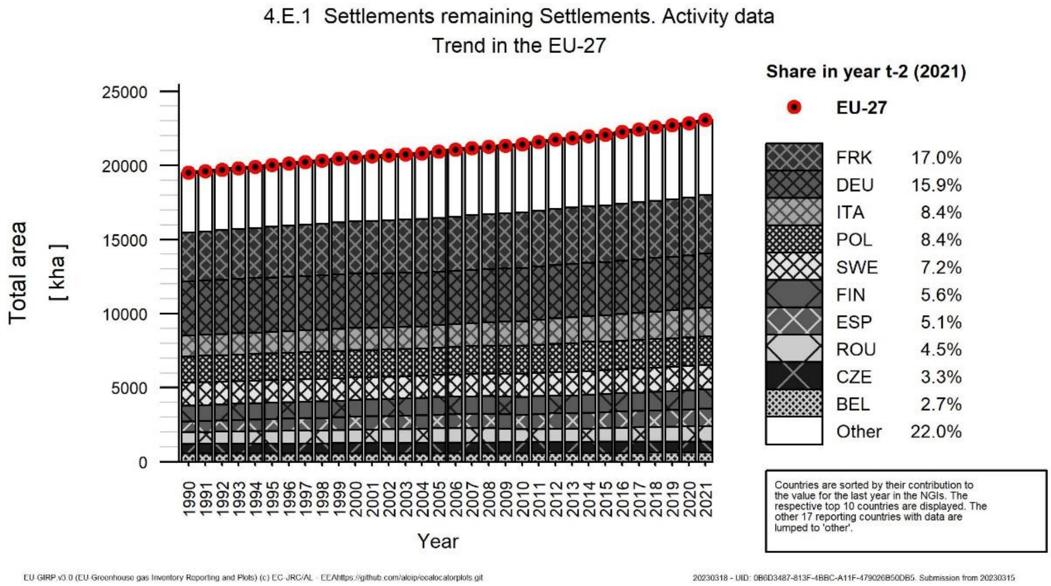
Nevertheless, a few countries have reported this subcategory as a net source of GHG emissions. For instance, Germany, and Netherlands have reported emissions as a result of disturbed organic soils in these areas.

By contrary, Latvia, Poland, Sweden and Slovenia have reported the subcategory 4E1 as a net sink of carbon due to carbon accumulation from living biomass on green urban areas (

Figure 6.17; Figure 6.18).

A particular case is Latvia that reports a remarkable increase in the sink of this category in 2012. It is explained because carbon stock changes in living biomass and dead organic matter for different land use categories are calculated using the most recent available national forest inventory data “floating NFI cycle” and then with average values used for different periods. The increase of carbon stock in living biomass in settlements reflects an increase of age and gross increment of trees growing on settlements, as well as increased area of settlements covered by woody vegetation. Reduction of increment in 2017 is a result of changes in age structure of woody vegetation, caused by more intensive extraction of trees in settlement areas such as roadsides, buffer zones of drainage ditches and other settlements. The losses due to extraction of wood in settlements are accounted using instant oxidation method due to lack of knowledge about further use of biomass.

Figure 6.17 Trend of activity data and emissions (+)/removals (-) in subcategory 4E1 "Settlements remaining Settlements" in EU-27 (kha, kt CO_2)



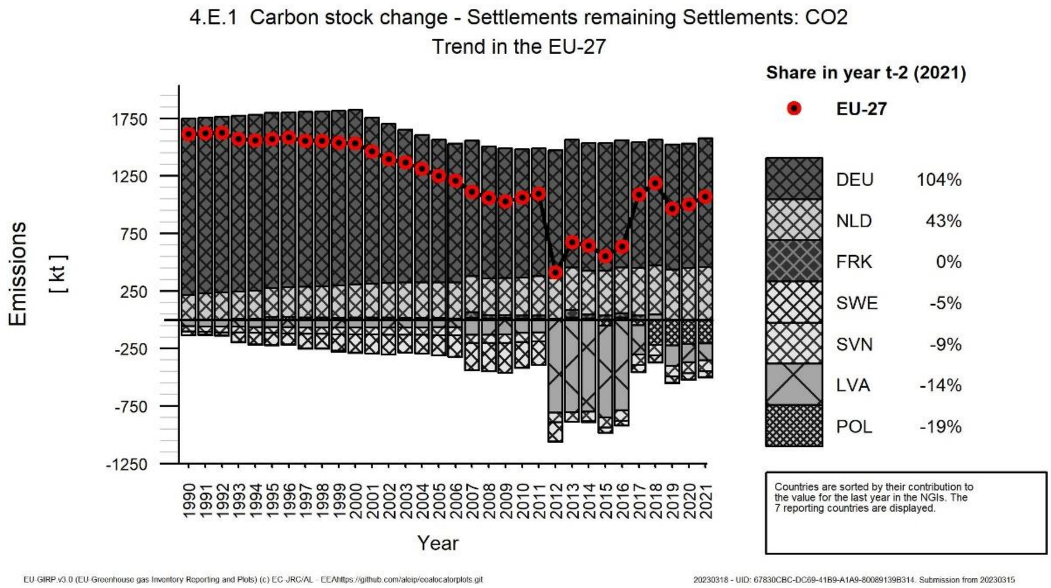
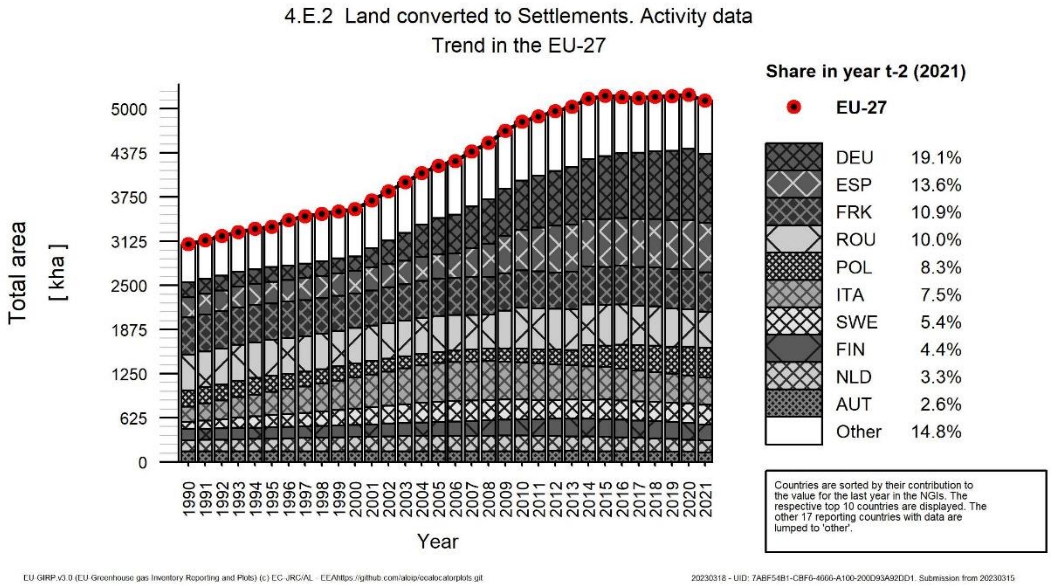
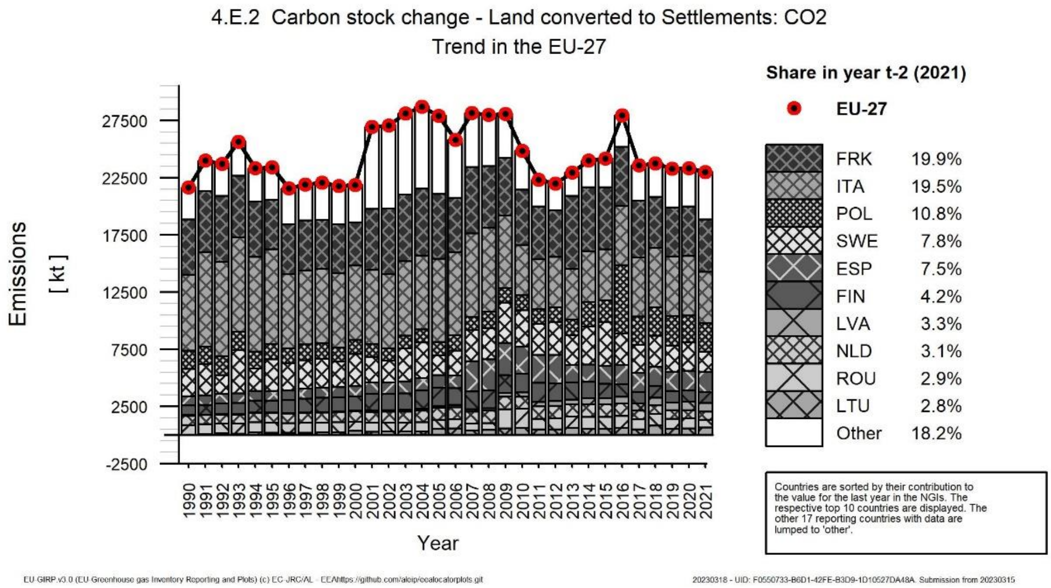


Figure 6.18 Trend of activity data and emissions (+)/removals (-) in subcategory 4E2 "Land converted to Settlements" in EU-27 kha, kt CO_2)





As regards the subcategory 4E2, annual emissions from Land converted to Settlements have increased by 6% since 1990 (Table 6.). For the year 2021 this subcategory was reported as a net source of emissions, reaching 23 007 kt CO_2.

Emissions are mainly the result of disturbed mineral soils and loss of carbon from living biomass when forests are converted to urban areas (e.g., France, Italy and Poland). In fact, the conversion of forests to Settlements is an important component of the total deforestation. It represents around 30% of total area reported as deforested. While conversions to Wetland or Other land may be caused by natural effects, a conversion to Settlement is by definition the result of human actions.

When a land is converted to Settlements, carbon pools are not uniformly disturbed over the whole area. For instance, usually only part of the converted area is paved, trees or upper soils layer is removed, and carbon stored in dead organic matter and soil organic matter diminish significantly. To address this issue, carbon stock changes associated with these deforestation events are reported using country-specific data and approaches.

Table 6. 29 4E2 Land converted to Settlements: EU-27 contributions to the net CO_2 emissions (+)/removals (-) (CRF table 4)

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	448	516	441	1.9%	-7	-2%	-75	-15%
Belgium	143	507	511	2.2%	367	257%	4	1%
Bulgaria	425	586	564	2.5%	139	33%	-22	-4%
Croatia	235	672	629	2.7%	394	167%	-42	-6%
Cyprus	0	4	4	0.0%	3	670%	0	-8%
Czechia	319	212	239	1.0%	-79	-25%	28	13%
Denmark	428	225	217	0.9%	-212	-49%	-8	-4%
Estonia	NO	407	309	1.3%	309	∞	-98	-24%
Finland	857	963	972	4.2%	115	13%	9	1%
France	4 817	4 341	4 568	19.9%	-249	-5%	227	5%
Germany	-280	-734	353	1.5%	633	226%	1 087	148%
Greece	50	125	125	0.5%	75	151%	0	0%
Hungary	96	170	150	0.7%	54	57%	-20	-12%
Ireland	80	178	133	0.6%	53	66%	-44	-25%
Italy	6 640	5 216	4 492	19.5%	-2 148	-32%	-724	-14%
Latvia	81	738	766	3.3%	685	846%	28	4%
Lithuania	5	545	638	2.8%	632	12284%	93	17%
Luxembourg	29	40	40	0.2%	10	36%	0	0%
Malta	2	9	2	0.0%	0	9%	-7	-76%
Netherlands	784	735	719	3.1%	-65	-8%	-16	-2%
Poland	1 608	2 329	2 474	10.8%	867	54%	146	6%
Portugal	271	86	96	0.4%	-175	-65%	10	11%
Romania	850	901	677	2.9%	-173	-20%	-224	-25%
Slovakia	97	79	86	0.4%	-10	-11%	7	9%
Slovenia	466	288	280	1.2%	-186	-40%	-8	-3%
Spain	801	1 720	1 730	7.5%	929	116%	10	1%
Sweden	2 382	2 485	1 792	7.8%	-590	-25%	-693	-28%
EU-27	**21 635**	**23 342**	**23 007**	**100%**	**1 372**	**6%**	**-335**	**-1%**

Major changes in the time series in Land converted to Settlements have been reported by Lithuania and Portugal, driven by the activity data. And, specifically for an increase in the conversion of areas that has associated large carbon stocks and therefore more carbon is lost from their conversions.

Noteworthy is also Poland, which reports for the year 2016 a significant increase of emissions from 4E.2 that is reflected in the overall trend of the LULUCF sector at EU level. Such increase results from significant conversion of forest lands used for expanding infrastructures required to support the growing population.

For reporting carbon stock changes in dead organic matter, it is generally assumed that all the carbon stock in the pool is instantaneously oxidized in the moment of conversion from Forest land to Settlements. It is also assumed that there is no dead wood and litter on Settlements. Emissions are estimated based on average carbon stock per area of these carbon pools, determined either at national or regional scale or specific to each deforestation site.

For reporting soil organic matter, different assumptions have been implemented by MS. These are generally based on expert judgment or, occasionally, on scientific studies. For instance, in Sweden the carbon stock in Settlements is estimated as the weighted average of carbon stocks in two strata: unpaved and paved. Unpaved area is usually considered to cover 40-60% of national settlements area (e.g. Austria, Luxembourg), going down to 2-3% in other cities (i.e. Bulgaria). Associated carbon stocks are derived from one of the following options (depending on MS):

- data from measurements in green area of the city (from scientific studies);
- same carbon stock as under 'GL remaining GL' (assuming that under national circumstances GL is the source of land for Settlement's expansion);
- lowest carbon stock value among the major land categories Forest land, Cropland and Grassland (assuming limited change of carbon stock in the soil under construction);
- applying a factor against carbon stock in previous land use (e.g., constant loss of 50%).

6.2.4.3 Other land (CRF 4F)

The land use category Other land reached in this reporting year 9 336 Kha, which represents about 2% of the total reported area. This land use category has been reported rather constant across the time series because of the balance among the decrease in the subcategory 4F1 and the increase in the subcategory 4F2 (Figure 6.19).

The largest areas under the category 4F1 are reported by Sweden, while new Other lands areas in the subcategory 4F2 are mainly reported by Poland, Romania and Slovakia.

In terms of emissions, the trend is driven by Austria, Netherlands, and Estonia.

Noteworthy is the case of Ireland, which reports for the year 2006 significant emissions from Forest land converted to Other land. This is due to a former area of peat extraction (pre-1990) that was abandoned and then (since 1990) classified as forest. Subsequently, a dump was built on the land, and the area was reclassified as Other land. Ireland has informed that a process is ongoing to improve the reporting of these areas.

Finally, Poland calculates the area in this category as the difference of the area of all land-use categories and the whole area of the country, thereby intending to avoid double accounting or omission of areas. Due to the land representation system, the year 2000 represents a change in the land use matrix. Starting from that year, Poland reports a leap on activity data of "Land converted to Other Land" that is reflected in the EU trend.

Definitions of Other land are close to each other among countries and overall match the IPCC general description (Table 6.). In most of the cases, following the IPCC approach, this category is used to ensure that the total area reported under LULUCF remains constant along the time series, and matches official country area. To this aim, this land category is on a lower level of hierarchy and includes all the areas that were not identified under any other land use category, and that are in all cases considered unmanaged.

Portugal has reclassified, previously reported under Other land shrubland areas under the land use category Grassland, which explain most of the recalculation under this category.

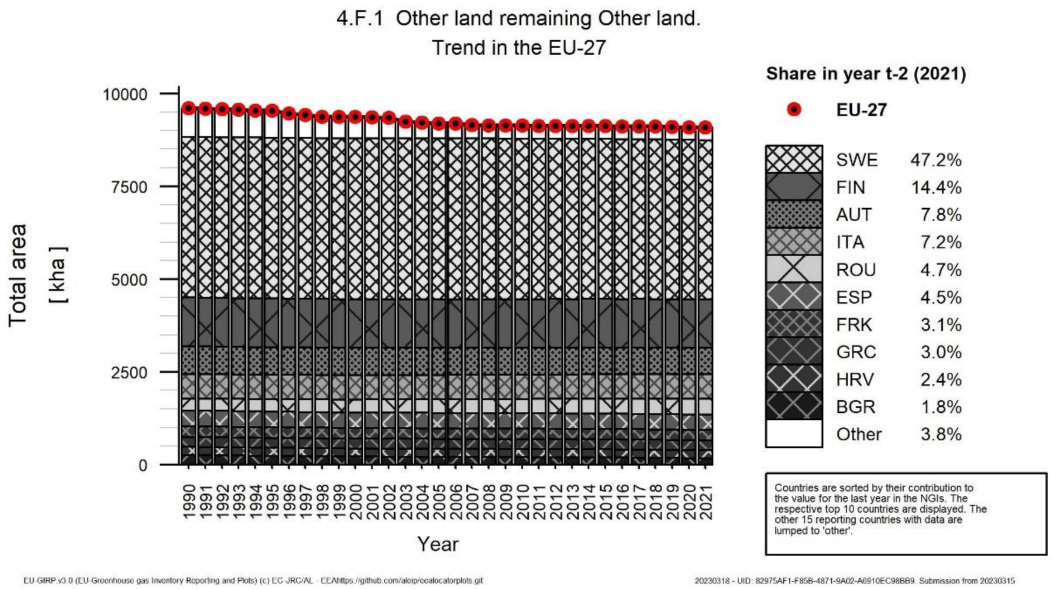
Table 6. 30 Definitions of lands included under the category 4F: Other lands.

Country	***Definition***
Austria	Area with i) rocks and screes, ii) glaciers and iii) unmanaged alpine dwarf shrub heaths. It is calculated as the difference of total country area and all other land uses, showing max 2% difference by relevant cadastral data.
Belgium	Bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories.
Bulgaria	Other land category includes bare soil, rock and all area that do not fall into any of other five land-use categories.
Croatia	Other land category represents a difference between the total area of Croatia and sum of all other land use categories.
Cyprus	Bare soil, rock, beaches, dunes and sand plains and all land areas that do not fall into any of the other five categories.
Czechia	Other land is not represented by any land use category within the Czech conditions and the national system of land use representation and land use change identification.
Denmark	Unmanaged area like moors, fens, beaches, sand dunes and other areas without human interference.

Country	*Definition*
Estonia	Land areas that do not fall into any of the other five land-use categories.
Finland	Mineral soils on poorly productive forest land, which do not fulfil the threshold values for forest, unproductive lands on mineral soils on rocky lands and treeless mountain areas.
France	All lands that do not correspond to any other land use categories (e.g., rock areas). Other lands (flush rocks, etc.) cover around 0.9 million hectares, and are the lowest source of emissions due to low soil disturbance. This is land with no significant carbon stock, neither in soils nor in biomass.
Germany	Waste and swaths/aisles, glacier areas, scree slopes and sand bars and other land which cannot be allocated under other land categories. "Other land" consists of areas that are neither influenced nor cultivated by people.
Greece	All land areas that do not fall into any of other land-use categories (e.g., rocky areas, bare soil, mine and quarry land).
Hungary	Other Land includes comprises any area not included in another categories.
Ireland	Residual lands that are determinate when all other land use areas have been determined.
Italy	Other Land includes comprises any area not included in another categories. It is included to match overall consistency of country land area.
Latvia	According to the national land use statistics other lands include unmanaged lands, wetlands and settlements (1 459.3 mill. ha in 2008). Instead of the official statistics since 2009 the NFI is used to estimate area of other lands. It is assumed that other lands are dunes not covered by woody vegetation.
Lithuania	All other land which is not assigned to any other category such as quarries, sand - dunes and rocky areas is defined as Other land.
Luxemburg	This category includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area.
Malta	This category includes bare soil, rock, and all unmanaged land areas that do not fall into any of the other five categories. Mineral extraction sites in Malta are included under this land-use category.
Netherlands	Surfaces of bare soil which are not included in any other category like: bare sands and the earliest stages of succession from sand in the coastal areas (beaches, dunes and sandy roads) or uncultivated land alongside rivers. It does not include bare areas that emerge from shrinking and expanding water surfaces (which are included in wetlands).
Poland	Other Land includes comprises any area not included in another categories. It is included to match overall consistency of country land area.
Portugal	Shrubland - includes all lands covered in woody vegetation that do not meet the forest or permanent crop definitions and Other land - includes all lands that do not meet the previous definitions, such as lands covered in rocks, sand dunes, etc.
Romania	Other land includes following categories: rocky areas, excavations, stone quarries (active, closed), stony debris, gravel/sand/earth pits, drilling perimeters and locally degraded lands.
Slovakia	Other land represents bare soil, rock and all unmanaged land areas that do not fall into any of the other categories.
Slovenia	Other land includes non-forest land covered with vegetation lover than 2 m or covered less than 75%, which is not used in agriculture. There are inbuilt areas with little or no vegetation as rocks, sands, sand banks (bigger than 5000 m2), waste and other opened areas. This is all land that is not classified in other land use definitions.
Spain	Bare soil, rock areas, ice and other areas of land that do not fall into any of the other land category.
Sweden	Waste land and most of the mountain area in northwest Sweden. It is assumed unmanaged.

In terms of emissions, Other land represents a small source of emissions of 1 106 Kt CO_2. Countries generally report emissions as a result of carbon oxidation from living biomass and soils when lands are converted to Other land.

Figure 6.19 Trend of activity data in subcategories 4F1 and 4F2 “Other land remaining Other Land” and “Land converted to Other land” in EU-27 (kha)



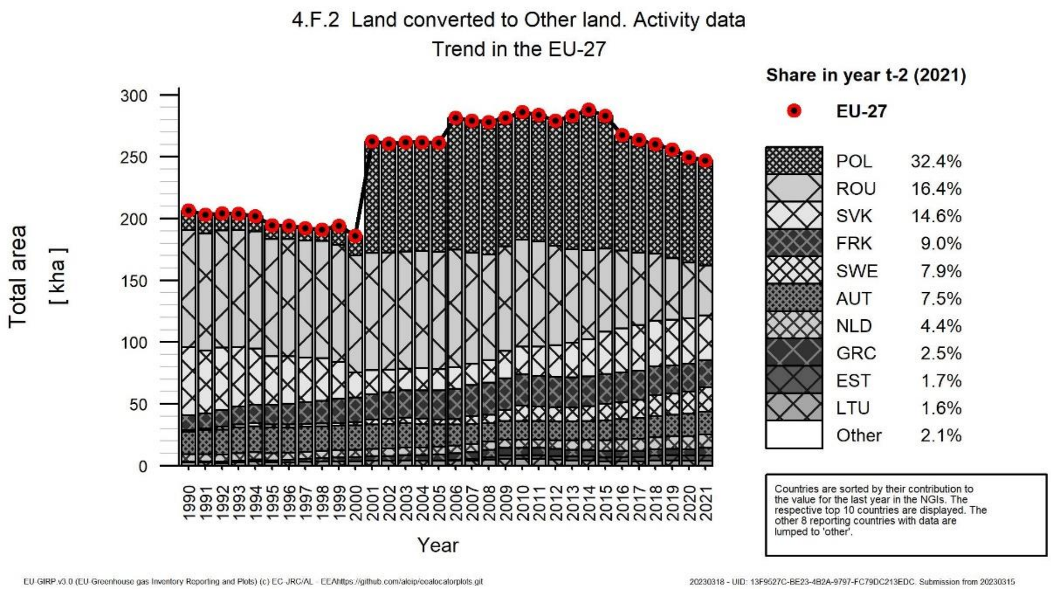
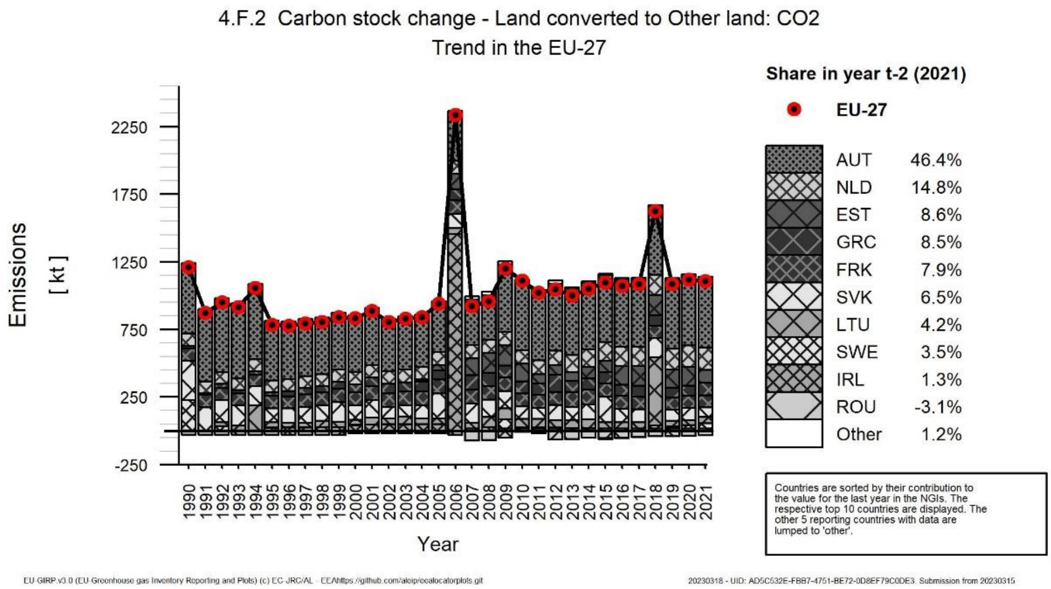


Figure 6.20 Trend of emissions (+)/removals (-) in subcategory 4F2, "Land converted to Other lands" in EU-27 (kt CO_2)



6.2.5 Harvest Wood Products (CRF 4G)

6.2.5.1 Overview of the Harvest Wood Products category

This carbon pool covers emissions and removals from carbon stock changes in harvested wood products (HWPs). The net contribution of this pool is the result of the annual carbon inflow to the pool (i.e., gains), and carbon outflow from the pool (i.e., losses) arising from previous years production.

According to the 2006 IPCC guidelines, HWPs includes all wood material (including bark) that leaves harvest sites, where this removal is initially counted as a loss of carbon from living biomass. Slash and other material left at harvest sites should be regarded as dead organic matter in the associated land use category and not as HWP. The inflow of biomass into the HWPs is counted as a gain in the HWPs category.

HWPs represent at the level of EU MS a net carbon sink of -47 390 kt CO_2 in the current inventory year. Most of the countries reported this carbon pool as a net sink; however, some countries, and for certain years, reported this pool as a net source. As for example Cyprus in this submission for 2021. The main contributors to the carbon sink are Sweden, Germany and Poland.

The methods and data sources for estimating carbon stock changes in HWPs are consistent with methodologies provided by 2006 IPCC GL. Individual inventories implemented the IPCC Approach B (i.e., production approach) to provide estimates on HWPs consistently with the reporting of the carbon pool under the KP reporting and subsequently according to EU Regulations No 2018/841.

Countries reported carbon stock changes in HWPs considering individual estimates for the semi-finished wood products categories of (i) Solid wood, disaggregated into Sawn wood and wood panels, and (ii) Paper and paperboard. To this aim, the IPCC default half-life values have been used by all individual inventories.

A particular case is given by Malta that has stated that carbon stock changes in HWPs pool, as considered under the Approach B, do not exist, as commercial logging does not occur in its territory.

With regards to the activity data, most of the MS have based their estimates on the information provided by the FAOSTAT database, the TIMBER database of the United Nations Economic Commission for

Europe (UNECE, 2011), national statistics when available, or, in specific cases, on information collected by surveying wood industries.

Table 6. 31 4G Harvest Wood Products: contributions to net CO_2 emissions (+)/removals (-) (CRF table 4)

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	-3 122	-122	-1 889	4.0%	1 233	39%	-1 768	-1452%
Belgium	-1 517	122	122	-0.3%	1 639	108%	0	0%
Bulgaria	-583	-1 203	-1 185	2.5%	-602	-103%	18	1%
Croatia	-318	-630	-685	1.4%	-367	-116%	-56	-9%
Cyprus	2	21	20	0.0%	18	832%	-1	-7%
Czechia	-1 680	-2 792	-2 457	5.2%	-776	-46%	335	12%
Denmark	-2	-118	-56	0.1%	-54	-2261%	62	52%
Estonia	-156	-935	-949	2.0%	-793	-507%	-14	-2%
Finland	-2 952	-1 290	-3 646	7.7%	-695	-24%	-2 356	-183%
France	-5 240	-1 052	-1 368	2.9%	3 872	74%	-316	-30%
Germany	-1 330	-8 651	-8 651	18.3%	-7 321	-550%	0	0%
Greece	-349	-178	-173	0.4%	176	51%	5	3%
Hungary	-315	-618	-933	2.0%	-618	-196%	-315	-51%
Ireland	-413	-809	-963	2.0%	-550	-133%	-154	-19%
Italy	-388	-2 240	-2 035	4.3%	-1 648	-425%	205	9%
Latvia	-166	-1 726	-2 038	4.3%	-1 872	-1127%	-312	-18%
Lithuania	-253	-834	-1 209	2.6%	-957	-379%	-376	-45%
Luxembourg	2	-5	-9	0.0%	-11	-532%	-4	-86%
Malta	NO	NO	NO	-	-	-	-	-
Netherlands	-69	132	125	-0.3%	194	282%	-6	-5%
Poland	-459	-4 469	-4 877	10.3%	-4 418	-962%	-408	-9%
Portugal	-2 127	57	-253	0.5%	1 874	88%	-310	-546%
Romania	354	-3 267	-3 300	7.0%	-3 654	-1031%	-32	-1%
Slovakia	-470	-247	-309	0.7%	161	34%	-62	-25%
Slovenia	-67	-142	-195	0.4%	-128	-191%	-53	-37%
Spain	-2 020	-1 358	-1 477	3.1%	543	27%	-119	-9%
Sweden	-5 028	-8 983	-8 998	19.0%	-3 971	-79%	-15	0%
EU-27	**-28 666**	**-41 337**	**-47 390**	**100%**	**-18 724**	**-65%**	**-6 053**	**-15%**

6.2.6 LULUCF – non-key categories

In this section, a general overview of emissions and removals for non-key categories is provided.

Table 6. 32 Aggregated GHG emission from non-key categories in the LULUCF sector

EU	Aggregated GHG emissions in kt CO_2 eq.			Share in sector 4. LULUCF in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 eq.	%	kt CO_2 eq.	%
4.A Forest Land: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CH_4)	2 078.8	1 572.5	1 580.8	-0.69%	-498	-24%	8.3	1%
4.A Forest Land: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CO_2)	336.6	471.6	477.2	-0.21%	141	42%	5.7	1%

EU	Aggregated GHG emissions in kt CO_2 eq.			Share in sector 4. LULUCF in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 eq.	%	kt CO_2 eq.	%
4.A Forest Land: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (N_2O)	3 617.8	3 930.1	3 940.4	-1.71%	323	9%	10.4	0%
4.A.1 Forest Land: Land Use (CH_4)	2 140.5	1 061.6	1 685.5	-0.73%	-455	-21%	623.9	59%
4.A.1 Forest Land: Land Use (N_2O)	710.3	533.6	584.7	-0.25%	-126	-18%	51.1	10%
4.A.2 Forest Land: Land Use (CH_4)	96.0	44.3	86.3	-0.04%	-10	-10%	42.1	95%
4.A.2 Forest Land: Land Use (N_2O)	515.2	324.3	324.2	-0.14%	-191	-37%	-0.1	0%
4.B Cropland: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CH_4)	827.2	579.2	586.7	-0.26%	-240	-29%	7.4	1%
4.B Cropland: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CO_2)	1 613.6	1 175.7	1 187.3	-0.52%	-426	-26%	11.6	1%
4.B Cropland: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (N_2O)	0.0	0.0	0.0	0.00%	0.0	0%	0.0	0%
4.B.1 Cropland: Land Use (CH_4)	190.1	77.0	96.0	-0.04%	-94	-50%	18.9	25%
4.B.1 Cropland: Land Use (N_2O)	73.6	39.7	46.7	-0.02%	-27	-37%	6.9	17%
4.B.2 Cropland: Land Use (CH_4)	67.9	70.4	71.8	-0.03%	4	6%	1.4	2%
4.B.2 Cropland: Land Use (N_2O)	1 995.2	1 193.0	1 190.0	-0.52%	-805	-40%	-3.0	0%
4.C Grassland: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CH_4)	1 758.6	1 875.6	1 837.6	-0.80%	79	4%	-38.0	-2%
4.C Grassland: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CO_2)	654.9	694.5	688.7	-0.30%	34	5%	-5.8	-1%
4.C Grassland: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (N_2O)	61.3	34.8	32.5	-0.01%	-29	-47%	-2.2	-6%
4.C.1 Grassland: Land Use (CH_4)	1 330.9	300.2	592.4	-0.26%	-739	-55%	292.1	97%
4.C.1 Grassland: Land Use (N_2O)	576.1	198.5	346.3	-0.15%	-230	-40%	147.8	74%
4.C.2 Grassland: Land Use (CH_4)	67.3	65.7	66.0	-0.03%	-1	-2%	0.3	0%
4.C.2 Grassland: Land Use (N_2O)	200.3	143.7	141.3	-0.06%	-59	-29%	-2.4	-1.7%
4.D Wetlands: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CO_2)	1 139.4	1 359.1	1 429.6	-0.62%	290	25%	70.4	5.2%
4.D Wetlands: Emissions and removals from drainage and rewetting and other management of organic and mineral soils (N_2O)	119.4	143.4	142.0	-0.06%	23	19%	-1.5	-1%
4.D.1 Wetlands: Land Use (CH_4)	74.9	22.2	8.9	0.00%	-66	-88%	-13.2	-60%
4.D.1 Wetlands: Land Use (N_2O)	17.8	6.1	3.0	0.00%	-15	-83%	-3.1	-50%
4.D.2 Wetlands: Land Use (CH_4)	6.5	7.2	6.9	0.00%	0	7%	-0.3	-4%
4.D.2 Wetlands: Land Use (N_2O)	67.2	78.1	63.6	-0.03%	-4	-5%	-14.5	-19%
4.E Settlements: Biomass Burning (CH_4)	46.4	40.9	40.7	-0.02%	-6	-12%	-0.2	-1%
4.E Settlements: Biomass Burning (CO_2)	0.0	0.0	0.0	0.00%	0	0%	0.0	0%
4.E Settlements: Biomass Burning (N_2O)	3.0	2.7	2.6	0.00%	0	-12%	0.0	-1%
4.E.1 Settlements: Land Use (CH_4)	17.2	11.5	12.5	-0.01%	-5	-27%	1.0	9%
4.E.1 Settlements: Land Use (CO_2)	1 613.0	1 004.8	1 072.7	-0.47%	-540	-33%	67.9	7%
4.E.1 Settlements: Land Use (N_2O)	1.2	11.6	12.9	-0.01%	12	935%	1.4	12%

EU	Aggregated GHG emissions in kt CO_2 eq.			Share in sector 4. LULUCF in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 eq.	%	kt CO_2 eq.	%
4.E.2 Settlements: Land Use (CH_4)	1.7	16.3	15.9	-0.01%	14	854%	-0.4	-3%
4.E.2 Settlements: Land Use (N_2O)	2 470.7	2 835.9	2 824.9	-1.23%	354	14%	-11.0	0%
4.F.2 Other Land: Land Use (CH_4)	0.0	0.0	0.0	0.00%	0	0%	0.0	0%
4.F.2 Other Land: Land Use (CO_2)	1 209.6	1 119.5	1 106.4	-0.48%	-103	-9%	-13.1	-1%
4.F.2 Other Land: Land Use (N_2O)	0.0	0.0	0.0	0.00%	0.0	-100%	0.0	0%
4.F.3 Other Land: Direct N_2O Emissions from N Mineralization/Immobilization (N_2O)	30.3	76.2	85.7	-0.04%	55	183%	9.5	12%
4.F.4 Other Land: Biomass Burning (CH_4)	0.5	0.6	0.6	0.00%	0.1	15%	0.0	0%
4.F.4 Other Land: Biomass Burning (CO_2)	0.0	0.0	0.0	0.00%	0	0%	0.0	0%
4.F.4 Other Land: Biomass Burning (N_2O)	0.0	0.0	0.0	0.00%	0	15%	0.0	0%
4.G Atmospheric Deposition: Land Use (N_2O)	-	-	-	-	-	-	-	-
4.G Nitrogen Leaching and Run-off: Land Use (N_2O)	-	-	-	-	-	-	-	-
4.H Other LULUCF: Land Use (CH_4)	0.0	244.3	244.2	-0.11%	244	100%	-0.2	0%
4.H Other LULUCF: Land Use (CO_2)	0.0	39.8	35.0	-0.02%	35	100%	-4.8	-12%
4.H Other LULUCF: Land Use (N_2O)	93.4	106.7	108.8	-0.05%	15	16%	2.1	1.9%

6.2.7 Other sources of emissions: Tables 4(I)-4(V)

6.2.7.1 Direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs to managed soils (CRF Table 4(I))

Under CRF table 4(I) countries reports N_2O emissions resulting from the addition of organic and inorganic fertilizers to managed soils under land use categories other than Cropland and Grassland.

The majority of countries have stated that fertilization is not part of the management practices of forests, while, if any, emissions from the addition of nitrogen inputs in Wetlands, Settlements, or in a few cases also under forests, are reported under Agriculture sector when it is not possible to separate emissions from fertilization among the land use categories. Therefore, under the LULUCF almost all the countries have reported these emissions using the notation key NO or IE (Table 6.).

Exceptions are Finland and Sweden that report N_2O emissions under this source category due to forest fertilization. Sweden reports emissions from nitrogen fertilization as a result of nitrogen inputs occasionally applied to increase the wood production in older forests stands. Finland reports also notable emissions in this category as a result of forest growth fertilization and, to a lesser extent, vitality fertilization.

In addition, Ireland reports N_2O emissions resulting from the addition of organic fertilizers in Settlements areas.

Activity data for reporting this source of emissions results from national or sectorial statistics (e.g. sales statistics), which provide the total amount and type of fertilizer. Then, the IPCC default value of 0.01 kg N_2O-N/kg N yr^{-1} is usually used to derive N_2O emissions from nitrogen inputs to managed soils.

For this inventory year, this source of emissions reaches 58 kt CO_2 equivalents, which is about 4% less than in 1990.

Table 6. 33 4 LULUCF Direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs to managed soils (kt CO_2 eq.)

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27	Change 1990-2021		Change 2020-2021	
	1990	2020	2021	Emissions in 2021	kt CO2 equiv.	%	kt CO2 equiv.	%
Austria	NO	NO	NO	-	-	-	-	-
Belgium	NO	NO	NO	-	-	-	-	-
Bulgaria	NO	NO	NO	-	-	-	-	-
Croatia	NO	NO	NO	-	-	-	-	-
Cyprus	NO	NO	NO	-	-	-	-	-
Czechia	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Denmark	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
Estonia	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Finland	18	34	27	45.6%	8	45%	-7	-22%
France	NO	NO	NO	-	-	-	-	-
Germany	NO	NO	NO	-	-	-	-	-
Greece	NO	NO	NO	-	-	-	-	-
Hungary	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
Ireland	NO,IE	5	5	8.5%	5	∞	0	0%
Italy	NO,IE	NO,IE	NO,IE	-	-	-	-	-
Latvia	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Lithuania	NO	NO	NO	-	-	-	-	-
Luxembourg	NO	NO	NO	-	-	-	-	-
Malta	NA,NO	NO	NO	-	-	-	-	-
Netherlands	NO,IE	NO,IE	NO,IE	-	-	-	-	-
Poland	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
Portugal	NO,IE	NO,IE	NO,IE	-	-	-	-	-
Romania	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
Slovakia	NO	NO	NO	-	-	-	-	-
Slovenia	NO	NO	NO	-	-	-	-	-
Spain	NO	NO	NO	-	-	-	-	-
Sweden	44	26	27	45.9%	-17	-39%	0	1%
EU-27	**62**	**65**	**58**	**100%**	**-4**	**-6%**	**-7**	**-11%**

6.2.7.2 Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CRF Table 4(II))

Under CRF table 4(II), CO_2, CH_4 and N_2O emissions and removals from drainage and rewetting and other management of organic and mineral soils areas are reported. However, part of these emissions is already covered under other sectors, so countries need to avoid double counting (e.g., nitrous oxide emissions from drained cropland and grassland soils are covered in the agriculture sector) or they may be reported under other tables within the LULUCF (e.g., CO_2 emissions or removals from drainage of wetlands areas are often already included in CRF tables 4.A to 4.F).

For this year, total emissions from this source reached 17 794 kt CO_2 equivalent (tables 6.34, 6.35 and 6.36) that occurred mostly in organic soils and that are mainly reported by Finland, Sweden, Lithuania, and Latvia.

Table 6. 34 4 LULUCF CO_2 Emissions and removals from drainage and rewetting and other management of organic and mineral soils (kt CO_2 eq.)

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	NO,IE	NO,IE	NO,IE	-	-	-	-	-
Belgium	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Bulgaria	NO,IE	NO,IE	NO,IE	-	-	-	-	-
Croatia	NO	NO	NO	-	-	-	-	-
Cyprus	NO	NO	NO	-	-	-	-	-
Czechia	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Denmark	180	140	140	3.7%	-40	-22%	0	0%
Estonia	NO,NE,IE	NO,NE,IE	NO,NE,IE	-	-	-	-	-
Finland	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
France	224	224	224	5.9%	0	0%	0	0%
Germany	NO,IE	NO,IE	NO,IE	-	-	-	-	-
Greece	NO	NO	NO	-	-	-	-	-
Hungary	180	49	47	1.2%	-133	-74%	-2	-5%
Ireland	457	507	506	13.4%	49	11%	-1	0%
Italy	NO	NO	NO	-	-	-	-	-
Latvia	856	1 282	1 359	35.9%	503	59%	77	6%
Lithuania	1 848	1 499	1 507	39.8%	-341	-18%	8	1%
Luxembourg	NO	NO	NO	-	-	-	-	-
Malta	NO	NO	NO	-	-	-	-	-
Netherlands	O,NE,IE,NA	O,NE,IE,NA	O,NE,IE,NA	-	-	-	-	-
Poland	NA	NA	NA	-	-	-	-	-
Portugal	NO	NO	NO	-	-	-	-	-
Romania	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Slovakia	NO	NO	NO	-	-	-	-	-
Slovenia	NO	NO	NO	-	-	-	-	-
Spain	0	0	0	0.0%	0	23%	0	0%
Sweden	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
EU-27	**3 744**	**3 701**	**3 783**	**100%**	**38**	**1%**	**82**	**2%**

Table 6. 35 4 LULUCF N_2O Emissions and removals from drainage and rewetting and other management of organic and mineral soils (kt CO_2 eq.)

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%
Austria	NO	NO	NO	-	-	-	-	-
Belgium	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Bulgaria	NO	NO	NO	-	-	-	-	-
Croatia	NO	NO	NO	-	-	-	-	-
Cyprus	NO	NO	NO	-	-	-	-	-
Czechia	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Denmark	24	22	22	0.5%	-2	-8%	0	1%
Estonia	239	244	244	5.8%	5	2%	0	0%
Finland	1 451	1 733	1 731	41.0%	280	19%	-2	0%
France	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Germany	491	500	501	11.9%	10	2%	1	0%
Greece	NO	NO	NO	-	-	-	-	-
Hungary	8	8	8	0.2%	0	4%	0	0%
Ireland	154	243	243	5.8%	90	58%	0	0%
Italy	NO	NO	NO	-	-	-	-	-
Latvia	481	451	448	10.6%	-33	-7%	-3	-1%
Lithuania	30	31	30	0.7%	0	1%	0	0%
Luxembourg	NO	NO	NO	-	-	-	-	-
Malta	NO	NO	NO	-	-	-	-	-
Netherlands	1	1	1	0.0%	0	-4%	0	-1%
Poland	NA	NA	NA	-	-	-	-	-
Portugal	NO	NO	NO	-	-	-	-	-
Romania	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Slovakia	NO	NO	NO	-	-	-	-	-
Slovenia	NO	NO	NO	-	-	-	-	-
Spain	0	0	0	0.0%	0	23%	0	0%
Sweden	1 013	984	995	23.6%	-18	-2%	11	1%
EU-27	**3 892**	**4 215**	**4 224**	**100%**	**332**	**9%**	**9**	**0%**

Table 6. 28 4 LULUCF CH_4 Emissions and removals from drainage and rewetting and other management of organic and mineral soils (kt CO_2 eq.)

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%
Austria	27	27	27	0.3%	0	0%	0	0%
Belgium	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Bulgaria	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Croatia	NO	NO	NO	-	-	-	-	-
Cyprus	NO	NO	NO	-	-	-	-	-
Czechia	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Denmark	293	289	291	2.9%	-2	-1%	2	1%
Estonia	73	75	75	0.8%	2	3%	0	0%
Finland	1 690	853	850	8.5%	-840	-50%	-3	0%
France	12	12	12	0.1%	0	0%	0	0%
Germany	6 301	6 531	6 538	65.6%	236	4%	7	0%
Greece	NO	NO	NO	-	-	-	-	-
Hungary	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Ireland	409	600	613	6.1%	203	50%	13	2%
Italy	NO	NO	NO	-	-	-	-	-
Latvia	495	833	849	8.5%	354	71%	17	2%
Lithuania	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Luxembourg	NO	NO	NO	-	-	-	-	-
Malta	0	NO	NO	-	0	-100%	-	-
Netherlands	306	245	244	2.5%	-62	-20%	-1	0%
Poland	NA	NA	NA	-	-	-	-	-
Portugal	NO	NO	NO	-	-	-	-	-
Romania	NO,NA	NO,NA	NO,NA	-	-	-	-	-
Slovakia	NO	NO	NO	-	-	-	-	-
Slovenia	NO	NO	NO	-	-	-	-	-
Spain	0	0	0	0.0%	0	23%	0	0%
Sweden	540	461	469	4.7%	-71	-13%	7	2%
EU-27	**10 146**	**9 925**	**9 967**	**100%**	**-179**	**-2%**	**42**	**0%**

6.2.7.3 Direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils (CRF Table 4(III))

Under CRF table 4(III), direct nitrous oxide emissions from nitrogen mineralization associated with loss of soil organic matter resulting from change of land use or management of mineral soils are reported by almost all countries. This indicates significant efforts devoted by countries to increase the completeness of reporting for this source of emissions during the last years.

For this year, net emissions from this source category reached 4 783 kt CO_2 equivalent, which represent a decrease of 10% as compared to 1990. Significant emissions under this category are reported by France, Germany, and Poland (Table 6. 3) and in most of the cases they were estimated using IPCC methodologies and default emissions factors.

Table 6. 37 Direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils (kt CO_2 eq.)

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%
Austria	101	103	100	2.1%	-1	-1%	-3	-2%
Belgium	5	85	84	1.8%	79	1651%	-1	-1%
Bulgaria	259	190	190	4.0%	-69	-27%	0	0%
Croatia	42	117	111	2.3%	68	161%	-6	-5%
Cyprus	0	1	1	0.0%	1	8900%	0	-11%
Czechia	8	2	2	0.0%	-6	-73%	0	4%
Denmark	39	18	18	0.4%	-21	-53%	0	0%
Estonia	0	23	23	0.5%	23	99601%	0	1%
Finland	25	26	25	0.5%	-1	-4%	-1	-5%
France	1 527	561	588	12.3%	-940	-62%	27	5%
Germany	317	526	540	11.3%	223	70%	14	3%
Greece	1	13	14	0.3%	13	1067%	1	8%
Hungary	10	13	13	0.3%	3	31%	0	0%
Ireland	16	149	182	3.8%	166	1017%	33	22%
Italy	514	412	347	7.2%	-168	-33%	-65	-16%
Latvia	2	108	117	2.4%	115	5781%	9	8%
Lithuania	65	86	95	2.0%	30	46%	9	11%
Luxembourg	6	6	6	0.1%	0	-7%	0	0%
Malta	0	1	1	0.0%	0	113%	0	0%
Netherlands	97	80	82	1.7%	-15	-16%	2	2%
Poland	1 590	1 736	1 738	36.3%	148	9%	2	0%
Portugal	116	162	156	3.3%	40	35%	-7	-4%
Romania	195	66	66	1.4%	-129	-66%	1	1%
Slovakia	98	19	17	0.4%	-81	-82%	-1	-7%
Slovenia	55	31	30	0.6%	-25	-46%	-1	-3%
Spain	210	162	156	3.3%	-54	-26%	-5	-3%
Sweden	26	81	82	1.7%	56	210%	1	1%
EU-27	**5 326**	**4 775**	**4 783**	**100%**	**-544**	**-10%**	**8**	**0%**

6.2.7.4 Indirect nitrous oxide (N_2O) emissions from managed soils (CRF Table 4(IV))

This category covers indirect N_2O emissions from managed soils. Under certain conditions and land use categories, these emissions can be reported under Agriculture sector. Examples of such cases are emissions associated with the addition on nitrogen inputs on Cropland and Grassland or with the mineralization of nitrogen associated with loss of soil organic matter resulting from change of land use or management on mineral soils in Cropland remaining Cropland. Moreover, if the sources of nitrogen cannot be separated in any other way than between cropland and grassland, these emissions were reported under the Agriculture sector.

Therefore, given that according to the CRF table 4 (I) most of the fertilizer are added in Cropland and Grassland areas, and that direct nitrogen emissions are mostly reported so far under Cropland remaining Cropland, an important number of countries have reported in the CRF table 4(IV) the notation key IE (i.e., included elsewhere).

Nevertheless, the completeness reporting of these emissions has also undergone a significant increase in the last year submission following recommendations provided during the EU QA/QC checks.

For this inventory year, indirect N_2O emissions reported under LULUCF reached 794 kt CO_2 equivalent (Table 6.). These emissions are mainly reported by Portugal, France and Germany. Others MS have provided for first time also minor quantities of indirect N_2O emissions.

Table 6. 29 Indirect nitrous oxide (N_2O) emissions from managed soils (kt CO_2 eq.)

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%
Austria	11	12	11	1.4%	0	-1%	0	-2%
Belgium	1	19	19	2.4%	18	1635%	0	-1%
Bulgaria	58	43	43	5.4%	-16	-27%	0	0%
Croatia	IE	IE	IE	-	-	-	-	-
Cyprus	0.002	0.2	0.2	0.0%	0	8900%	0	-11%
Czechia	2	0.5	0.5	0.1%	-1	-73%	0	4%
Denmark	IE	IE	IE	-	-	-	-	-
Estonia	0.01	5	5	0.7%	5	99601%	0	1%
Finland	2	2	2	0.2%	0	11%	0	-5%
France	344	126	132	16.7%	-211	-62%	6	5%
Germany	71	118	122	15.3%	50	70%	3	3%
Greece	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Hungary	1	3	3	0.3%	2	261%	0	2%
Ireland	IE	IE	IE	-	-	-	-	-
Italy	15	20	20	2.5%	6	38%	0	0%
Latvia	IE,NA	2	3	0.3%	3	∞	0	6%
Lithuania	15	18	21	2.7%	7	46%	3	19%
Luxembourg	4	3	3	0.4%	-1	-29%	0	0%
Malta	IE	IE	IE	-	-	-	-	-
Netherlands	IE	IE	IE	-	-	-	-	-
Poland	IE	IE	IE	-	-	-	-	-
Portugal	293	396	386	48.5%	93	32%	-10	-3%
Romania	IE	IE	IE	-	-	-	-	-
Slovakia	13	4	4	0.5%	-9	-68%	0	-2%
Slovenia	13	7	7	0.9%	-6	-46%	0	-3%
Spain	20	10	9	1.2%	-11	-54%	0	-4%
Sweden	7	4	4	0.5%	-3	-38%	0	1%
EU-27	**869**	**793**	**794**	**100%**	**-75**	**-9%**	**1**	**0%**

6.2.7.5 CO_2, CH_4 & N_2O emissions from Biomass Burning (CRF Table 4(V))

This source category covers CO_2, and non-CO_2 emissions from biomass burning because of wildfires and controlled burning, affecting all land use categories.

Following the IPCC approach, many countries that implement the stock-different method to estimate carbon stock changes in forest living biomass use the notation key IE in the CRF table 4(V), so avoiding double counting of CO_2 emissions. In addition, countries have also used the notation keys NO or NA when wildfires or controlled burning have not taken place under certain categories, or NE for those land use categories for which the IPCC does not provide methods. An example is the reporting of emissions from biomass burning in Settlement (e.g., Estonia).

In general, countries informed that controlled burning on managed lands is not a common practice. With few exceptions for confined areas that are reported by Finland and Sweden in forest lands and Spain in grasslands. In general, northern countries report generally low emissions from biomass burning (i.e., controlled burning and wildfires).

Methodologies used to report CO_2 emissions from fires are always based on Tier 2 methods by using information on activity data provided by national statistics and country-specific emission factors. By contrary, Tier 1 methodologies are used for estimation of CH_4 and N_2O emissions resulting from fires.

Overall, emissions from biomass burning decreased in 2021 compared to 1990, reaching in this inventory year 9 841 kt CO_2 equivalent (Table 6. , Table 6. and Table 6.). However, emissions from biomass burning do not show a clear trend since their occurrence is in many cases beyond the control of the countries. In Mediterranean territories the occurrence of wildfires in certain years result in enormous GHG emissions that are clearly identified in the trend of the LULUCF sector.

Overall, this source of emissions presents a very variable trend and interannual variability that is related to several factors, in many cases driven by climate conditions. It is well known that the countries that often report the larger quantities of emissions from biomass burning are Italy, France, Spain, and Greece. However, it is remarkable that during the last years more central and northern countries are also reporting significant number of emissions from this source (e.g., Ireland, Germany) as a result of the impact of wildfires in their territories.

Table 6. 39 **CO_2 emissions from Biomass Burning (in kt CO_2)**

Member State	CO2 Emissions in kt			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2	%	kt CO2	%
Austria	NO,IE	2	NO,IE	-	-	-	-2	-100%
Belgium	NO,NE,IE	NO	7	0.1%	7	∞	7	∞
Bulgaria	NO,NE,IE	NO,NE,IE	NO,NE,IE	-	-	-	-	-
Croatia	15	388	57	0.9%	42	278%	-331	-85%
Cyprus	NO,IE	NO,IE	NO,IE	-	-	-	-	-
Czechia	16	58	49	0.8%	33	206%	-9	-15%
Denmark	IE,NA	IE,NA	IE,NA	-	-	-	-	-
Estonia	NO,NE,IE	NO,NE,IE	NO,NE,IE	-	-	-	-	-
Finland	0	0	0	0.0%	0	-82%	0	405%
France	1 881	456	250	3.9%	-1 631	-87%	-206	-45%
Germany	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
Greece	NO,IE	NO,IE	NO,IE	-	-	-	-	-
Hungary	NO,IE,NA	NO,IE,NA	NO,IE,NA	-	-	-	-	-
Ireland	480	183	70	1.1%	-411	-85%	-114	-62%
Italy	5 072	715	2 283	35.7%	-2 789	-55%	1 568	219%
Latvia	23	39	94	1.5%	71	302%	55	141%
Lithuania	1	1	0	0.0%	-1	-90%	-1	-88%
Luxembourg	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Malta	NO	NO	NO	-	-	-	-	-
Netherlands	5	7	7	0.1%	2	39%	0	1%
Poland	107	15	18	0.3%	-89	-83%	4	25%
Portugal	11 389	1 398	3 278	51.2%	-8 111	-71%	1 880	134%
Romania	9	106	42	0.7%	33	351%	-64	-60%
Slovakia	47	142	48	0.7%	1	2%	-94	-66%
Slovenia	15	2	1	0.0%	-14	-95%	-1	-66%
Spain	546	108	197	3.1%	-349	-64%	89	83%
Sweden	NO,IE	NO,IE	NO,IE	-	-	-	-	-
EU-27	**19 607**	**3 618**	**6 401**	**100%**	**-13 206**	**-67%**	**2 783**	**77%**

Table 6. 30 **CH_4 emissions from Biomass Burning (in kt CO_2 eq.)**

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%
Austria	1	0.3	0.5	0.0%	0	-9%	0	76%
Belgium	0.1	NO	0.3	0.0%	0	107%	0	∞
Bulgaria	3	14	142	5.4%	139	5139%	128	937%
Croatia	1	36	7	0.2%	5	374%	-30	-82%
Cyprus	0.0	0.4	5	0.2%	5	16627%	5	1195%
Czechia	57	33	9	0.3%	-48	-85%	-25	-74%
Denmark	1	0.001	0.01	0.0%	-1	-98%	0	903%
Estonia	0.3	0.3	0.1	0.0%	0	-80%	0	-80%
Finland	3	2	1	0.0%	-2	-67%	-1	-40%
France	1 042	856	859	32.3%	-183	-18%	3	0%
Germany	10	2	1	0.0%	-9	-90%	-1	-59%
Greece	70	21	154	5.8%	83	119%	133	633%
Hungary	23	12	13	0.5%	-10	-44%	1	5%
Ireland	98	33	14	0.5%	-84	-86%	-19	-58%
Italy	1 440	371	978	36.8%	-462	-32%	607	164%
Latvia	28	12	19	0.7%	-9	-32%	7	53%
Lithuania	3	0.4	0.1	0.0%	-3	-97%	0	-78%
Luxembourg	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Malta	NO	NO	NO	-	-	-	-	-
Netherlands	0.4	1	1	0.0%	0	41%	0	1%
Poland	55	59	8	0.3%	-47	-86%	-51	-87%
Portugal	818	117	249	9.4%	-568	-69%	132	113%
Romania	1	9	4	0.1%	3	351%	-5	-60%
Slovakia	12	27	20	0.7%	7	59%	-8	-28%
Slovenia	1	0.2	0.1	0.0%	-1	-95%	0	-66%
Spain	351	81	170	6.4%	-182	-52%	89	110%
Sweden	2	2	2	0.1%	0	-5%	0	20%
EU-27	**4 021**	**1 690**	**2 655**	**100%**	**-1 366**	**-34%**	**965**	**57%**

Table 6. 31 **N_2O emissions from Biomass Burning (in kt CO_2 eq.)**

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%
Austria	0.3	0.1	0.2	0.0%	0	-9%	0	119%
Belgium	0.1	NO	0.3	0.0%	0	242%	0	∞
Bulgaria	1	7	74	9.5%	73	5139%	67	937%
Croatia	1	20	4	0.5%	3	427%	-16	-80%
Cyprus	0	0	3	0.4%	3	16627%	3	1195%
Czechia	30	18	5	0.6%	-25	-85%	-13	-74%
Denmark	0.38	0.001	0.01	0.0%	0	-97%	0	903%
Estonia	0.03	0.14	0.01	0.0%	0	-69%	0	-93%
Finland	2	1	1	0.1%	-1	-67%	0	-40%
France	458	363	366	46.6%	-92	-20%	2	1%
Germany	5	1	1	0.1%	-5	-90%	-1	-59%
Greece	5	1	10	1.3%	5	119%	9	633%
Hungary	14	7	7	0.9%	-7	-52%	0	3%
Ireland	22	6	3	0.4%	-19	-87%	-4	-56%
Italy	232	33	106	13.4%	-127	-55%	72	218%
Latvia	3	1	2	0.3%	-1	-22%	1	68%
Lithuania	3	0.3	0.03	0.0%	-3	-99%	0	-91%
Luxembourg	NO,NE	NO,NE	NO,NE	-	-	-	-	-
Malta	NO	NO	NO	-	-	-	-	-
Netherlands	0.2	0.3	0.3	0.0%	0	40%	0	1%
Poland	29	31	4	0.5%	-25	-86%	-27	-87%
Portugal	206	30	63	8.0%	-143	-69%	33	113%
Romania	0.4	5	2	0.2%	1	351%	-3	-60%
Slovakia	7	14	10	1.3%	4	59%	-4	-28%
Slovenia	1	0.1	0.03	0.0%	-1	-95%	0	-66%
Spain	253	63	125	15.9%	-129	-51%	62	98%
Sweden	0.1	0.1	0.1	0.0%	0	-5%	0	20%
EU-27	**1 273**	**603**	**785**	**100%**	**-488**	**-38%**	**182**	**30%**

6.2.8 Emissions from organic soils in the EU GHG inventory

Area of organic soils reported by EU MS under the three main land use categories (i.e., Forest land, Cropland and Grassland) cover about 16 914 kha that are mainly located in northern countries.

Total CO_2 emissions linked to that area in in the inventory year reached 97 880 kt CO_2 (Table 6. 4), which correspond to an amount of about 40% of total EU net removals from LULUCF. Emissions from organic soils in these land categories decreased as compared with 1990. Finland and Sweden report together more than half of the total area of organic soil in these categories.

Organic soils are an important source of emissions when they are under management practices that disturb the organic matter stored in the soil. In general, emissions from these soils are reported using country-specific values when they represent an important source within the total budget of GHG emissions. In contrast, countries with small areas of organic soil often use default IPCC factors to report emissions from this carbon pool.

Overall, among Forest land, Cropland and Grassland, most of the organic soil area is reported under Forest land, although most of the emissions are due to managed organic soils in Grasslands and Croplands (Table 6. 4).

In Finland, organic soil areas are derived from national forest inventory database and a geo-referenced soil database across all land uses. In Sweden, data is also provided by national forest inventory, combined with Swedish Forest Soil Inventory. Emission factors are derived based on field measurements from systematic monitoring system.

Organic soils in Forest land show the lowest values of implied emission factors due to the fact that not the entire area of organic soils under forest land is drained.

Table 6. 42 Area, CO_2 emissions and maximum and minimum value of implied C stock change factors in the EU MS reported for the year 2021 for organic soils.

Land use subcategory	Area (Kha)	ICECF (tC/ha)	Emissions from Org. Soils. (Kt CO_2)
4A1	12 424	[-2.90; -0.33]	20 519
4A2	416		1 589
4B1	989	[-10.00; -3,79]	24 695
4B2	274		6 359
4C1	2 497	[-7.65; -0,04]	39 278
4C2	314		5 440

6.3 Uncertainties

For the year 2021, LULUCF uncertainty was estimated in 39,9% for the uncertainty of the level and 17,7% for the uncertainty of the trend (0).

For more information on the uncertainty analysis please refer to chapter 1.6.

Table 6. 32 Level and trend uncertainty assessment of the annual EU-27 emission/removal on LULUCF land subcategories and GHG sources.

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
4.A Forest Land	CO2	-329 219	-273 701	-16.9%	20.3%	9.2%
4.A Forest Land	CH4	2 417	2 243	-7.2%	63.6%	26.2%
4.A Forest Land	N2O	3 030	2 939	-3.0%	68.1%	5.2%
4.B Cropland	CO2	62 675	19 193	-69.4%	188.4%	27.4%
4.B Cropland	CH4	580	399	-31.2%	84.2%	17.9%
4.B Cropland	N2O	1 921	1 063	-44.7%	96.3%	51.4%
4.C Grasland	CO2	43 898	22 752	-48.2%	110.0%	16.8%
4.C Grasland	CH4	2 565	2 044	-20.3%	191.1%	13.2%
4.C Grasland	N2O	623	402	-35.5%	79.6%	27.6%
4.D Wetlands	CO2	10 298	14 908	44.8%	57.1%	16.2%
4.D Wetlands	CH4	5 509	5 868	6.5%	67.2%	4.0%
4.D Wetlands	N2O	119	104	-12.8%	85.4%	24.6%
4.E Settlements	CO2	22 698	23 325	2.8%	37.7%	10.9%
4.E Settlements	CH4	65	69	5.9%	72.1%	11.7%
4.E Settlements	N2O	2 247	2 511	11.8%	99.1%	13.9%
4.F Other Land	CO2	1 205	1 100	-8.7%	68.9%	20.1%
4.F Other Land	CH4	0	1	15.1%	100.0%	15.1%
4.F Other Land	N2O	14	65	379.5%	96.1%	295.4%
4.G Harvested wood products	CO2	-27 770	-45 262	63.0%	36.1%	21.1%
4.G Harvested wood products	CH4	0	0	0.0%	0.0%	0.0%
4.G Harvested wood products	N2O	0	0	0.0%	0.0%	0.0%
4.H Other	CO2	0	35	Inf	30.4%	Inf
4.H Other	CH4	0	244	Inf	100.0%	Inf
4.H Other	N2O	0	0	0.0%	0.0%	0.0%
4.I	CO2	0	0	0.0%	0.0%	0.0%
4.I	CH4	0	0	0.0%	0.0%	0.0%
4.I	N2O	18	27	44.9%	201.3%	90.4%
4.II	CO2	2 028	1 647	-18.8%	53.0%	9.5%
4.II	CH4	2 523	1 610	-36.2%	77.9%	38.1%
4.II	N2O	2 519	2 778	10.3%	94.7%	12.6%
4.III	CO2	0	0	0.0%	0.0%	0.0%
4.III	CH4	0	0	0.0%	0.0%	0.0%
4.III	N2O	107	154	43.8%	763.6%	658.2%
4.IV	CO2	0	0	0.0%	0.0%	0.0%
4.IV	CH4	0	0	0.0%	0.0%	0.0%
4.IV	N2O	332	443	33.3%	12.3%	10.0%
4.V	CO2	15	57	277.9%	36.6%	101.8%
4.V	CH4	6	8	35.3%	38.1%	45.4%
4.V	N2O	3	5	58.6%	36.3%	46.9%
4 (where no subsector data were submitted)	*all*	*-19 223*	*-17 013*	-11.5%	*53.9%*	*38.6%*
Total - 4	**all**	**-208 795**	**-229 985**	**10.1%**	**39.9%**	**17.7%**

6.4 Sector-specific quality assurance and quality control and verification

6.4.1 Time series consistency

The EU greenhouse gas inventory is compiled rigorously by aggregation of national inventories; thus, its consistency strictly depends on the consistency of the individual inventories.

The time-series consistency is checked every year for each individual submission as part of the quality control procedures implemented under the EU Regulations No 2018/841 and 2018/842. Consistency is assessed, in terms of each land use subcategory, and the overall land representation system, across time and space. Ensuring for instance, that the sum of all land use areas is constant over time and matches the official country area. Moreover, there are no circumstances that can justify discontinuities of areas across years. Therefore, the area for each land use category, at the end of one year must be the same as the area at the beginning of the next year.

For the sake of consistency, all parameters used to estimate GHG fluxes are checked. In this sense, activity data, implied carbon stock change factors, and emissions or removals reported for each land use subcategory across the years of the time series are checked to discard errors, identify outliers and to ensure the plausibility of their trends.

Countries provide early submissions to the European Commission (EC) that undergo quality control procedures. As regards with LULUCF information these control checks are implemented by the EEA and aim to ensure the consistency and completeness of the information. But also, to increase the accuracy, transparency, and comparability of the inventories. For each potential issue identified during this phase, a dialogue is established with the country to discuss the best way to resolve the issue, if any.

One of the key features of the methodologies implemented by national systems is to ensure full consistency in definitions, parameters and datasets used for preparing the entire time series for the LULUCF sector. The main challenge is to ensure consistency when historical data are not fully adequate to fulfill reporting requirements or when data is not available on an annual basis.

Land use definitions are not identical among countries. As shown in the previous chapters, each country has its own definition according with its land representation and data collection systems. However, they all are in accordance with IPCC definitions. Differences are caused by small variations in the treatment of particular lands and are in many cases related to historical definitions and available datasets. Some examples are the different thresholds used to define forest; the categorization of hedges or bush areas under Cropland, Grassland or Forest land; or the inclusion of woody plantations either under Cropland or Forest land.

After years implementing QA/QC procedures, and undoubtedly because of the efforts devoted by countries to overcome identified issues, and to improve their inventories in line with the IPCC methods and UNFCCC reporting guidelines, it is undeniable that EU LULUCF information has shown significant improvements during the last years.

Moreover, during the recent years the EC and MS have put in place projects to improve the LULUCF information, and currently better data is available to further improve the land representation system and the estimation of carbon stock changes and other GHG emissions. These improvements are also visible in the recalculations implemented every year by the countries.

6.4.2 Quality Assurance and Quality Control

Information submitted under the LULUCF sector by EU MS are under a double QA/QC system. One implemented at country level, and another one, carried out in the context of the EU No 2018/841 and 2018/842, which is performed for this sector by the European Environment Agency in collaboration with the countries, and European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM)

Under these Regulations, the checks focus on early versions of national GHG inventories that are submitted by 15th January. The checks aim to assess and improve the completeness and consistency, but also the accuracy, transparency, and to the extent possible the comparability of the inventories. A second round of submissions received in March is also checked in terms of the implementation status of issues previously identified and the reasons for recalculations among the January and March submission.

Ultimately, the checks are intended to identify and resolve calculation errors, to provide suggestions to address completeness issues, to identify the need for further information and to amend the lack of transparency, and to spot outliers on time-series that hamper the consistency, and to identify discrepancies among data included on the different sections of the submission. In all the cases, QA/QC procedures are implemented by interacting with national experts to get clarifications and to plan possible improvements.

During the analysis every year about 150 findings (i.e., potential issues) are communicated to the countries. Examples of issues include the use and justifications of notations keys, potential inconsistencies in land representation, wrong interpretation of how to fill in the tables, inconsistent reporting of activity data among CRF tables and between CRF tables and NIR, outliers in IEFs values for different categories, and lack of transparency in specific national circumstances that affected the EU trend.

The following list aims to provide an overview of the checks that are implemented on the LULUCF by countries, but it does not intend to represent an exhaustive description of the checks.

1. Completeness check: the use of any notation key "NE", but also possible inappropriate use of "NA", "NO", "IE", whenever IPCC methods are available, is monitored and followed up with the relevant countries. Furthermore, the check also aims to identify empty cells that should have been filled in with information.
2. Time-series check of activity data information:
    a. The sum of areas reported for each land use category is constant over time.
    b. The feasibility of the time series of area and land use changes occurring in a single year.
    c. The area at the end of the previous year (t-1) matches the area at the beginning of the current year (t).
    d. Check to ensure that only annual land use changes from one year to another are reported in the CRF table 4.1.
3. Time-series check of emissions/removals and implied carbon stock change factors (ICSCF):
    a. Check the feasibility of potential discontinuities in ICSCF and emissions or removals.
    b. Check for outliers in ICSCF and emissions or removals.
    c. Check the coherence of emissions and removals with activity data.
    d. Check the plausibility of constant values of emissions and removals across years.
4. Check the consistency of areas reported across different CRF tables:
    a. The area reported for each land use category in CRF table 4.1 matches the area reported under the sectorial background data tables (i.e. 4.A-4.F). (**To note**: Despite this check and the recommendation provided by the EU in the context of the QAQC procedures to ensure the consistency among tables, following a recommendation from the 2016 ERT, Estonia is not reporting unmanaged wetlands under "other wetlands" in the CRF table 4.D; however, those areas are included in CRF 4.1. This leads to an inconsistency among the information of these tables that is directly translated to the LULUCF sector of the EU GHG inventory.
5. Check the consistency among LULUCF and Agriculture: Histosols areas reported in Agriculture are equal or less than organic soils areas reported in Cropland plus Grassland (N.B.: organic soils areas for non-cultivated grasslands (no matter whether considered managed or unmanaged) are reported in LULUCF sector but not in Agriculture)
6. Additional checks implemented on LULUCF information:
    a. Check that unresolved and partially resolved issues from previous year are addressed.
    b. Check that ERT team's recommendation that concern country 'submissions are addressed.
    c. Check that HWP information on LULUCF is complete and properly allocated under the correct approach.
    d. Check the coherence among units and activity data used for reporting Biomass burning in CRF table 4(V)

In addition to the routine implementation of QA/QC checks, some additional activities have been implemented during the past years that were meant to improve the quality of both national, and EU GHG inventories, as follows:

- In 2012 an exercise was carried out involving LULUCF reviewers that participate in the UNFCCC review process to assess the reporting of dead organic matter and soils and identify common issues and alternative solutions. Some decision trees were created and shared with inventory compilers. (E.g. is the “not a source” provision properly applied?)
- In 2014 and 2015 two assessments were carried out to verify data on burned areas reported by individual GHG inventories and those reported in EFFIS[49].
- In 2021 a trial LULUCF review was done with the participation of 15 Member States that resulted in several observations.
- The Join Research Centre of the European Commission has collaborated during the past years, and continues to do so, on several capacity building projects launched by DG CLIMA to support the LULUCF reporting on MS.

Furthermore, with the purpose of enhancing the LULUCF reporting, sharing experiences amongst countries, and the harmonization of methods for estimating GHG emissions and CO_2 removals in the sector, a series of technical workshops dedicated to UNFCCC reporting (including Kyoto Protocol), under the auspices of the Joint Research Centre have been organized.

- JRC LULUCF Workshop 2022. Villa Borghi (Varano Borghi, Italy) and online 20-21 June 2022.
- JRC virtual technical workshop: LULUCF in transition: present and future challenges for reporting and accounting 7-8 June 2021
- JRC technical workshop on LULUCF reporting under the Kyoto Protocol 28-29 May 2019, Varese (VA), Italy.
- JRC technical workshop on LULUCF reporting under the Kyoto Protocol, 16-17 May 2018 Arona (NO), Italy
- JRC technical workshop on LULUCF reporting under the Kyoto Protocol, 26-27 April 2017 Stresa (NO), Italy
- JRC technical workshop on LULUCF reporting under the Kyoto Protocol, 02-03 May 2016 Stresa (NO), Italy.
- JRC technical workshop on LULUCF reporting under the Kyoto Protocol, 26-27 May 2015 Arona (NO), Italy.
- JRC technical workshop on LULUCF reporting under the Kyoto Protocol, 05-07 May 2014, Arona (NO), Italy.
- II JRC technical workshop on LULUCF reporting under the Kyoto Protocol, 04-06 November 2013, Arona (NO), Italy.
- JRC technical workshop on LULUCF reporting under the Kyoto Protocol, 27 February-1 March 2013, Ispra (VA), Italy.
- “JRC technical workshop on LULUCF issues under the Kyoto Protocol”, held in Brussels, November 21, 2011.
- “JRC technical workshop on LULUCF issues under the Kyoto Protocol”, held in Brussels, November 9-10, 2010.
- Technical workshop on projections of GHG emissions and removals in the LULUCF sector, Ispra (VA), Italy. 27-28 January 2010.
- Technical workshop on LULUCF reporting issues under the Kyoto Protocol, Ispra (VA), Italy. November 13-14, 2008.

[49] http://forest.jrc.ec.europa.eu/effis/

- "Technical meeting on specific forestry issues related to reporting and accounting under the Kyoto Protocol" Ispra (VA), Italy. 27-29 November 2006).
- "Improving the Quality of Community GHG Inventories and Projections for the LULUCF Sector". Ispra (VA), Italy. September 22-23, 2005.

For further information on these workshops and additional activities see: http://forest.jrc.ec.europa.eu/activities/lulucf/workshops/.

6.4.3 Verification

Relatively little information on verification is included in national GHG inventories. For forest land, the JRC has implemented the Carbon Budget Model (CBM), a forest growth model developed by the Canadian Forest Service and adapted to the EU conditions (Pilli et al. 2014[50], Pilli et al. 2016[51],[52]), to estimate carbon stock changes in all forest carbon pools for 26 MS (all EU countries except Malta and Cyprus). Overall, at EU level, the results from CBM were very close to the sum of individual inventories (a difference of only 3% for the average sink 2000-2015 in the category "forest land remaining forest land"). However, for few MS the differences were larger and deserve further investigations. The results of this modeling have been offered to MS as a potential verification exercise (see Bulgaria's NIR); in some cases, the comparison of model results with GHG inventories resulted in identifying errors in the GHG inventory. It is expected that more comparisons of national GHG inventories with CBM results will be carried out in coming years.

Besides that, a comprehensive analysis of individual submissions has been also carried out in 2015[53]. In this context, some inconsistencies were found that were communicated to concerned country during the 2016 QA/QC process. Finally, the JRC recommended to national LULUCF experts to verify, where available data allow, the gain-loss methodology applied for estimating their forest land with an alternative estimate prepared by applying the stock-difference method, and vice versa.

6.4.4 Improvement status and plan

Improvements and major changes introduced in this chapter from previous submissions

For this year submission, a double-eyes principle has been introduced. Two LULUCF experts have worked in parallel, and each of them reviewed the section drafted by the other expert.

The following improvements have been introduced in the GHG inventory submission 2022 to address recommendations received from the UNFCCC's expert review team (ERT), to correct issues identified during our internal quality control process, and/or to introduce developments identified during our internal peer review:

- Addition of transparent and updated explanations in the specific land use sections on the reasons for changes in trends and inter-annual variability of the emissions and removals reported this year.
- Correction of identified typo errors that were found across the chapter.

[50] Pilli R., Grassi G., Kurz W.A., Smyth C.E. and Blujdea V. (2013). Application of the CBM-CFS model to estimate Italy's forest carbon budget, 1995 to 2020. Ecological modelling. 266, 144-171.

[51] Pilli, R., Grassi, G., Kurz, W., Abad Viñas, R., Guerrero Hue, N. (2016) Modelling forest carbon stock changes as affected by harvest and natural disturbances. I. Comparison with countries' estimates for forest management. Carbon Balance and Management vol. 11 no. 1 p. 5. doi: 10.1186/s13021-016-0047-8

[52] Pilli, R., Grassi, G., Kurz, W., Moris, J., Abad Viñas, R. (2016) Modelling forest carbon stock changes as affected by harvest and natural disturbances. II. EU-level analysis Carbon Balance and Management vol. 11 no. 1 p. 20. doi:10.1186/s13021-016-0059-4

[53] Viorel NB Blujdea, Raúl Abad Viñas, Sandro Federici & Giacomo Grassi (2016): The EU greenhouse gas inventory for the LULUCF sector: I. Overview and comparative analysis of methods used by EU member states, Carbon Management, DOI: 10.1080/17583004.2016.1151504

- Resulting from the work carried out in collaboration with Member states, the EU has addressed a recommendation received from the UN ERT on the use of the notation key NA for reporting information on carbon pools which are considered in equilibrium.
- Continuing the efforts on the need to close inconsistencies identified across the activity data reported in CRF tables 4.1 and 4.A-4.F, also this year, the EU worked with its MSs in order to address this issue. As a result, in this submission differences in areas between these tables were, for each of the land use categories, further reduced. And they appear with an insignificant impact in the EU GHG inventory in terms of emissions and removals. An exception is the reporting of Wetlands due in the submission by Estonia that follows a different recommendation from its UN ERT. (See section 6.4.2).
- Addition of transparent information on the reporting, by Italy, of carbon stock changes under 4.B.2 to address a reiterated recommendation by the UN ERT on the use of higher Tier methods for reporting key categories. (See section 6.2.2.3).
- Portugal introduced a comprehensive recalculation of the LULUCF sector, which among others result in the re-allocation of shrubland areas under the category Grassland, which address a reiterated UN ERT´s recommendation received in the past years.
- References to UK and Iceland were removed from these chapter these countries are no longer part of the scope of this inventory.
- As every year the EU LULUCF inventory has increased its completeness and improved the accuracy as a result of the efforts implemented by MS to improve the LULUCF information, as well as the support provided to the countries by the EU. Notable examples in this submission are: (i) Romania which introduced refined data and approach for estimating changes in DW, litter and mineral soils in Forest land remaining forest land. (ii) Finland introduced new findings regarding carbon stock changes in soil organic carbon for forest land on drained organic soils which considers the effect of temperature on soil respiration. (iii) Germany introduced a new method for estimating emissions from mineral soils. The implementation of the high-resolution soil maps (1 ha) as a function of numerous site-related parameters leads to the clearly more differentiated calculation of the differences in carbon stocks in the mineral soils which involves high-resolution soil maps (1 ha) as a function of numerous site-related parameters. (iv) France performed a complete update of the methodology for land use change monitoring and the calculation of carbon fluxes, using a comprehensive spatially explicit approach.

Planned improvements

The following improvements are foreseen for next submission:

- Follow up individual submissions to ensure that small differences on areas that remain in the reporting of the information in CRF table 4.1 and 4.A - 4.F are addressed.
- Continue working with MS to increase the accuracy, and completeness, and reduce uncertainty of the LULUCF information, as far as can be achieved, as part of the continue efforts to improve LULUCF data quality.

7 WASTE (CRF SECTOR 5)

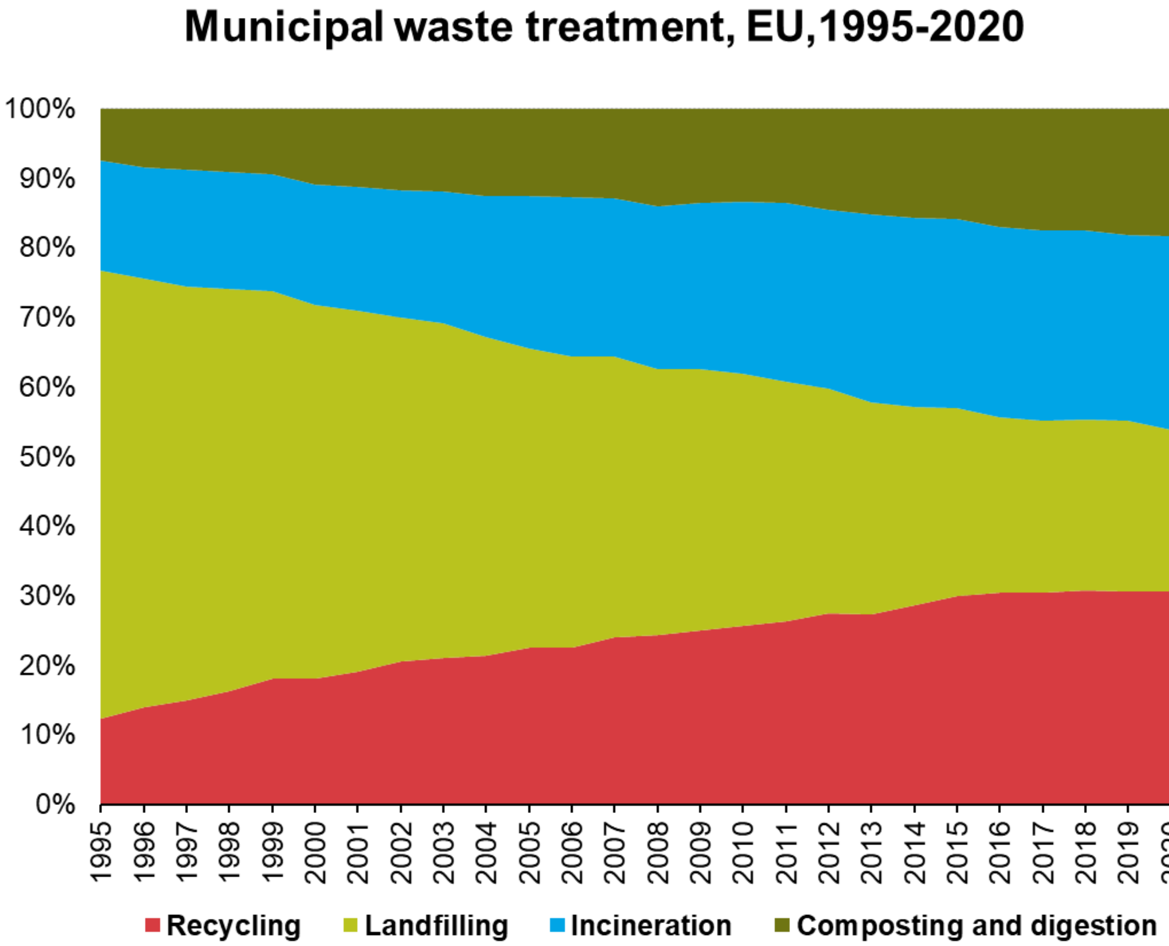
GHG emissions in the waste sector are generated from the treatment and disposal of liquid and solid waste. According to the IPCC 2006 Guidelines emission estimates in the waste sector need to be carried out for four subcategories:

- 5.A Solid waste disposal
- 5.B Biological treatment of solid waste
- 5.C Incineration and open burning of waste
- 5.D Wastewater treatment and discharge.

Of the above, the first three categories mainly refer to possible routes for treatment and disposal of solid waste. Solid waste can be recycled, landfilled, incinerated and biological treated. The decrease of total GHG emissions in the waste sector is mainly driven by the development of the different waste treatment routes. Figure 7.1 shows the share of the Municipal Solid Waste (MSW) treatments over the time series 1995 to 2020 based on activity data for municipal solid waste as published in 2021. The figure is based on Eurostat data as there is a common definition for the reporting of municipal waste to Eurostat and information on waste recycling is also included. On the basis of the Regulation on waste statistics (EC) No. 2150/2002, amended by Commission Regulation (EU) No. 849/2010, data on the generation and treatment of waste is collected from the Member States. The information on waste treatment reported to Eurostat is broken down to five treatment types (recovery, incineration with energy recovery, other incineration, disposal on land, biological treatment) and in waste categories. Eurostat data shown in the figures below include only information for municipal waste treatment, while in the GHG inventory also industrial waste, sludge and hazardous waste are reported by some countries under the categories solid waste disposal, biological treatment and waste incineration. However, the Eurostat data is used to show the overall trend of waste treatment in the European Union.

Between 1995 and 2020 the amount of municipal solid waste landfilled is continuously decreasing in the 27 EU countriesand other waste treatment methods like recycling, biological treatment of waste and waste incineration with energy recovery are applied more. In 1995, 65 % of waste has been landfilled, 16 % was incinerated (with and without energy recovery), 12 % recycled and only 8 % of the municipal solid waste has been composted or digested. In 2020, the share of waste landfilled decreased to 23 % of total waste treated while incineration including energy recovery increased to 28%, recycling increased to 31 % and biological treatment of waste makes up 18 % of total municipal solid waste treated.

Figure 7.1 Sector 5 Waste: Development of municipal waste treatment in the EU



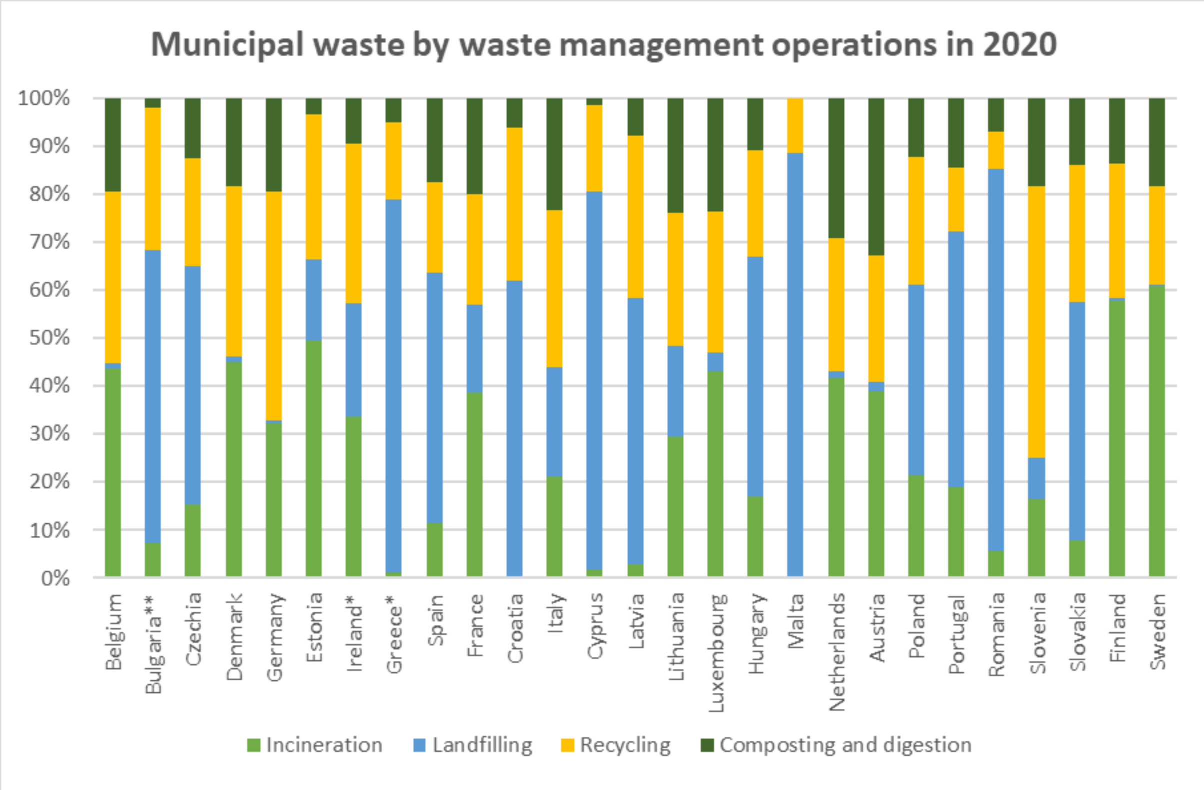
Note: estimated by Eurostat.

Source: Eurostat (online data code: env_wasmun)

Many countries experienced a reduction of waste landfilled and an increase of recycling, composting, landfill gas recovery and waste incineration with energy recovery. These trends have already started before the Landfill Directive 1999/31/EC and the Directive on packaging waste 94/62/EC and 2008/98/EC, but are further supported by these directives.

The share of the single municipal waste treatment routes differs significantly among countries in 2020 (comparison in Figure 7.2). Indeed, the waste management practices and policies which determine the fraction of municipal solid waste (MSW) disposed to solid waste disposal sites (SWDS), the fraction of waste incinerated and the fraction of waste recycled or with biological treatment differ significantly between the countries. For example, disposing municipal waste on SWDS is the predominant (>60%) municipal waste disposal route in Bulgaria, Greece, Croatia, Cyprus, Malta and Romania with correspondingly fewer quantities of waste incinerated, recycled or biological treated. In Belgium, Denmark, Germany, Luxembourg, the Netherlands, Austria, Slovenia, Finland andSweden, it is the opposite (<20%). Since 2005, landfills in Germany remaining in operation may only store waste that conforms to strict categorization criteria. Landfills also must reduce landfill gas formation from such waste by more than 90 % compared to gas production from untreated waste. In the Netherlands (also in Belgium), waste policy also has the aim of reducing landfilling by introducing bans for the landfilling of certain categories of waste, e.g. by limiting the authorized organic fraction of landfilled waste and by raising the landfill tariff to shift waste streams to other treatment routes.

Figure 7.2 Waste management practices in the EU (shares) in 2020



7.1 Overview of sector

CRF Sector 5 Waste is the fourth largest sector in the EU, after energy, agriculture and industrial processes, contributing 3.3 % to total GHG emissions including indirect CO_2, with LULUCF, with international aviationin 2021. Total emissions from waste decreased by 40,7% from 184 Mt in 1990 to 109 Mt in 2021 (Figure 7.3). In 2021, emissions decreased by 1.9 % compared to 2020.

The strong decrease of emissions from the waste sector is mainly influenced by a strong decline of emissions in the waste sector from Germany, the Netherlands and Poland. Reductions from category 5.A solid waste disposal on land make up about 55 % of total emission reductions in the waste sector (between 1990 and 2021). Emissions from the waste sector show a continuously decreasing trend during the last years, but as many countries with large emissions from this sector already decreased emissions since 1990 by more than 70 % and most technical mitigation options are implemented in those big countries, the declining emission trend is slowing down.

Figure 7.3 Sector 5 Waste: EU GHG emissions, 1990-2021

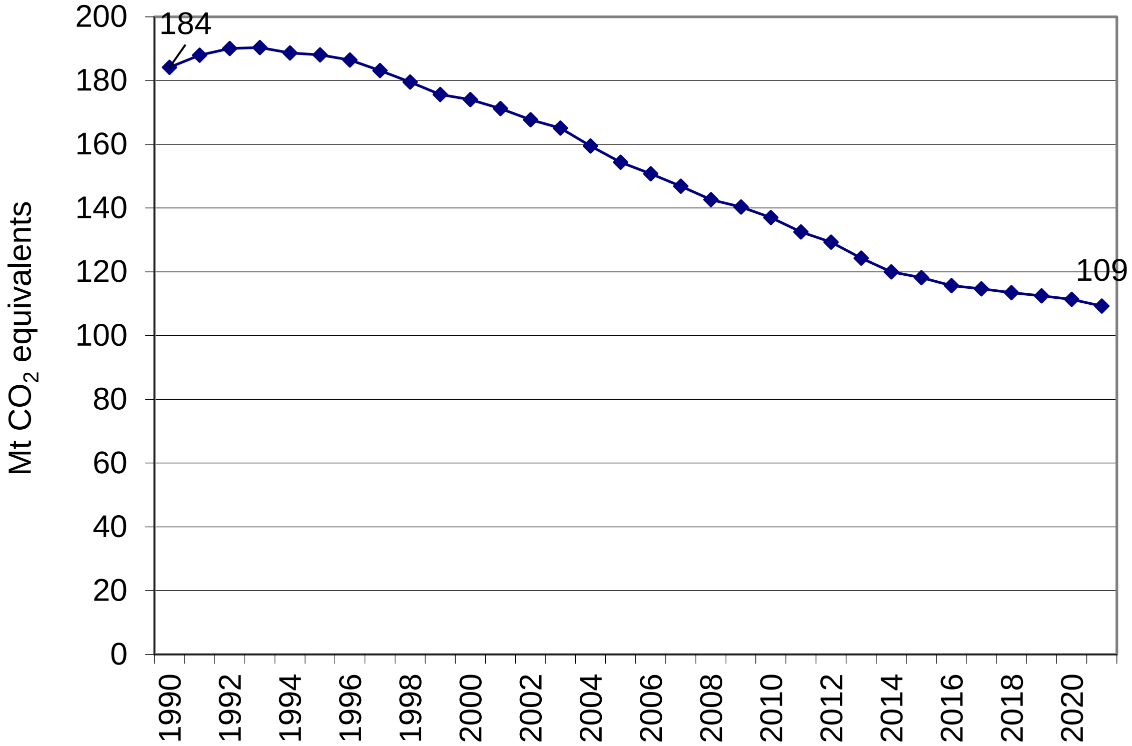
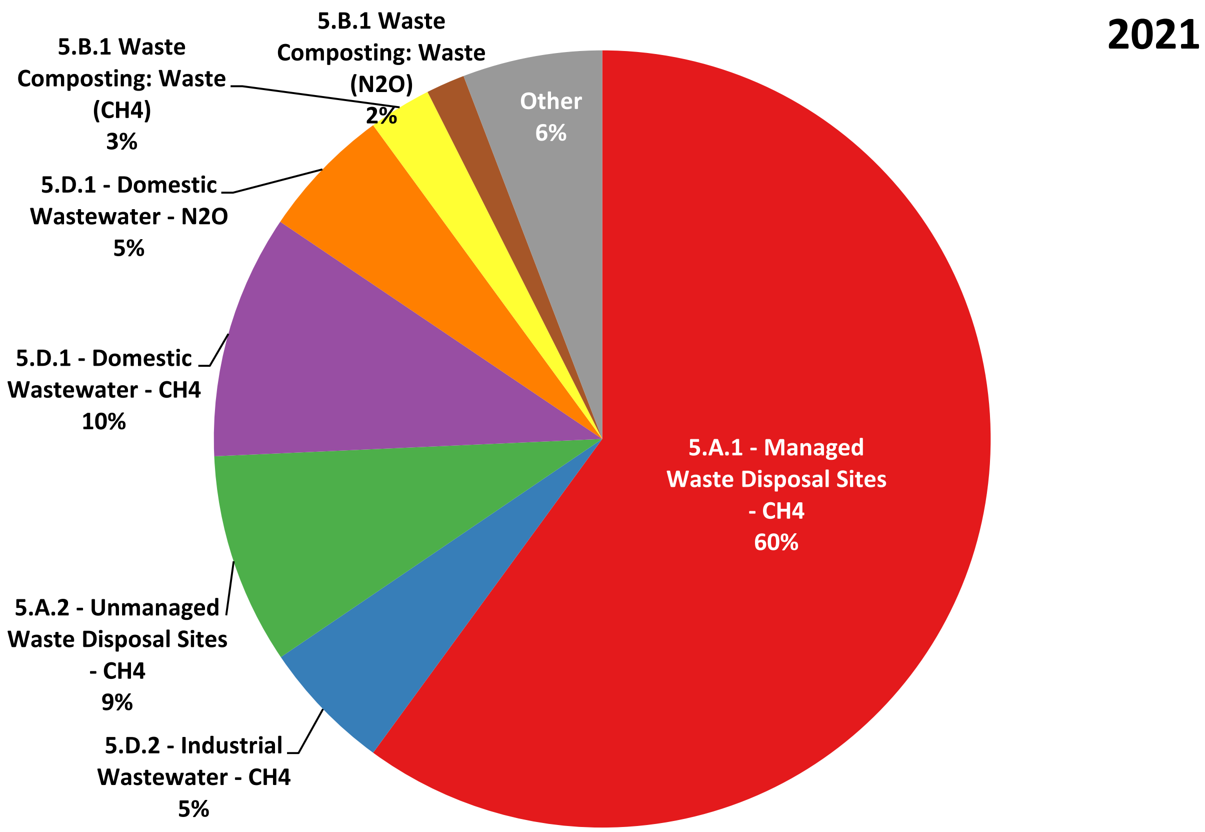


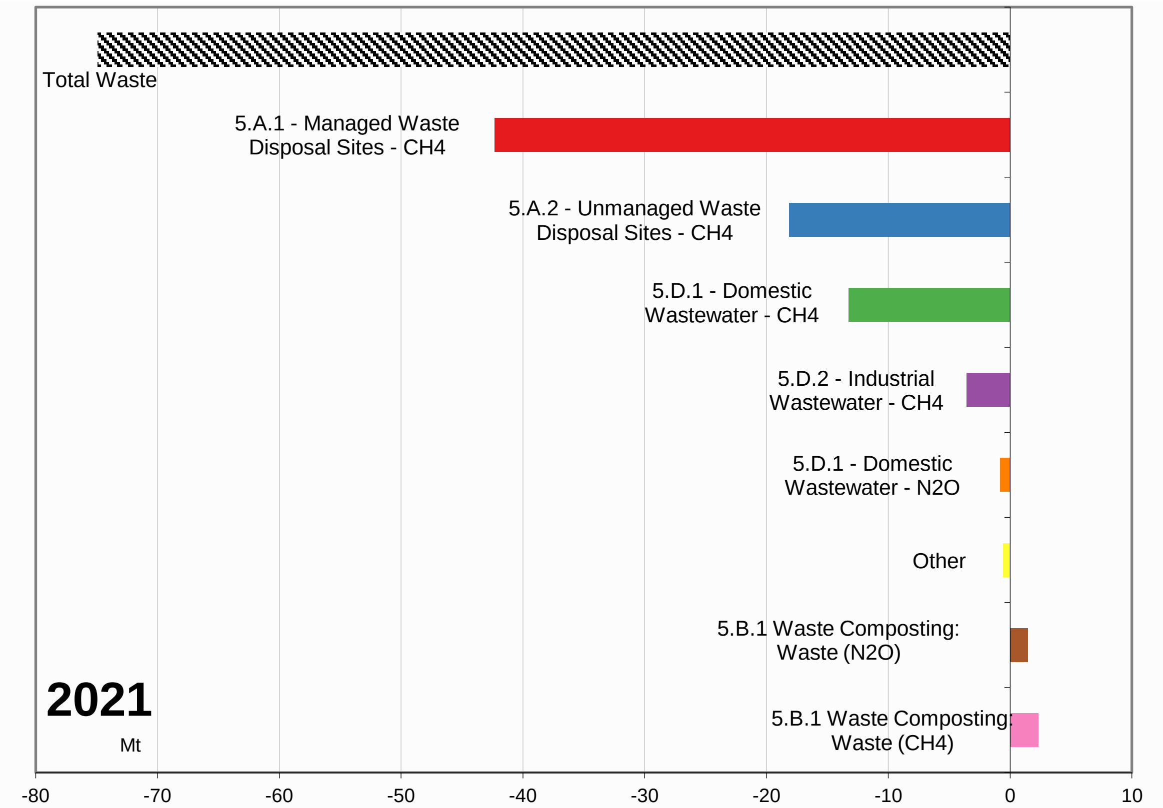
Figure 7.5 shows that CH_4 emissions from 5A1 Managed Waste Disposal on Land had the greatest decrease of all waste-related emissions, but still accounts for 60 % of waste-related GHG emissions in the EU in 2021 as shown in Figure 7.4.

Figure 7.4 Sector 5 Waste: Share of key source categories and all remaining categories in 2021 for EU



Note: Other is calculated by subtracting the presented categories from the sector total

Figure 7.5 Sector 5 Waste: Absolute change between 1990 and 2021 of GHG emissions (in CO_2 equivalents) by large key source categories for EU



Note: Other is calculated by subtracting the presented categories from the sector total

7.2 Source categories and methodological issues

This chapter includes information on emission levels and emission trends for all 27 countries (EU) for the EU key source categories. Additionally, information for EU key source categories on national methods and circumstances, which are available in the countries' national inventory reports, are provided in the Annex III.

In this section we present information relevant for the EU key source categories in the sector 5 Waste. Source categories considered in detail are:

Table 7.1 Key source categories for level and/or trend analyses and share of MS emissions using higher tier methods

Source category gas	kt CO_2 eq.		Trend	Level		share of higher Tier
	1990	2021		1990	2021	
5.A.1 Managed Waste Disposal Sites: Waste (CH_4)	107 939	65 617	T	L	L	94,2%
5.A.2 Unmanaged Waste Disposal Sites: Waste (CH_4)	27 744	9 592	T	L	L	100%
5.B.1 Waste Composting: Waste (CH_4)	516	2 861	T	0	0	54.0%
5.D.1 Wastewater Treatment and Discharge: Domestic Wastewater (CH_4)	24 354	11 093	T	L	L	41.6%
5.D.1 Wastewater Treatment and Discharge: Domestic Wastewater (N_2O)	6 833	6 028	0	0	L	47.7%
5.D.2 Wastewater Treatment and Discharge: Industrial Wastewater (CH_4)	9 569	5 978	0	L	L	64.6%

The share of higher Tier corresponds to the share of EU emissions documented by countries reporting the method as an IPCC Tier 2 method (T2) or a country-specific method (CS), or countries reporting EF as country-specific (CS) or plant specific (PS).

Almost all countries report CH_4 emissions from solid waste disposal on managed and unmanaged landfills 5.A using a Tier 2 methodology. In all other source categories in the waste sector the share of countries using a higher Tier method is much lower.

For CH_4 emissions from composting (5.B.1) France and Germany mainly influence the share of higher Tiers because they have one of the highest shares for this gas, respectively 28.2 % and 12.5 % in this category and are using a higher Tier. However, Spain which has the third highest share of CH_4 from composting (12.2 %) is applying a Tier 1.

For CH_4 emissions from domestic wastewater treatment (5.D.1), Poland, which represents 15,9% of the EU emissions from this category, mainly influence the share of higher Tiers. However, France and Italy, which represent respectively 22.1 % and 10.0 % of CH_4 from the category are applying a Tier 1. Regarding N_2O emissions from domestic wastewater treatment (5.D.1), Italy and Spain, which represents respectively 17.6 %, and 14.1 % of the EU emissions from this category, are applying Tier1. On the other hand, 10 countries, with lower contribution the EU emissions from this category, are applying higher Tier, including Poland and the Netherlands which represents respectively 11.4 % and 10.3 % the EU emissions from this category.

For CH_4 emissions from industrial wastewater, Spain and Greece contribute respectively to 22.9 % and 18.9 % to the 64.6 % of CH_4 emissions that are reported in this sub-category using higher Tiers. Italy, which contributes to 26.4 % of CH_4 emissions from industrial wastewater, applies a Tier 1.

Other source categories in the waste sector are not contributing to a key source and only information on total emissions from these categories is provided for completeness reasons (see chapter 3.2.8). Further information on emission trends and methodological information on other source categories from the waste sector are not provided.

7.2.1 Solid waste disposal on land (CRF Source Category 5A)

Methane is produced from anaerobic microbial decomposition of organic matter in solid waste disposal sites. This source category includes two key categories: CH_4 from 5A1 Managed waste disposal on land and CH_4 from 5.A.2 Unmanaged waste disposal on land. In addition, source category 5A includes the category 5.A.3 CH_4 emissions from uncategorized landfills, but only Estonia (1990-1993) and Poland (1990-2021) report emissions from this category. As this is no EU key category no further information on 5.A.3 is included in the following chapters.

The source category 5A contributes 2.3 % to total GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021.

The methane recovery that takes place in the managed or unmanaged solid waste landfills is also reported in CRF-table 5A but those amounts are not included in the reported CH_4-emissions, as prescribed by the IPCC guidelines. In the unmanaged solid waste landfills, mainly no CH_4-recovery is taken place. Only Ireland (1996-1998) and Latvia (2002-2017) report CH_4 recovery from unmanaged landfills for a few years in the time series.

Table 7.2 provides total greenhouse gas and CH_4 emissions by Member State from 5A Solid Waste Disposal on Land. CH_4 emissions from this category decreased by 45 % between 1990 and 2021 in the EU. Fourteen EU countries reduced their emissions from this source, while Bulgaria, Croatia, Cyprus, the Czech Republic, Greece, Hungary, Italy, Latvia, Malta, Portugal, Romania, Slovakia and Spain did not. In many of these countries waste disposal changed from unmanaged to managed landfills during the time period 1990 and 20120 which leads to increasing CH_4 emissions from managed landfills. In 2021, CH_4 emissions from landfills decreased by 2.7 % compared to 2020.

Table 7.2 5A Solid Waste Disposal on Land: Countries contributions to total GHG emissions and CH_4 emissions

Member State	GHG emissions in kt CO_2 equivalents		CH_4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021
Austria	4 081	878	4 081	878
Belgium	3 323	581	3 323	581
Bulgaria	2 100	2 239	2 100	2 239
Croatia	371	1 266	371	1 266
Cyprus	295	572	295	572
Czechia	2 008	3 725	2 008	3 725
Denmark	1 526	434	1 526	434
Estonia	239	197	239	197
Finland	4 847	1 470	4 847	1 470
France	13 142	12 255	13 142	12 255
Germany	37 191	2 574	37 191	2 574
Greece	2 512	4 183	2 512	4 183
Hungary	2 837	3 226	2 837	3 226
Ireland	1 476	703	1 476	703
Italy	13 671	15 674	13 671	15 674
Latvia	353	373	353	373
Lithuania	1 152	617	1 152	617
Luxembourg	103	48	103	48
Malta	46	183	46	183
Netherlands	15 321	2 356	15 321	2 356
Poland	14 621	1 303	14 621	1 303
Portugal	3 159	3 856	3 159	3 856
Romania	1 536	4 353	1 536	4 353
Slovakia	782	1 258	782	1 258
Slovenia	418	206	418	206
Spain	6 131	10 378	6 131	10 378
Sweden	3 832	543	3 832	543
EU-27	**137 074**	**75 450**	**137 074**	**75 450**

Note: The first two column show total emissions from 5A reported in kt CO_2 eq. The last two columns show CH_4 emissions in kt CO_2 eq. As only CH_4 emissions are reported under 5.A the figures in the columns are identical Abbreviations explained in the Chapter 'Units and abbreviations'.

7.2.1.1 Managed waste disposal sites (CRF Source Category 5A1)

Table 7.3 provides information on emission trends of the key source CH_4 from 5A1 Managed Waste Disposal on Land by Member State. CH_4 emissions from this source account for 2.0 % of total EU GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021. Between 1990 and 2021, CH_4 emissions from managed landfills declined by 39.2 % in the EU.

Twelve EU countries reduced their emissions from this source during that period while Croatia, the Czech Republic, Greece, Hungary, Italy, Portugal, Slovakia and Spain did not. Bulgaria, Cyprus, Estonia, Ireland, Latvia, Malta, and Romania did not report CH_4 emissions from managed landfills in 1990. In 2021, CH_4 emissions from managed landfills decreased by 2.3 % compared to 2020.

Table 7.3 5A1 Managed Waste Disposal on Land: Countries contributions to CH_4 emissions and information on method applied and emission factor

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	4 081	931	878	1.3%	-3 203	-78%	-53	-6%	T2	CS,D
Belgium	3 323	644	581	0.9%	-2 742	-83%	-62	-10%	T2	D
Bulgaria	NO	1 217	1 236	1.9%	1 236	∞	19	2%	T2	CS,D
Croatia	18	1 327	1 186	1.8%	1 168	6361%	-141	-11%	T2	CS
Cyprus	NO	136	160	0.2%	160	∞	23	17%	T2	D
Czechia	2 008	3 689	3 725	5.7%	1 717	86%	36	1%	T1	D
Denmark	1 526	458	434	0.7%	-1 093	-72%	-25	-5%	CS,T2	CS,D
Estonia	NO	195	197	0.3%	197	∞	2	1%	T2	D
Finland	4 847	1 551	1 470	2.2%	-3 377	-70%	-81	-5%	T2	CS,D
France	13 142	13 083	12 255	18.7%	-887	-7%	-828	-6%	T2	CS,D
Germany	37 191	2 973	2 574	3.9%	-34 617	-93%	-399	-13%	T2	CS
Greece	90	2 338	2 729	4.2%	2 640	2945%	391	17%	T2	CS,D
Hungary	440	1 996	2 028	3.1%	1 588	361%	33	2%	T2	D
Ireland	NO	739	703	1.1%	703	∞	-36	-5%	T2	CS,D
Italy	7 153	13 816	13 623	20.8%	6 470	90%	-193	-1%	T2	CS
Latvia	NO	260	253	0.4%	253	∞	-6	-2%	T2	D
Lithuania	766	514	490	0.7%	-276	-36%	-24	-5%	T2	D
Luxembourg	103	50	48	0.1%	-55	-53%	-2	-4%	T1	D
Malta	NO	167	176	0.3%	176	∞	9	5%	T2	M
Netherlands	15 321	2 473	2 356	3.6%	-12 965	-85%	-116	-5%	T2	CS
Poland	7 222	1 085	1 020	1.6%	-6 202	-86%	-65	-6%	T2	CS,D
Portugal	834	3 186	3 202	4.9%	2 368	284%	15	0%	T2	CS,D
Romania	NO	2 422	2 536	3.9%	2 536	∞	115	5%	T2	CS,D
Slovakia	782	1 256	1 258	1.9%	476	61%	2	0%	T2	CS
Slovenia	418	231	206	0.3%	-211	-51%	-24	-11%	T2	CS,D
Spain	4 843	9 791	9 749	14.9%	4 906	101%	-42	0%	T2	CS,D,OTH
Sweden	3 832	641	543	0.8%	-3 289	-86%	-98	-15%	T2	CS,D
EU-27	**107 939**	**67 168**	**65 617**	**100%**	**-42 322**	**-39%**	**-1 550**	**-2%**	**-**	**-**

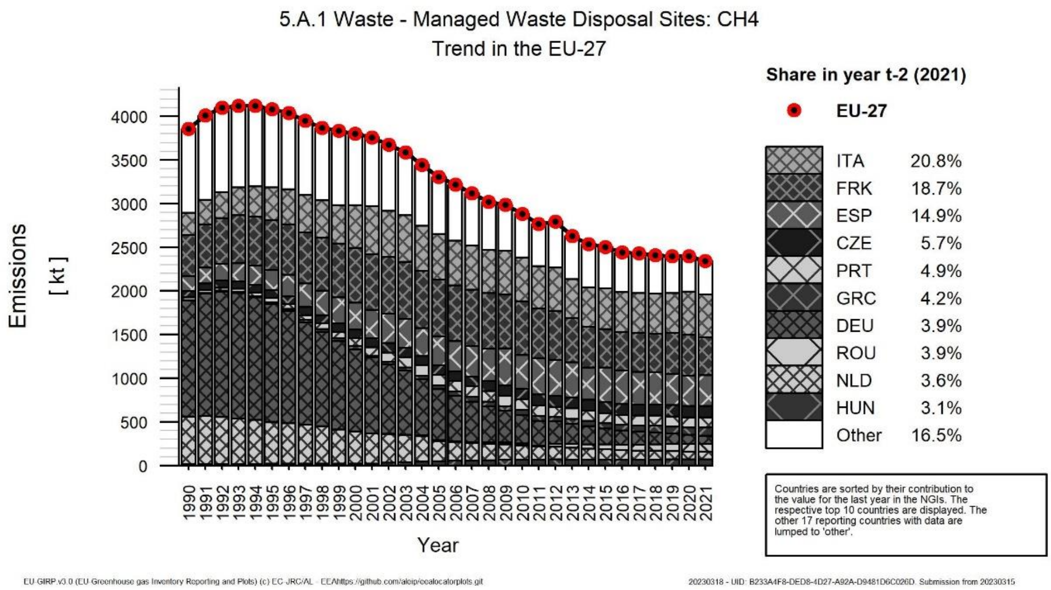
Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Trends in Emissions and Activity Data

CH_4 emissions from solid waste disposal on managed land decreased considerably between 1990 and 2021 by 39.2%. Figure 7.6 shows the trend of emissions indicating the countries contributing most to EU total.

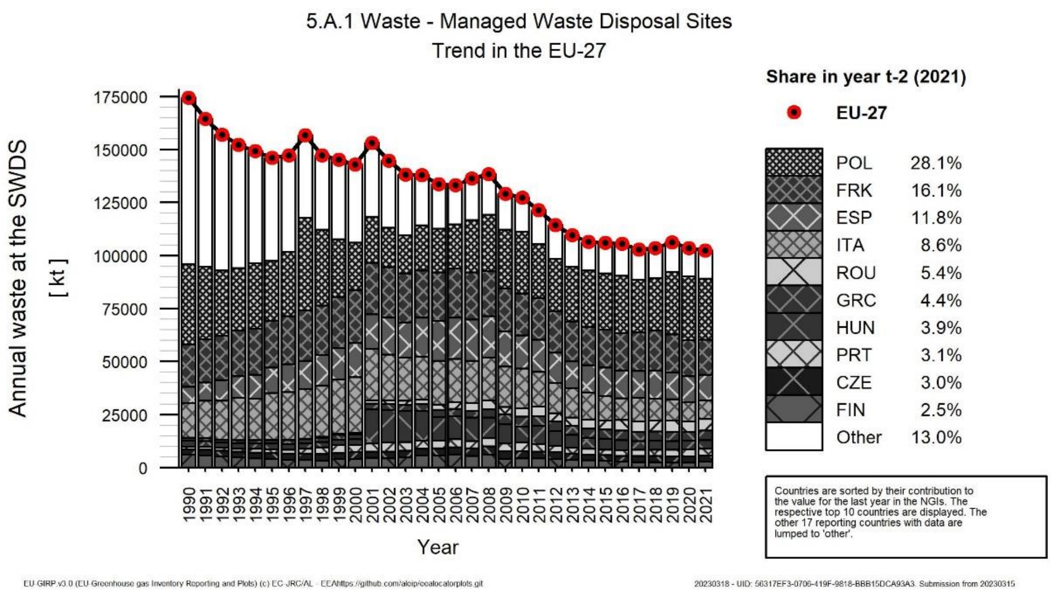
The countries with highest emissions from this source in 2021 were France, Italy andSpain. These MS account for 54.3 % of EU CH_4 emissions from 5A1. The largest reductions in absolute terms between 1990 and 2021 were reported by Germany (–34,6 Mt CO_2 equiv.). The emission reductions are partly due to the (early) implementation of the landfill waste directive or similar legislation in these countries. The landfill waste directive was adopted in 1999 and requires the Member States to reduce the amount of biodegradable waste disposed untreated to landfills and to install landfill gas recovery at all new sites.

Figure 7.6 *5A1 Managed waste disposal on land: CH_4 emissions (Trend in relevant countries)*



A main driving force of CH_4 emissions from managed waste disposal on land is the amount of waste, especially of biodegradable waste going to landfills. According to the CRF Tables submitted in 2023 the yearly total amount of waste disposal on managed landfills declined by 41.2 % between 1990 and 2021 (see *Figure 7.7*). In addition, CH_4 emissions from landfills are influenced by the amount of CH_4 recovered and utilized or flared. The share of CH_4 recovery has increased significantly in EU since 1990 (see Figure 7.8).

Figure 7.7 *5A1 Managed waste disposal on land: Waste disposal (Trend in relevant countries)*



In the following description more information is provided for the countries that are contributing most to the trend of this key category on the level of the EU.

Italy, contributing with 20,8 % to EU emissions in 2021 of this sector, featured a rapid increasing trend of CH_4 emissions from landfills until 2001 and a slow decreasing trend thereafter. This is driven, inter alia, by the increasing amount of waste landfilled until 2000 and a decrease thereafter. Also, CH_4 recovery has increased throughout the time series up to 2013 and decrease onward. The key drivers for the fall in emissions are the national policy diverting solid waste from landfill to waste incineration plants and waste diversion measures (composting and mechanical and biological treatment have showing a remarkable rise due to the enforcement of legislation). Anyway, in 2021, CH_4 emissions from managed solid waste disposal decreased by 1,4 % compared to 2020.

France, contributing with 18.7 % to EU emissions in 2021, increased its emissions from managed solid waste disposal sites steadily until 2003; followed by a declining trend until 2015 and a steady trend thereafter. Emissions followed the increased amount of municipal waste going to landfills until 2000, which decreased until 2016. Between 2016 and 2018, the amount of municipal waste going to landfills increased temporary before decreasing sharply since 2018. This situation over recent years leads to a decrease in CH_4 emissions by 6.3 % between 2020 and 2021. Small amounts of CH_4 have been flared and recovered already in 1990, increasing up to 2015. Since 2015 a quite steady amount of CH_4 recovery can be found despite annual variations.

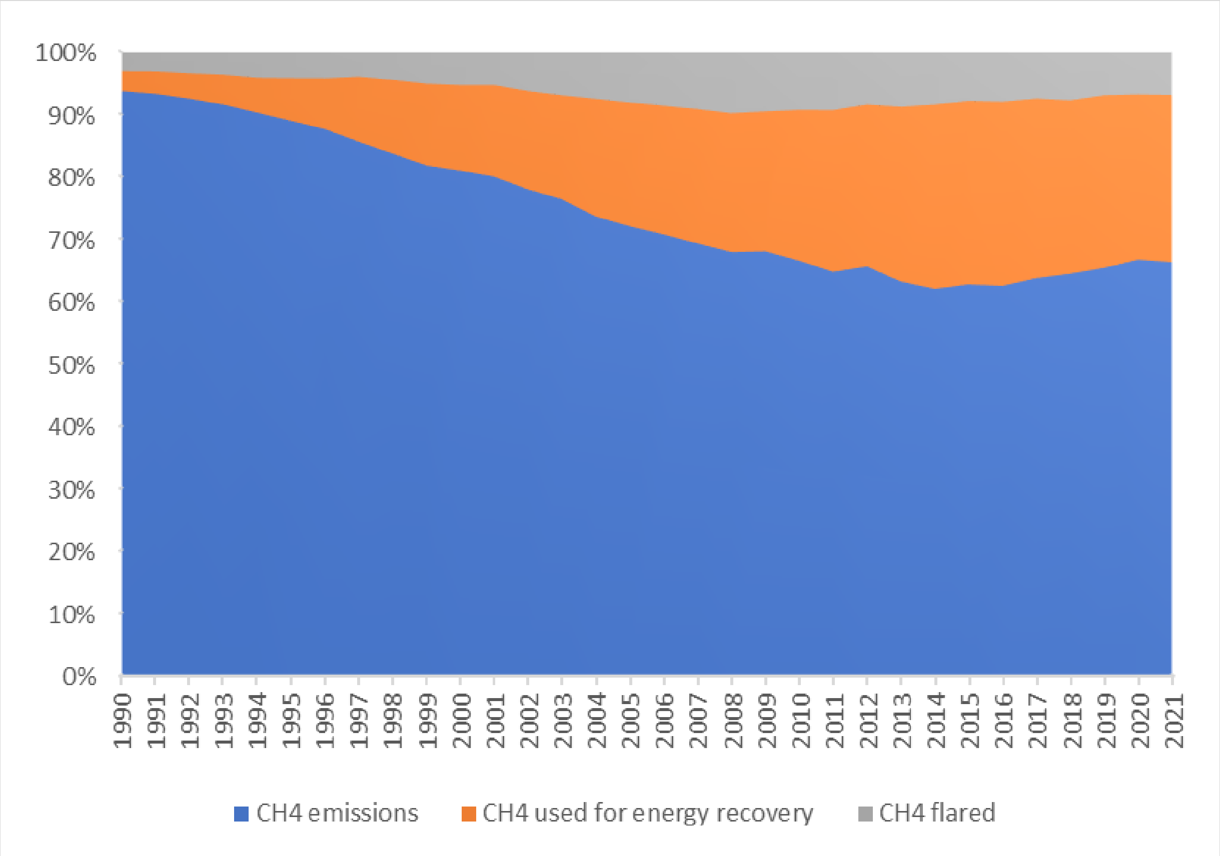
CH_4 emissions in **Spain**, contributing with 14.9 % to EU emissions in 2021, increased almost continuously between 1990 and 2009 due to a growth of the annual municipal solid waste going to solid waste disposal sites. Key drivers are a growing population and the shift of waste disposal from unmanaged to managed landfills. CH_4 emissions are decreasing since 2009 with fluctuations from 2008 to 2015 due to fluctuations in the amount of CH_4 recovery. CH_4 recovery and flaring of CH_4 has already been practiced in earlier years and increased significantly from 2002 to 2009. In 2021, CH_4 emissions from solid waste disposal decreased slightly by 0.4 % compared to 2020.

Methane recovery and flaring

Besides lower quantities of organic carbon deposited on landfills, the major determining factor for the decrease in net CH_4 emissions are increasing methane recovery rates from landfills and flaring of CH_4.

CH_4 recovery and flaring of CH_4 in EU increased from 5.7% of the total amount of CH_4 generated ("generated" = CH_4 emitted / (1-Ox) + CH_4 flared + CH_4 recovered where the oxidation factor Ox = 0.9) in managed landfills (only 5A1) in 1990 to 31.4 % in 2021 (Figure 7.8, Figure 1.9). Methane recovery is further promoted by the Landfill Directive, and monitoring programs are established. The recovery potential depends on the waste management strategies, e.g. diverting organic fractions to composting leaves more inert materials on landfills and reduces the potentials to recover and use CH_4. Compared to 2020, CH_4 for energy recovery decreased by 0.4 % and CH_4 flaring decreased by 0.6 % in 2021 in managed landfills. This is caused by reduced amounts of waste landfilled and the ban of organic material in the landfilled waste.

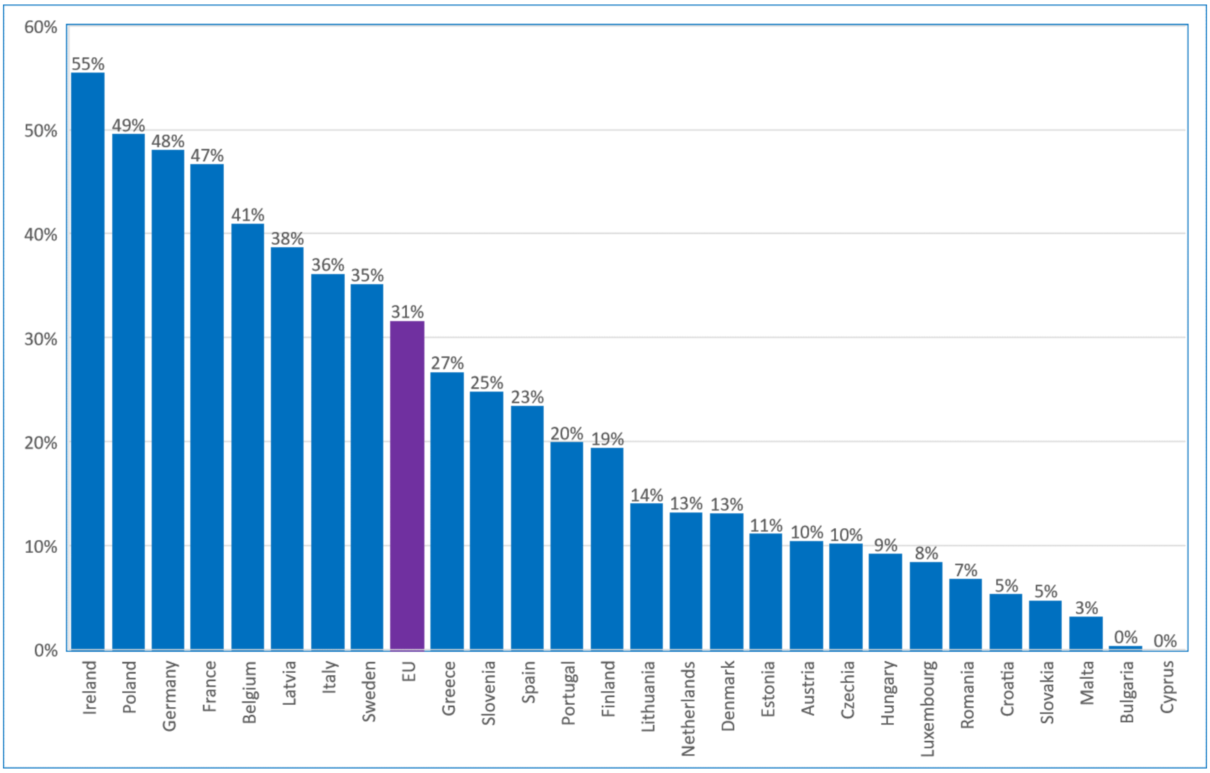
Figure 7.8 5A1 Managed Solid Waste Disposal: Evolution of the share of methane used for energy recovery, methane flared and CH_4 emissions in managed landfills in the EU



Source: CRF 2023, Table 5A

The recovered CH_4 is the amount of CH_4 that is captured for energy use and is a country-specific value which has significant influence on the emission level. Additionally, the amount of CH_4 flared is considered. The percentage of CH_4 recovered and flared, in Figure 7.9, varies among the countries between 0 % in Cyprus and 55 % in Ireland and depends - amongst other - on the share of solid waste disposal sites where recovery installations exist. Cyprus does not report any data under 5.A CH_4 recovery and flaring in 2021. For 2011 - 2014 and since 2017 Malta reported a small amount of CH_4 flared and reported a small amount for CH_4 recovery in 2013 and 2014 and since 2017.

Figure 7.9 5A1 Managed Solid Waste Disposal: Methane recovery fraction (energy recovery and flaring) for 2021



CH_4 recovery and flaring in % = (CH_4 recovery in Gg + CH_4 flared in Gg)/ (CH_4 recovery in Gg + CH_4 flared in Gg + CH_4 emissions 5A1/0,9 in Gg)
CH_4 emissions from 5A2 unmanaged landfills are not included in this calculation
Source: CRF 2023 Table 5A

Methodological issues

For key sources in the source category 5A it is good practice to use the First Order Decay (FOD) method to calculate the emissions and to display emission trends over time. According to Table 7.3 the Czech Republic and Luxembourg apply a Tier 1 method to estimate CH_4 emissions from solid waste disposal on managed landfills. Giving the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, the First Order Decay (FOD) method that accounts for the fact that the degradable organic components decay slowly over decades, has to be applied for all Tier levels. The Tier 1 method applies mainly default parameters and default activity data. The Tier 2 FOD method requires data on current as well as historic waste quantities, composition and disposal practices for several decades. Historical waste disposal data for 10 years or more should be based on country-specific statistics, surveys or other similar sources. In the following, a short overview of the most important parameters and methodological aspects of the FOD method is presented. The main factors influencing the quantity of CH_4 produced are the amount of waste disposed on land and the concentration of biodegradable carbon in that waste. Further methodological information for all EU countries is provided in the Annex III of this submission.

Municipal Waste landfilled

The amount of waste disposed on SWDS depends on the total amount of waste generated and the share of waste disposed. The total amount of waste disposed can be calculated by using total population numbers, waste generation rate per capita and the share of waste disposed. The FOD method requires historic data on waste generation and the share of waste landfilled over decades, but it is difficult to achieve consistent time series for the activity data over such long periods.

countries that do not have historic data on waste generation and waste disposal available use the default IPCC values for the waste generation rate per capita and the share of waste disposed and apply inter- or extrapolation methods to create a time series. Recent data on waste generation and waste disposal is available in most EU countries and is not estimated based on the per capita waste generation rate and a share of waste landfilled, but on direct measurements.

The data sources used for generating time series of activity data by the countries are summarized in the Annex III.

Industrial waste

Data on industrial waste may be difficult to obtain in many countries and there are only very few default values available. Only industrial waste that contains organic or fossil carbon fractions needs to be included in the inventory. Many countries do not provide any information on industrial waste landfilled, while other countries report that industrial waste is not reported separately and included under municipal solid waste. Further information on the reporting of industrial waste by the countries is summarized in the Annex III.

Sludge

Some countries dispose of sludge from domestic and industrial wastewater plants in landfills. The amount of sludge from domestic wastewater might be included under municipal waste or sludge from industrial wastewater may be included under industrial waste. Double counting needs to be avoided by reporting a consistent amount of sludge that is disposed of on SWDS; only sludge that goes along with solid waste has to be accounted under this category. All other sludge that is composted, incinerated, treated in wastewater plants or applied to agricultural land should be accounted under other categories. There is no IPCC default activity data available. If no country-specific activity data is available on the amount of sludge that is disposed, composted, incinerated or spread on agricultural land, all emissions from sludge are included under wastewater treatment.

Waste composition

The amount of methane generated on SWDS depends strongly on the waste composition. Disposing waste with no or hardly degradable carbon (e.g. metal or plastics) does not contribute to CH_4 emissions, but the disposal of paper or food waste with large degradable organic carbon fractions leads to high CH_4 emissions. The composition of the waste landfilled is strongly influenced by waste management practices, such as recycling or composting. This leads also to varying waste compositions along the time series. Based on the information provided in the CRF tables and the NIR it is not possible to conduct a time series for waste composition in the EU. Country specific information on waste composition is provided in the Annex III.

Landfill gas recovery

Countries use different methods to determine CH_4 recovery. Several countries combine different methods and sources to estimate the amounts of CH_4 recovered for flaring or for energy purposes, while other countries are using only one method. Data on landfill gas recovery can be based on measured plant specific data, questionnaires and surveys or can be taken from the energy statistics. Further information on CH_4 recovery in the country is provided in the Annex III of this submission.

Emission factors and parameters

Besides information on the amount of waste landfilled, the waste composition and the amounts of CH_4 recovered, other parameters are relevant for the calculation of CH_4 emissions from waste disposal. The fraction of degradable organic carbon (DOC) dissimilated in the individual waste fractions and the methane generation rate constant, which reflects the years necessary for the degradable organic carbon to decompose, are the most relevant parameters for calculating CH_4 emissions. Further parameters included in the calculation are the methane correction factor (MCF), the fraction of DOC that decomposes, the fraction of CH_4 in generated landfill gas and the oxidation factor.

Fraction of Degradable Organic Carbon (DOC): There are default IPCC values for DOC of the different waste fractions available (paper, food waste etc.). Some countries have conducted own chemical analysis to determine the DOC value of different waste fractions. The DOC content of total landfilled waste is based on the composition of waste and can be calculated from a weighted average of the carbon content of various components of the waste. Countries have MSW with widely differing waste compositions. If large amounts of organic waste is composted and waste is pretreated before disposed on landfills the average DOC is very low, even if still a high amount of waste is disposed. As waste composition varies over time and single DOC values are used for individual waste fractions the DOC-values also vary over time. A few examples: in Austria composting became a more important waste treatment method. Consequently, considerable amounts of waste with high DOC are excluded from category 5A which results in a lower DOC for the remaining MSW. In addition, the DOC reflects the considerable reductions achieved in diverting biodegradable waste to other waste management methods such as composting or mechanical-biological treatment. Within this submission a table in Annex III is provided containing detailed information on the DOC values extracted from the NIR.

Methane generation rate constant: CH_4 is emitted on SWDS over a long period of time rather than instantaneously. The FOD model can be used to model landfill gas generation rate curves for individual landfills over time. One important parameter is the methane generation rate constant (also referred to as k-value or half-life value). It is determined by a large number of factors associated with the composition of waste and the conditions at the site. The restructured CRF tables do not include information on the methane generation rate constant anymore. Within this submission a table in the Annex III is provided that contains corresponding detailed information on the methane generation rate constant extracted from the individual NIRs from the countries.

7.2.1.2 Unmanaged waste disposal sites (CRF Source Category 5A2)

CH_4 emissions from 5A2 Unmanaged Waste Disposal on Land account for 0.3 % of total EU GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021. Between 1990 and 2021, CH_4 emissions from this source decreased by 65.4 % (Table 7.4). In 2021, CH_4 emissions from unmanaged landfills decreased by 4.9 % compared to 2020. Almost all countries with unmanaged waste disposal feature a decreasing emission trend, due to a decreasing amount of municipal waste going to unmanaged waste disposal sites. Only Cyprus and Romania showed an increase of CH_4 emissions from unmanaged landfills between 1990 and 2021 (respectively +39.6% and +18.3 %). In Romania CH_4 emissions from unmanaged waste disposal sites increased until 2010 but showed a decreasing trend from 2010 onwards. Between 2010 and 2021 the CH_4 emissions decreased by 31.4 %. In Cyprus, CH_4 emissions from unmanaged waste disposal sites increased until 2013 and showed a steady trend from 2010 to 2019 and decrease onward (-4.4 % between 2020 and 2021).

Table 7.4 5A2 Unmanaged Waste Disposal on Land: Countries contributions to CH_4 emissions and information on method applied and emission factor

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	NO	NO	NO	-	-	-	-	-	NA	NA
Belgium	NO	NO	NO	-	-	-	-	-	NA	NA
Bulgaria	2 100	1 087	1 003	10.5%	-1 097	-52%	-85	-8%	T2	CS,D
Croatia	353	66	79	0.8%	-273	-77%	13	20%	T2	CS
Cyprus	295	432	412	4.3%	117	40%	-19	-4%	T2	D
Czechia	NO	NO	NO	-	-	-	-	-	NA	NA
Denmark	NO	NO	NO	-	-	-	-	-	NA	NA
Estonia	NO	NO	NO	-	-	-	-	-	NA	NA
Finland	IE	NO	NO	-	-	-	-	-	NA	NA
France	NO	NO	NO	-	-	-	-	-	NA	NA
Germany	NO	NO	NO	-	-	-	-	-	NA	NA
Greece	2 423	1 508	1 453	15.2%	-969	-40%	-55	-4%	T2	CS,D
Hungary	2 397	1 252	1 198	12.5%	-1 199	-50%	-55	-4%	T2	D
Ireland	1 476	IE	IE	-	-1 476	-100%	-	-	NA	NA
Italy	6 518	2 144	2 051	21.4%	-4 467	-69%	-93	-4%	T2	CS
Latvia	353	130	119	1.2%	-233	-66%	-11	-8%	T2	CS,D
Lithuania	386	139	127	1.3%	-259	-67%	-12	-9%	T2	D
Luxembourg	IE	IE	IE	-	-	-	-	-	NA	NA
Malta	46	8	7	0.1%	-40	-86%	-2	-20%	M	M
Netherlands	NO	NO	NO	-	-	-	-	-	NA	NA
Poland	6 247	43	42	0.4%	-6 205	-99%	-1	-3%	T2	CS,D
Portugal	2 326	701	654	6.8%	-1 672	-72%	-47	-7%	-	-
Romania	1 536	1 910	1 817	18.9%	281	18%	-93	-5%	T2	CS,D
Slovakia	NO	NO	NO	-	-	-	-	-	NA	NA
Slovenia	NO	NO	NO	-	-	-	-	-	NA	NA
Spain	1 288	661	629	6.6%	-659	-51%	-32	-5%	T2	D
Sweden	NO	NO	NO	-	-	-	-	-	NA	NA
EU-27	**27 744**	**10 083**	**9 592**	**100%**	**-18 152**	**-65%**	**-491**	**-5%**	**-**	**-**

Note: According to the MS NIR Ireland, Portugal and Malta apply a Tier 2 method to calculate CH_4 emissions from waste disposal on unmanaged landfills.
Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Trends in Emissions and Activity Data

CH_4 emissions from unmanaged solid waste disposal sites decreased considerably between 1990 and 2021 by 65.4 %. *Figure 7.10* shows the trend of emissions indicating the countries contributing most to EU total. In comparison to the rather drastic decrease of the amount of waste disposed on unmanaged landfills (see *Figure 7.11*) CH_4 emissions from unmanaged landfills show only a moderate decrease during the time series.

Not all countries reported emissions from this source since all waste disposal sites in the countries are managed (Austria, Belgium, the Czech Republic, Denmark, Estonia, France, Germany, the Netherlands, Slovakia, Slovenia and Sweden) or they are included elsewhere (Finland, Ireland, Luxembourg). Italy, Romania, Greece and Bulgaria are responsible for about 66 % of the total EU emissions from unmanaged waste disposal sites in 2021, representing respectively 21.4 %, 18.9 %, 15.2 % and 10.5 % of CH_4 emissions of the category in 2021. Poland and Italy show the larger absolute reductions between 1990 and 2021.

Figure 7.10 *5A2 Waste disposal on unmanaged landfills: CH_4 emissions (Trend in relevant countries)*

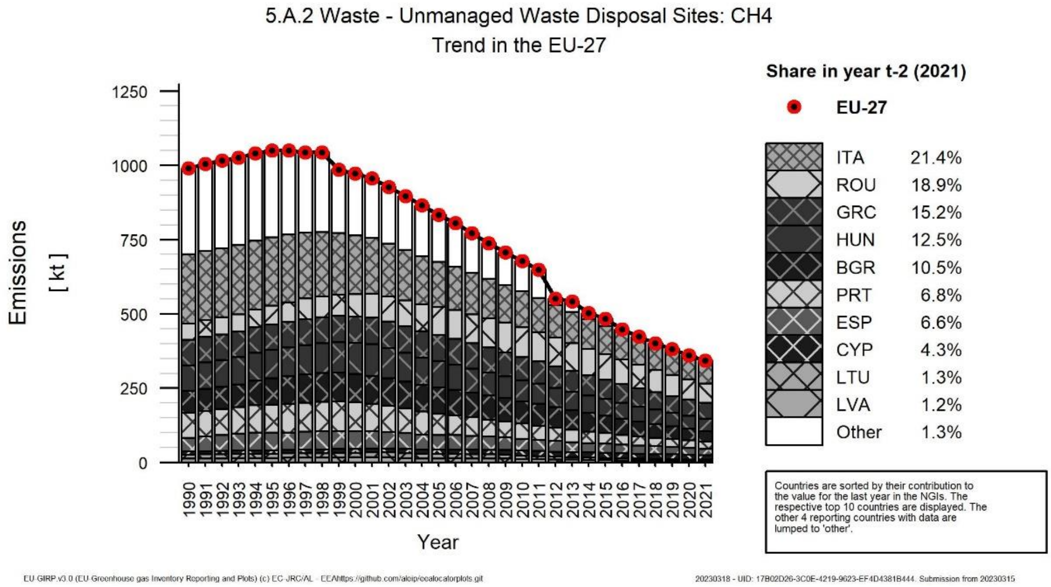
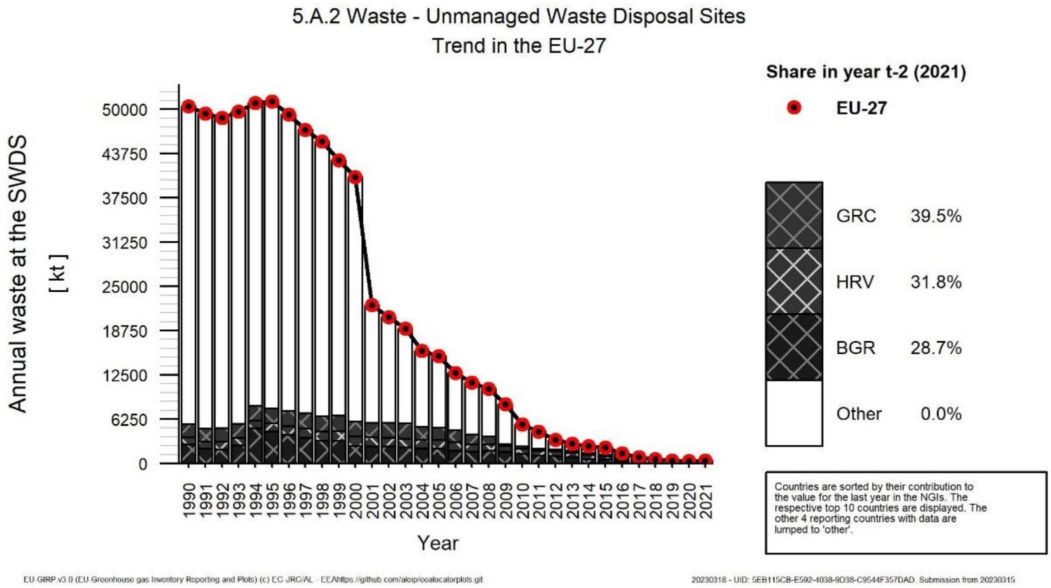


Figure 7.11 shows the relevant trends for the amount of waste disposed on unmanaged landfills. In the description below Figure 1.11 we focus on the countries with the highest CH_4 emissions from unmanaged SWDS in 2021. Note that, in some countries, waste disposal in unmanaged landfills was practiced but does not occur anymore. However, emissions are still produced from the waste disposed in the past. For the following countries, there are still emissions, but no more waste is disposed on the unmanaged landfills as from the year mentioned: Ireland since 1999, Italy since 2000, Hungary since 2001, Finland since 2002, Portugal and Malta since 2005, Slovakia since 2010, Poland since 2012, Latvia and Spain since 2013, Romania in 2018, Cyprus since 2019 and Lithuania since 2020.

For countries still using unmanaged landfills (Bulgaria, Croatia, Greece), solid waste disposal on unmanaged landfill sites is still practiced, but the amount of waste disposed is considerably decreasing since 1990. The highest reductions in the amount of waste disposed between 1990 and 2021 are found for Bulgaria and Greece. In countries which still dispose waste in unmanaged landfills in 2021, the relative decrease of waste disposed is higher than 88 % in comparison with 1990.

Figure 7.11 5A2 Waste disposal on unmanaged landfills: Total waste disposed on unmanaged landfills (Trend in relevant countries)



Italy, contributing with 21.4 % to EU emissions in 2021, managed to reduce CH_4 emissions from solid waste disposal on unmanaged landfills already from 1991 onwards. The reduction of emissions from unmanaged waste disposal on land is caused by legal acts. The first legal provision concerning waste management was issued in 1982. In this decree, uncontrolled waste dumping as well as unmanaged landfilling is forbidden, but the enforcement of these measures was concluded only in 2000. Thus the share of waste disposed on uncontrolled landfills gradually decreased, and in the year 2000 it is assumed to be zero; nevertheless emissions still occur due to the waste disposed in the past years.

Romania is contributing with 118.9 % to EU CH_4 emissions from unmanaged landfills in 2021. From 2010 CH_4 emissions are declining. The amount of waste disposed on unmanaged landfills is zero since 2018.

Greece is contributing with 15.2 % to EU CH_4 emissions from unmanaged landfills in 2021. CH_4 emissions are declining over the time series especially since 2004, due to an important reduction of waste disposed on unmanaged landfills. After a sharp reduction, the amount of wastedisposed on uncontrolled landfills is steady.

Methodological issues

CH_4 emissions from unmanaged solid waste disposal sites were reported in 13 EU countries (Bulgaria, Croatia, Cyprus, Greece, Hungary, Italy, Latvia, Lithuania, Malta, Poland, Portugal, Romania and Spain). Only three of these EU countries (Bulgaria, Croatia, and Greece) still dispose MSW to unmanaged SWDS, although in small quantities, while in all other countries waste disposal from the past still cause emissions in 2021 (see Table 7.4). 100 % of all EU emissions from this category are calculated using higher tier methods.

CH_4 emissions from waste disposal on unmanaged landfills are calculated similar to CH_4 emissions from managed landfills, using the amount of waste disposed on unmanaged landfills. If no other data is available the same data on waste composition and the same parameters as used for managed landfills can be applied in the calculation. The Methane Correction Factor (MCF) is the relevant parameter that differentiates between managed and unmanaged landfills. The Methane Correction Factor reflects the way in which a SWDS is managed and the effect of management practices on CH_4

generation. According to the 2006 IPCC Guidelines, the MCF for unmanaged disposal of solid waste depends of the type of site – shallow or deep. The IPCC default MCF for deep unmanaged landfills is 0.8, while shallow unmanaged landfills have an MCF of only 0.4 as in shallow landfills more waste decomposes aerobically. The three EU countries still dispose MSW to unmanaged SWDS (Bulgaria, Croatia, and Greece) are applying an MCF of 0.8.

7.2.2 Biological treatment of solid waste (CRF Source Category 5B)

Source category 5B Biological treatment of solid waste includes the key source CH_4 from 5B1 Composting. Besides composting the source category 5B includes the subcategory 5B2 anaerobic digestion and also emissions from mechanical-biological treatment according to the IPCC 2006 Guidelines. The whole sector 5.B contributes only 0.2 % to EU total GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021. Decomposition of biomass during biological treatment is much faster than on landfills and the CH_4 emissions are estimated on an annual basis without the need for long time series as in the case of landfills. For composting the decomposition of the organic waste fraction takes place under aerobic conditions. In anaerobic digestion processes the decomposition takes place without oxygen. Further information on emission trends and methodologies is only provided for source category composting 5B1, as anaerobic digestion 5B2 is no EU key source.

Table 7.5 provides total GHG and CH_4 and N_2O emissions by Member State from 5B Biological treatment of solid waste. Total emissions from this category increased considerably since 1990. Nine countries (Bulgaria, Croatia, Cyprus, Greece, Ireland, Luxembourg, Malta, Romania and Slovenia) did not practice this kind of waste treatment in 1990. Due to landfill regulations etc. this type of waste treatment increased considerably during the last years and all countries report emissions from this category since 2011.

Table 7.5 5B Biological treatment of solid waste: Countries contributions to total GHG emissions and CH_4 and N_2O emissions

Member State	GHG emissions in kt CO_2 equivalents		N2O emissions in kt CO2 equivalents		CH_4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021
Austria	35	153	20	74	15	79
Belgium	6	56	4	31	3	25
Bulgaria	NO	5	NO	2	NO	3
Croatia	IE,NO	27	NO,IE	7	NO,IE	20
Cyprus	NO	21	NO	8	NO	14
Czechia	NE,IE	804	NE,IE	66	NE,IE	738
Denmark	56	562	20	65	36	497
Estonia	1	30	0	11	1	19
Finland	45	108	16	34	29	74
France	173	1 058	61	220	112	838
Germany	79	975	20	184	59	791
Greece	1	108	NO	14	1	94
Hungary	9	150	3	39	6	111
Ireland	NO	49	NO	16	NO	33
Italy	23	558	18	432	5	126
Latvia	29	67	11	19	19	48
Lithuania	0	101	0	21	0	80
Luxembourg	NE,IE,NO	34	NO,NE	5	NO,IE	29
Malta	NO	1	NO	NO,NA	NO	1
Netherlands	11	219	6	82	5	137
Poland	22	331	8	120	14	211
Portugal	9	132	3	43	6	88
Romania	NE,NA,NO	94	NO,NE,NA	24	NO,NE	70
Slovakia	114	283	41	90	73	193
Slovenia	NO	23	NO	8	NO	15
Spain	209	580	76	198	133	381
Sweden	13	98	5	22	8	77
EU-27	**836**	**6 628**	**311**	**1 836**	**524**	**4 793**

Abbreviations explained in the Chapter 'Units and abbreviations'.

7.2.2.1 Waste Composting (CRF Source Category 5B1)

Emission and Trends

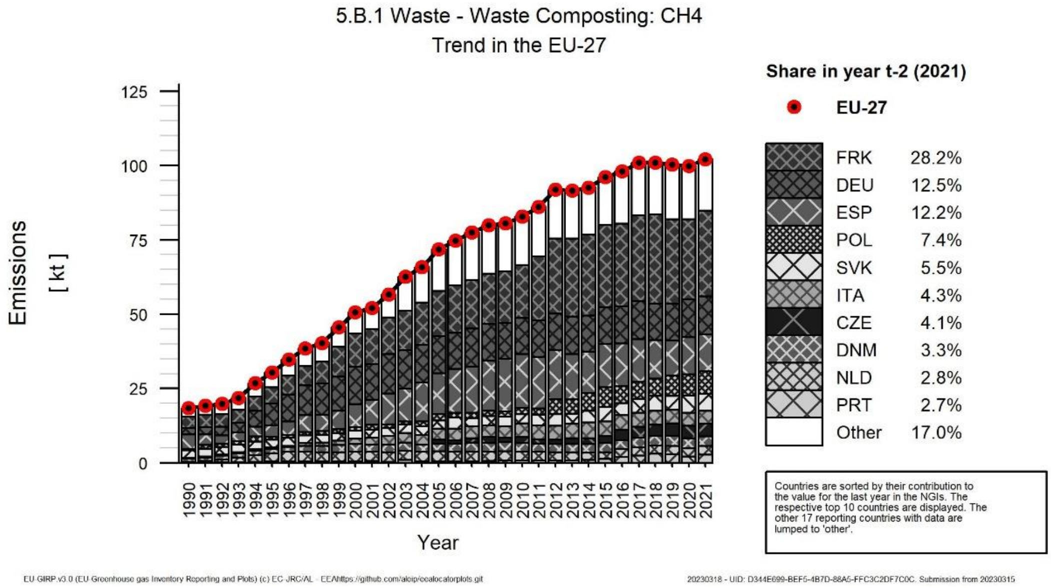
CH_4 emissions from 5B1 Composting account for 0.09 % of total EU GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021. Between 1990 and 2021, CH_4 emissions from this source increased considerably from 516 kt CO_2 equivalents to 2861 kt CO_2 equivalents in 2021 (Table 7.6). Malta reports emissions from composting only in the period 1993 - 2006. All countries that practice composting feature an increasing emission trend from 1990 onwards. Nevertheless between 2020 and 2021 twelves countries experienced a decrease in CH_4 emissions from composting, among which five experienced a decrease higher than 9 % (Bulgaria, Finland, Greece, Lithuania, and Romania). Total CH_4 emissions from composting in EU increased slightly by 2.4 % between 2020 and 2021 with the most important increase in Luxembourg (14.5 %).

Table 7.6: 5B1 Waste Composting: Countries contributions to CH_4 emissions and information on method applied and emission factor

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	15	55	56	2.0%	42	287%	2	3%	T2	CS
Belgium	3	26	25	0.9%	22	772%	-1	-3%	T1	CS
Bulgaria	NO	6	3	0.1%	3	∞	-3	-45%	T1	D
Croatia	NO,IE	11	13	0.4%	13	∞	2	15%	T1	D
Cyprus	NO	12	14	0.5%	14	∞	1	9%	T1	D
Czechia	NE	116	117	4.1%	117	∞	0	0%	T1	D
Denmark	30	94	94	3.3%	64	215%	0	0%	T1,T2	CS,D
Estonia	1	20	19	0.7%	18	2424%	-1	-6%	T1	D
Finland	29	68	59	2.1%	31	107%	-8	-12%	T1	D
France	111	752	808	28.2%	696	625%	56	7%	T2	CS
Germany	59	358	357	12.5%	298	502%	-1	0%	T2	CS
Greece	NO	28	24	0.8%	24	∞	-4	-15%	D	D
Hungary	6	68	69	2.4%	63	1129%	1	1%	T1	D
Ireland	NO	28	29	1.0%	29	∞	1	3%	T1	D
Italy	5	124	124	4.3%	119	2294%	0	0%	D	CS
Latvia	19	30	33	1.2%	15	78%	3	11%	D	D
Lithuania	0	41	37	1.3%	37	16240%	-4	-10%	T1	D
Luxembourg	NO	8	9	0.3%	9	∞	1	14%	T1	D
Malta	NO	NO	NO	-	-	-	-	-	NA	NA
Netherlands	5	78	80	2.8%	75	1571%	2	3%	T1	CS
Poland	14	197	211	7.4%	197	1385%	14	7%	T1	D
Portugal	6	60	77	2.7%	71	1260%	16	27%	T1	D
Romania	NO,NE	49	42	1.5%	42	∞	-7	-14%	T1	D
Slovakia	73	163	159	5.5%	86	118%	-4	-2%	T1	D
Slovenia	NO	13	15	0.5%	15	∞	2	16%	T1	D
Spain	133	349	349	12.2%	215	161%	0	0%	T1	D
Sweden	8	40	38	1.3%	30	379%	-2	-4%	T1	D
EU-27	**516**	**2 793**	**2 861**	**100%**	**2 345**	**454%**	**68**	**2%**	**-**	**-**

Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Figure 7.12 5B1 Waste Composting: CH_4 emissions (Trend in relevant countries)



Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Emissions from 5.B.1 relate with composting of municipal (5.B.1.a) and composting of other waste (5.B.1.b). As stated in figure ***Figure 7.14 5B1b Waste Composting of other waste : CH4 emissions (Trend in relevant countries)***, only 11 countries (Denmark, Slovakia, the Netherlands, Czech Republic, Finland, Hungary, Estonia, Lithuania, Poland, Latvia and Luxembourg) report emissions from other waste composting. Other countries generally report emissions from composting of all types of waste (municipal, industrial, sludge…) in the category 5.B.1.a since statistal data concerning composting generally relate to total waste and do not make a distinction between the various types of waste.

Figure 7.13 5B1a Waste Composting of municipal waste: CH_4 emissions (Trend in relevant countries)

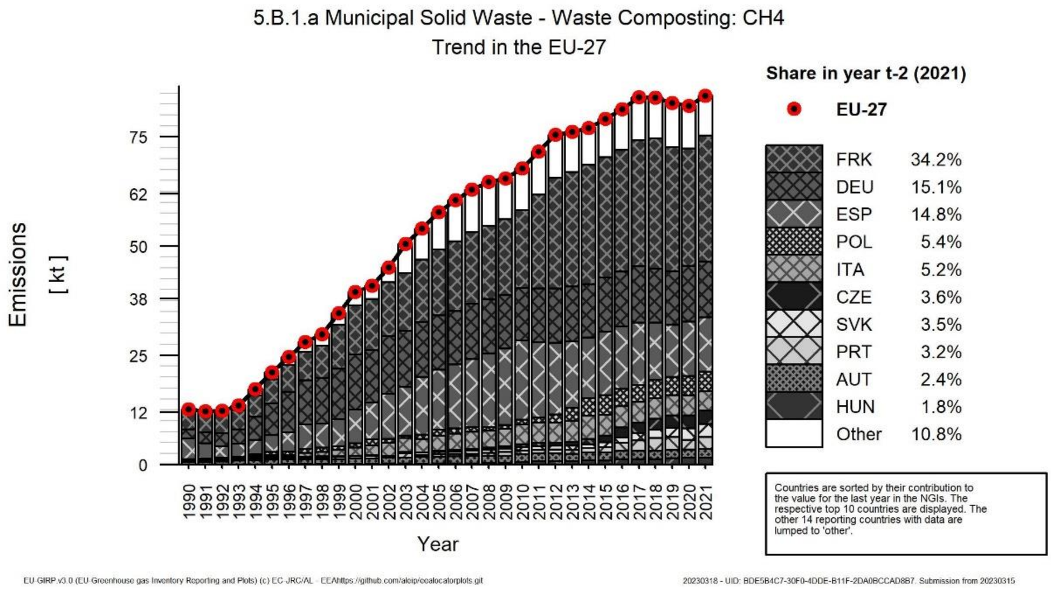
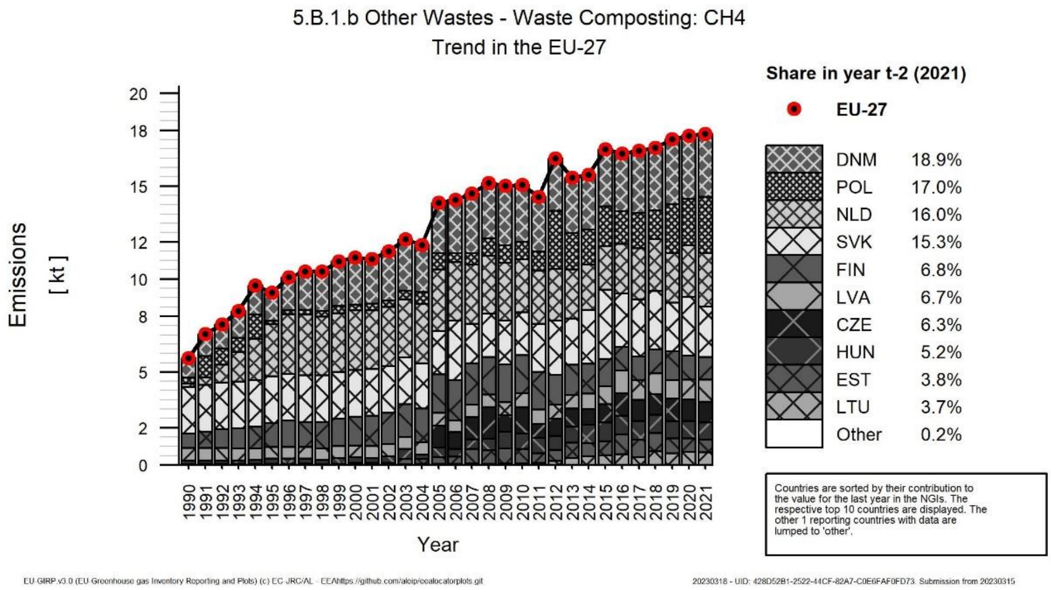


Figure 7.14 5B1b Waste Composting of other waste : CH_4 emissions (Trend in relevant countries)



Methodological information

According to the IPCC 2006 Guidelines CH_4 from composting is estimated by using the quantity of organic waste processed by composting and the respective emission factor. The application of a Tier 2 method requires the use of a country specific emission factor based on representative measurements. The IPCC default emission factor for CH_4 emissions from composting is 10 g CH_4/kg waste treated on a dry weight basis and 4 g CH_4/kg based on a wet weight basis. The range of this emission factor varies between 0.8 and 11.4 g CH_4/kg waste treated. Most countries apply the default EF for CH_4 emissions (see

Table 7.7). In all cases the EFs (wet vs. dry) applied by the countries are consistent with the unit of AD (wet vs. dry), even if few Member States (Cyprus and Czechia) reported on a wet basis in the CRF tables although dry basis should be reported. Only Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Poland and Sweden present IEFs different from the default one and these EFs are within the interval indicated in the 2006 IPCC guidelines. In most cases country specific EFs are much lower than the IPCC default EF.

Table 7.7 5B1 Composting: IEFs reported by countries in CRF table 5B in 2021 in g CH_4/kg waste treated (dry basis)

Member State	CH4 IEF g/kg dry matter		Member State	CH4 IEF g/kg dry matter
Austria	1,8		Italy	1,6
Belgium	1,3		Latvia	10,0
Bulgaria	10,0		Lithuania	10,0
Croatia	10,0		Luxembourg	0,0
Cyprus	4,2		Malta	0,0
Czechia	4,0		Netherlands	0,8
Denmark	NE		Poland	6,7
Estonia	10,0		Portugal	10,0
Finland	5,8		Romania	0,0
France	5,4		Slovakia	10,0
Germany	1,4		Slovenia	0,0
Greece	10,0		Spain	10,0
Hungary	10,0		Sweden	11,4
Ireland	10,0			

Further methodological information for all countries is provided in the Annex of this submission

7.2.3 Incineration and open burning of waste (CRF Source Category 5.C)

This category includes incineration and open burning of waste. Emissions from waste incinerated for energy use are reported under 1A Fuel combustion activities. Emissions from on field burning of agricultural wastes should be reported under 3 Agriculture.

Incineration and open burning of waste is not a key category for the European Union. Some additional information can be found in the chapter 3.2.8 dedicated to waste- non key categories.

7.2.4 Wastewater treatment and discharge (CRF Source Category 5D)

Source category 5D includes the CH_4 and N_2O emissions from domestic and industrial and other wastewater treatment and discharge. Methane and nitrous oxide are produced from microbial processes (anaerobic decomposition of organic matter, nitrification) in sewage systems and facilities. N_2O is also indirectly released from disposal of wastewater effluents into aquatic environments[54]. According to the key category analysis CH_4 and N_2O emissions from 5D1 Domestic wastewater and CH_4 emissions from 5D2 Industrial wastewater are an EU key source and analysed in more detail in this chapter. N_2O emissions from industrial wastewater are not a EU key source and are therefore not further analysed in this chapter.

Domestic wastewater includes the handling of liquid wastes and sludges from housing and commercial sources through wastewater collection and treatment, open pits/latrines, ponds, or discharge into surface waters. Industrial wastewater can also be released into domestic sewer systems and resulting emissions are in that case included under domestic wastewater. On the other hand, industrial

[54] In most countries, indirect N_2O emissions from disposal of wastewater effluents are the major source of N_2O emissions from wastewater handling, whereas direct N_2O emissions from wastewater treatment plants are small or not relevant.

wastewater can be treated on the industrial site and then the resulting emissions will be accounted under the separate category 5D2 industrial wastewater.

Total emissions from 5D wastewater handling, including N_2O and CH_4 emissions account for 0.7 % of total EU GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021. Table 7.8 shows total GHG, CH_4 and N_2O emissions by Member State from 5D Wastewater Handling. Between 1990 and 2021, total emissions from wastewater handling decreased by 43.7 % in EU. All countries except for France and Ireland decreased their emissions from wastewater treatment and discharge between 1990 and 2021. Due to the implementation of new wastewater treatment technologies CH_4 emission decreased considerably by 49.8 % between 1990 and 2021, while N_2O emissions decreased moderately by 15.4 %.

Table 7.8 5D Wastewater handling: Countries' contributions to total GHG, CH_4 and N_2O emissions from 5D

Member State	GHG emissions in kt CO_2 equivalents		N2O emissions in kt CO2 equivalents		CH_4 emissions in kt CO2 equivalents	
	1990	2021	1990	2021	1990	2021
Austria	223	177	86	152	137	25
Belgium	1 165	350	123	94	1 042	255
Bulgaria	3 138	583	176	120	2 961	463
Croatia	719	577	59	78	660	499
Cyprus	140	69	10	15	130	54
Czechia	1 291	1 067	208	173	1 083	894
Denmark	368	214	301	127	67	87
Estonia	161	89	34	28	126	61
Finland	315	240	68	65	247	175
France	2 170	2 877	522	341	1 648	2 536
Germany	3 939	913	1 057	372	2 881	541
Greece	2 871	1 559	249	257	2 622	1 301
Hungary	1 142	332	131	75	1 011	257
Ireland	135	156	67	96	68	60
Italy	4 703	3 794	1 120	1 109	3 584	2 686
Latvia	423	125	47	29	376	96
Lithuania	534	173	60	42	474	132
Luxembourg	13	6	5	4	8	2
Malta	28	16	9	8	19	8
Netherlands	1 148	935	727	711	421	224
Poland	3 152	2 760	643	690	2 509	2 071
Portugal	1 877	938	178	168	1 699	769
Romania	4 098	2 076	383	380	3 715	1 695
Slovakia	637	342	115	43	522	298
Slovenia	354	185	35	34	319	151
Spain	6 569	2 624	767	849	5 802	1 776
Sweden	242	219	201	185	42	34
EU-27	**41 553**	**23 395**	**7 381**	**6 243**	**34 172**	**17 152**

Abbreviations explained in the Chapter 'Units and abbreviations'.

7.2.4.1 Domestic wastewater (CRF Source Category 5D1)

CH_4 emissions

CH_4 emissions from 5D1 Domestic Wastewater account for 0.33 % of total EU GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021. Between 1990 and 2021, CH_4 emissions decreased by 54.4 % (Table 7.9). Key drivers for the large emission reduction are the development of centralized wastewater treatment plants (especially implementing aerobic treatments) and an increase of CH_4 recovery and flaring on anaerobic systems (see ***Figure 7.16***). In 2021, CH_4 emissions decreased by 3.3 % in comparison to 2020.

Table 7.9 5D1 Domestic and commercial wastewater: Countries' contributions to CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	136	21	21	0.2%	-114	-84%	0	0%	T2	CS,D
Belgium	1 042	273	255	2.3%	-786	-75%	-18	-7%	CR,T1	CR,D
Bulgaria	473	257	253	2.3%	-220	-47%	-4	-2%	T2	D
Croatia	551	374	373	3.4%	-179	-32%	-1	0%	T1	D
Cyprus	103	23	23	0.2%	-80	-77%	0	1%	T1	D
Czechia	677	406	377	3.4%	-300	-44%	-30	-7%	T1	D
Denmark	67	89	87	0.8%	20	31%	-1	-1%	CS	CS
Estonia	126	55	57	0.5%	-69	-55%	3	5%	T1	D
Finland	218	156	154	1.4%	-64	-29%	-2	-1%	CS,T2	CS,D
France	1 575	2 419	2 447	22.1%	871	55%	28	1%	T1	D
Germany	2 871	488	487	4.4%	-2 384	-83%	-1	0%	CS,D	CS,D
Greece	1 703	170	170	1.5%	-1 532	-90%	1	1%	D	D
Hungary	859	232	228	2.1%	-630	-73%	-3	-1%	T1	D
Ireland	68	60	60	0.5%	-8	-12%	1	1%	T1,T2	CS,D
Italy	1 881	1 119	1 107	10.0%	-774	-41%	-12	-1%	T1	D
Latvia	222	86	93	0.8%	-129	-58%	7	8%	T2	CS
Lithuania	474	132	132	1.2%	-342	-72%	0	0%	T1,T2	D
Luxembourg	8	2	2	0.0%	-6	-74%	0	-5%	T1	CS
Malta	19	6	8	0.1%	-11	-57%	2	30%	D	CS
Netherlands	163	134	131	1.2%	-32	-20%	-3	-2%	T1,T2	D
Poland	1 807	1 798	1 762	15.9%	-45	-2%	-35	-2%	T1,T2	CS,D
Portugal	1 409	566	558	5.0%	-851	-60%	-8	-1%	T2	CS,D
Romania	3 292	1 508	1 439	13.0%	-1 853	-56%	-70	-5%	D	D
Slovakia	489	307	294	2.6%	-196	-40%	-14	-4%	T2	D
Slovenia	208	139	143	1.3%	-66	-32%	4	3%	T1	CS,D
Spain	3 876	622	404	3.6%	-3 472	-90%	-219	-35%	T2	D
Sweden	35	28	28	0.2%	-7	-21%	0	1%	T2	CS
EU-27	**24 354**	**11 469**	**11 093**	**100%**	**-13 261**	**-54%**	**-376**	**-3%**	**-**	**-**

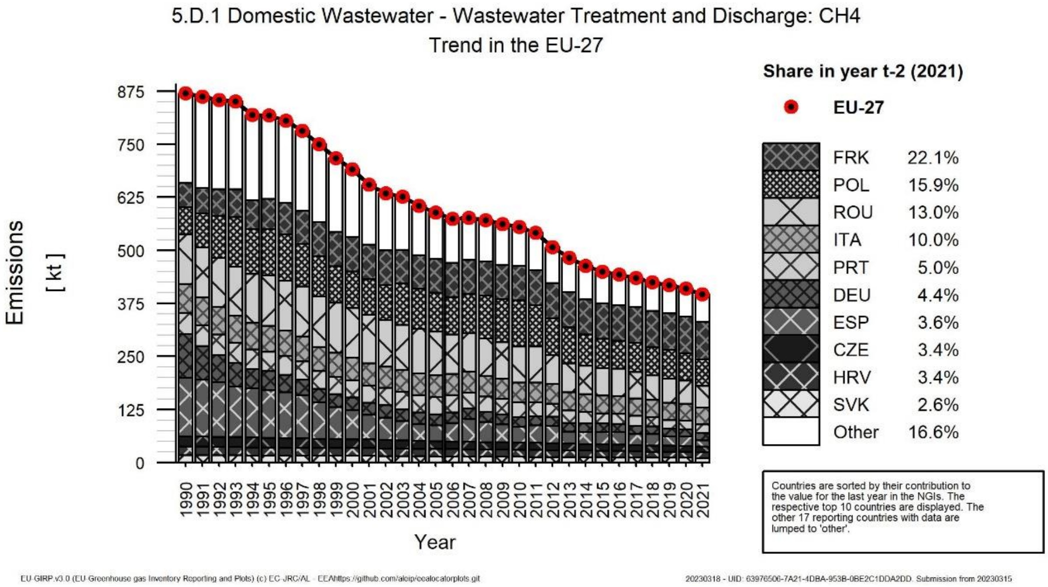
Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Trends in Emissions and Activity Data for CH_4 emissions from domestic wastewater

CH_4 emissions from domestic wastewater treatment and discharge decreased considerably between 1990 and 2021 by 54.4 %. Figure 7.15 shows the trend of emissions indicating the countries contributing most to EU total.

Large decreases in absolute terms between 1990 and 2021 are reported by Spain, Germany, Romania and Greece, contributing together to only 22.5 % of EU emissions from source 5D1 in 2021. Whereas France shows significant emission increases (Table 7.9) between 1990 and 2021. France is responsible for 22.1 %, Poland for 15.9 %, Romania for 13.0 % and Italy for 10.0 % of EU emissions from this source in 2021. Although France increased its emissions between 1990 and 2021 by 55.3 %, the trend of EU emissions is dominated by the large emission reductions in Spain, Germany, Greece, and Romania.

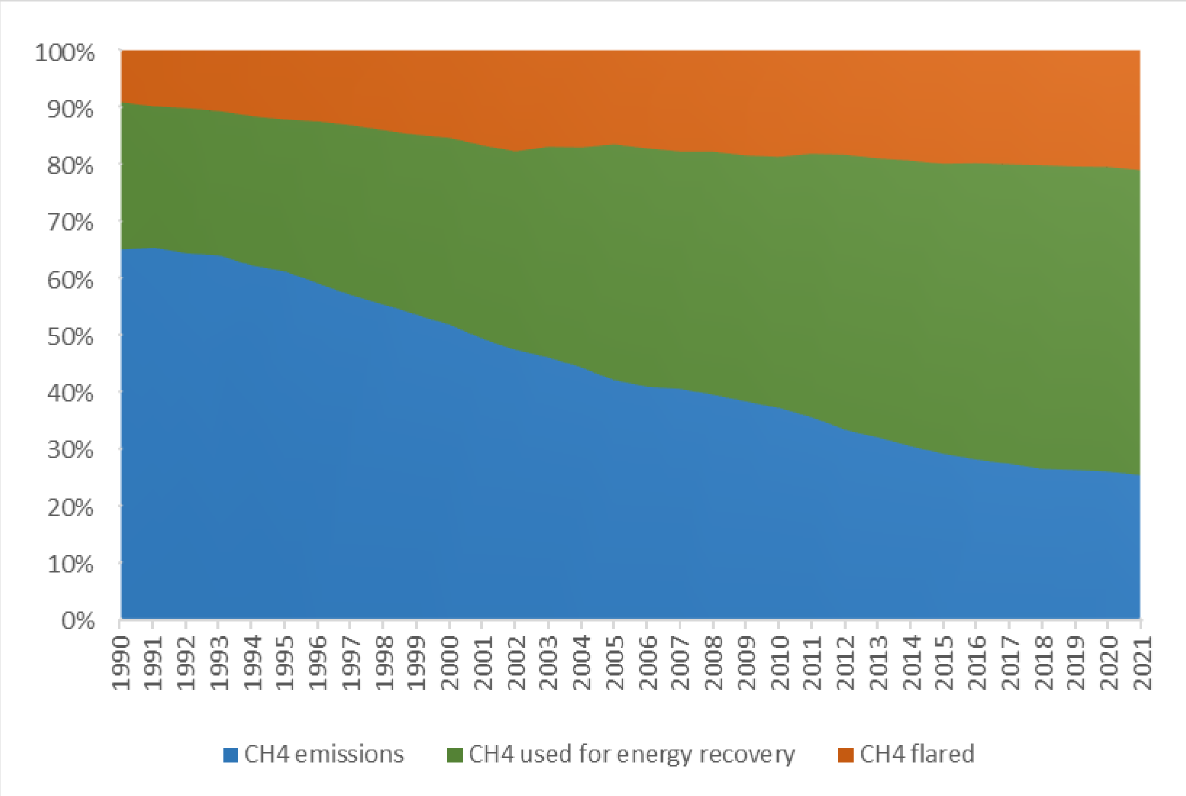
Figure 7.15 *5D1 Domestic wastewater: CH_4 emissions (Trend in relevant countries)*



The decreasing trend of CH_4 emissions from wastewater is not related to a decreasing quantity of wastewater and the amount of the total organic product in the wastewater. In fact the decrease is based on several reasons:

- Improvements of wastewater disposal routes with the development of centralized wastewater treatment plants, especially applying aerobic processes
- Amount of sludge removed
- Increased share of CH_4 flared or recovered (see *Figure 7.16*) on anaerobic wastewater and sludge treatment systems

Figure 7.16 5D1 Domestic wastewater: Share of CH_4 recovered or flared and CH_4 emissions on total CH_4 produced from domestic wastewater handling



Source: CRF 2023, Table 5D

In 2021, 21.0 % of the CH_4-emissions generated by Domestic Wastewater Handling were flared and 53.6 % was recovered for energy purposes.

An important driver for the total CH_4 emissions decrease from 5D Wastewater Handling for the EU are CH_4 emissions from 5D1 Domestic Wastewater in Spain, Germany, Romania and Greece, . Therefore, more information about the development of CH_4 emissions from wastewater handling in these and other important countries is presented.

Spain's CH_4 emissions from domestic and commercial wastewater decreased of 89.6 %. between 1990 and 2021. The reduction occurred mainly between 1990 and 2005 with a decrease about 73.4 %. The decrease was mainly due to the decrease of population not connected to sewers, from 77.4 % in 1990 to 14.0 % in 2005. Since 1997, the percentage of population whose wastewater is collected and treated is greater than the percentage of untreated population. Since 2005 the population not connected to sewer continue to decrease to 1.6 % in 2021. This evolution is consistent with the progressive implementation of the obligations of Directive 91/271/EEC in Spain.

Germany's reduction in CH_4 emissions from domestic and commercial wastewater (5D1) occurred mainly between 1990 and 1998. The decrease of 69 % in that period was due to the legal requirement to connect households to decentralised wastewater treatment plants. The basis for legal requirements for the collection and treatment of domestic and commercial wastewater is the Council directive 91/271/EWG concerning urban wastewater treatment from 1991. Many wastewater plants had to be built in the former GDR after the German reunification, as most households were not connected to a sewage system, but used septic tanks.

CH_4 emissions from domestic wastewater are continuously decreasing from 1999 onwards in **Romania**. The amount of wastewater that underlies sufficient treatment increases over the years.

About 69 % of the total wastewater has been treated appropriate and 21 % received only insufficient treatment in 2021. Still about 9 % of the total wastewater remained untreated. Between 2000 and 2021 public sewage systems have been expanded and modernized.

The **Greek**'s CH_4 emissions from domestic and commercial wastewater decreased of 90.0 %. between 1990 and 2021. The decreased mainly occurred between 1990 and 2007 (-88.6 %) due to the increased number of wastewater handling facilities with aerobic conditions. Domestic wastewater handling in aerobic treatment facilities shows a substantial increase since 1999.

France's CH_4 emissions from domestic wastewater (5D1) show an increasing trend from 1990 to 1999, remain at a rather constant level between 1998 and 2005 and show a slight and regular increase since 2006. One driver influencing the trend is the share of population connected to different wastewater treatment systems. The share of the population connected to septic tanks increased from 1990 to 2000 (from 13 % in 1990 to 18 % in 2000) and remained almost constant thereafter (17 % average 2001-2020). In the same period, the share of the population with direct discharge of wastewater decreased from 8 % in 1990 to 2 % in 2005 and to 1 % in 2020. Wastewater treatment in collective systems increased slightly from 79 % in 1990 to 81 % since 2005 and to 82 % in 2020. The share of septic system and of anaerobic lagooning is rather high in France and the organic load treated using these treatment pathways is increasing along the time series, resulting in increasing CH_4 emissions from domestic wastewater (5D1).

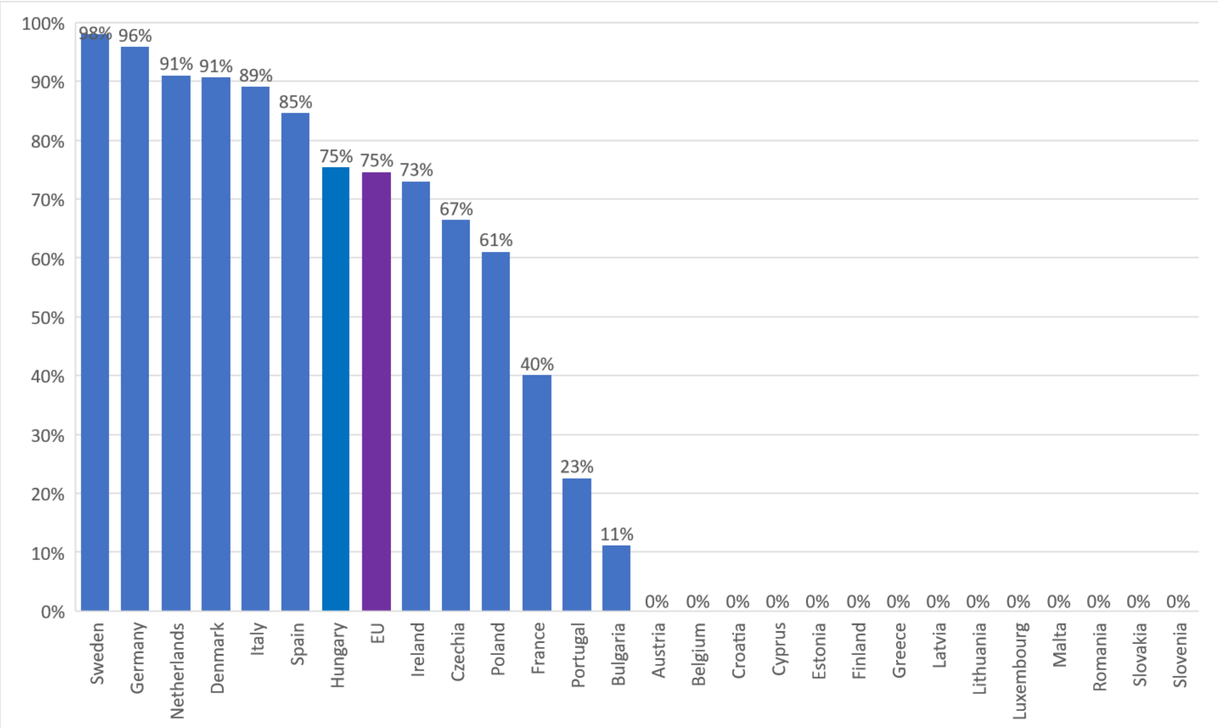
Methodological information for CH_4 emissions from domestic wastewater

All wastewater generated by households as well as any wastewater not disposed on-site in industrial installations is reported as domestic wastewater. CH_4 emissions from wastewater are formed by anaerobic conditions, these can originate during all stages: from wastewater generation to final disposal. CH_4 emissions from domestic wastewater handling (5D1) are a significant emission source in category 5D and key source in the EU. The IPCC 2006 Guidelines introduce three different Tier methods to calculate CH_4 emissions from waste water handling. Activity data needed to estimate CH_4 emissions from domestic wastewater handling is the amount of total degradable organic carbon (TOW) produced in a country. The TOW needs to be calculated based on the total population and the quantity of carbon discharged per person and day expressed in Biochemical Oxygen Demand (BOD). Many countries apply the default value for BOD (0.6 kg CH_4/kg BOD) to estimate the total degradable organic carbon. Furthermore, the country specific share of the different treatment pathways and systems of wastewater need to be identified. This is mainly done by analyzing wastewater statistics and determining the share of the population that is connected to the central sewage system and remaining wastewater that is treated in septic tanks or other wastewater treatment plants. The IPCC 2006 Guidelines provide default MCFs (methane correction factor) for each pathway, but also country specific MCFs can be applied. In the Annex III of this submission a table on countries specific methodology is provided.

If methane is recovered and burned (see *Figure 7.16*), the emissions from wastewater need to be adjusted accordingly. If sludge is removed from the wastewater, a corresponding quantity needs to be deducted from the Total Organically Degradable Content (TOW). Emissions from sludge decomposition are reported under solid waste disposal, biological treatment, burning or in the AFOLU sector depending on the disposal method.

An important remark in the interpretation of data on CH_4-recovery that are reported in the EU's CRF tables (and the countries CRF tables) for wastewater treatment (5D) is that, not all countries are reporting data related to CH_4 recovery, (for energy use of flaring) in CRF table 5D. The reported CH_4 recovery is generally recovered during sludge digestion for biogas production in a follow-up step of aerated wastewater treatment plants. On the opposite, CH_4 emissions relate mainly to anaerobic treatment systems (septic tanks and natural lagoons). Therefore, comparing CH_4 emissions to CH_4 recovery is meaningless. Three countries are reporting this information as included elsewhere (notation key IE), whereas others countries are reporting not occurring (NO), not applicable (NA) or not estimated (NE). Moreover, information related to the amount of CH_4 recovered on sludge digesters is not necessary to apply the 2006 IPCC Guidelines to estimate CH_4 emissions neither from wastewater treatment nor from sludge digestion. Therefore, not reporting any CH_4 recovered doesn't mean that sludge digestion is not occurring (NO) but that the information is not used for the CH_4 estimate from 5D1.

Figure 7.17 5D1 Managed Solid Waste Disposal: Methane recovery fraction (energy use and flaring) for 2021



Further methodological information for all countries is provided in the Annex III of this submission.

N_2O emissions

Table 7.10 5D1 Domestic and commercial wastewater: Countries' contributions to N_2O emissions

Member State	N2O Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	85	150	150	2.5%	65	76%	0	0%	CS,D	CS,D
Belgium	123	92	94	1.6%	-29	-23%	2	2%	D	D
Bulgaria	176	121	120	2.0%	-57	-32%	-1	-1%	T1	D
Croatia	59	80	78	1.3%	18	31%	-3	-3%	T1	D
Cyprus	10	14	15	0.2%	5	53%	0	1%	T1	D
Czechia	208	176	173	2.9%	-35	-17%	-3	-2%	T1	CS,D
Denmark	104	118	119	2.0%	14	14%	0	0%	CS	CS
Estonia	34	28	28	0.5%	-6	-19%	0	0%	T1	D
Finland	49	56	55	0.9%	6	12%	-1	-2%	CS,T1	D
France	493	319	318	5.3%	-175	-36%	-1	0%	T1	D
Germany	1 029	351	348	5.8%	-681	-66%	-3	-1%	CS,D	CS,D
Greece	244	250	251	4.2%	7	3%	1	1%	D	CS
Hungary	131	76	75	1.2%	-56	-43%	0	-1%	CS	D
Ireland	67	95	96	1.6%	29	43%	1	1%	T1	D
Italy	1 059	1 065	1 062	17.6%	3	0%	-3	0%	T1	D
Latvia	45	29	29	0.5%	-16	-35%	0	1%	D	D
Lithuania	60	42	42	0.7%	-18	-31%	0	0%	T1	D
Luxembourg	5	4	4	0.1%	-1	-12%	0	1%	T1	D
Malta	9	7	8	0.1%	-1	-12%	1	12%	D	D
Netherlands	545	623	623	10.3%	79	15%	0	0%	T2	D
Poland	643	693	690	11.4%	47	7%	-3	0%	T2	D
Portugal	178	167	168	2.8%	-9	-5%	2	1%	D	CS,D
Romania	383	378	380	6.3%	-3	-1%	3	1%	D	D
Slovakia	106	44	43	0.7%	-63	-60%	-1	-3%	T2	D
Slovenia	35	34	34	0.6%	-1	-4%	0	0%	T1	D
Spain	767	936	849	14.1%	81	11%	-87	-9%	D	D
Sweden	185	178	178	2.9%	-7	-4%	0	0%	T1	CS,D
EU-27	**6 833**	**6 124**	**6 028**	**100%**	**-806**	**-12%**	**-97**	**-2%**	**-**	**-**

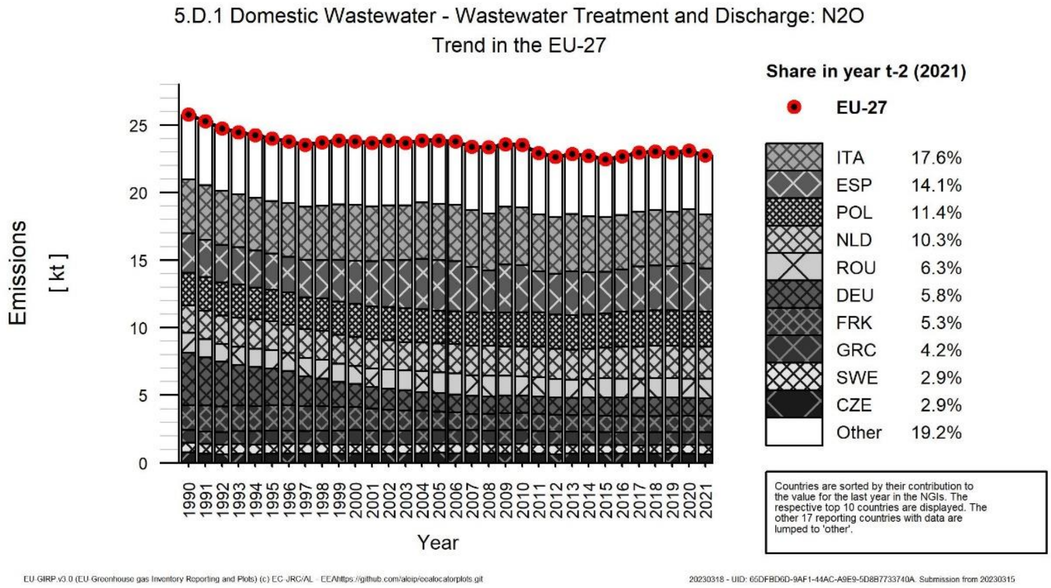
Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Trends in Emissions and Activity Data for N_2O emissions

N_2O emissions from 5D1 Domestic Wastewater account for 0.18 % of total EU GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021. N_2O emissions from domestic wastewater treatment and discharge decreased moderately between 1990 and 2021 by 11.8 % (Table 7.10). *Figure 7.18* shows the trend of emissions indicating the countries contributing most to EU total. The countries contributing most to the observed decrease between 1990 and 2021 are Germany and France. Key drivers for the emission reduction are the development of centralized wastewater treatment plants with nitrogen abatement technologies. In 2021, N_2O emissions decreased by 1.6 % in comparison to 2020 because of the important increase observed for Spain -9.3 %).

Countries with large population have a high share of EU N_2O emissions from this source in general. In 2021, Italy is responsible for 17.6 %, Spain for 14.1 %, Poland for 11.4 % and the Netherland for 10.3 % of EU N_2O emissions from domestic wastewater treatment (see Table 7.10). Large decreases in absolute terms are reported by Germany and France between 1990 and 2021, as the amount of wastewater treated in advanced centralized wastewater treatment plants with nitrogen abatement increased over the years.

Figure 7.18 5D1 Domestic wastewater: N_2O emissions (Trend in relevant countries)



Methodological information for N_2O emissions from domestic wastewater

Direct emissions of N_2O during processing only occur in countries with predominantly advanced centralized wastewater treatment plants with nitrification and denitrification steps. Indirect emissions come from wastewater treatment effluent discharged into aquatic environments. For direct emissions the quantity of wastewater treated in such facilities needs to be multiplied with a default emission factor. For indirect emissions, it is necessary to estimate the nitrogen in wastewater based on protein intake per person and correction factors to reflect non-consumed proteins and industrial/commercial co-discharged into the sewer system. If sludge is removed, a corresponding quantity of nitrogen needs to be deducted.

For the calculation of N_2O emissions from domestic wastewater no different tier levels are provided in the IPCC 2006 Guidelines and it is good practice to estimate N_2O emissions from domestic wastewater effluent by applying the methodology provided in the 2006 IPCC Guidelines. According to Table 7.10 only Austria, Denmark, Finland, Germany, Hungary and Slovakia apply a country specific methodology and/or emission factor, and Czechia, Greece, Portugal and Sweden apply country specific emission factors.

Further methodological information for all countries is provided in the Annex III of this submission.

7.2.4.2 Industrial wastewater (CRF Source Category 5D2)

CH_4 emissions from 5D2 Industrial Wastewater account for 0.18 % of total EU GHG emissions including indirect CO_2, with LULUCF, with international aviation in 2021. Between 1990 and 2021, CH_4 emissions decreased by 37.5 %. Key drivers for the development of CH_4 emissions are primarily economic activities and the share of CH_4 flared or recovered. CH_4 emissions are related to production data in certain industries with high organic contents in the wastewater. Therefore, the trend in CH_4 emissions is fluctuating throughout the time series based on the economic situation in the countries. In 2021, CH_4 emissions from 5D2 Industrial Wastewater increased of 3.9 % in comparison to 2020 (see Table 7.11).

Table 7.11 5D2 Industrial wastewater: Countries' contributions to CH_4 emissions

Member State	CH4 Emissions in kt CO2 equiv.			Share in EU-27 Emissions in 2021	Change 1990-2021		Change 2020-2021		Method	Emission factor Informa-tion
	1990	2020	2021		kt CO2 equiv.	%	kt CO2 equiv.	%		
Austria	1	4	4	0.1%	3	289%	0	1%	CS	CS,D
Belgium	IE,NE	IE,NE	IE,NE	-	-	-	-	-	NA	NA
Bulgaria	2 488	188	211	3.5%	-2 277	-92%	22	12%	T2	D
Croatia	108	127	126	2.1%	18	17%	-1	-1%	T1	D
Cyprus	27	31	31	0.5%	4	15%	0	0%	T1	D
Czechia	406	484	517	8.7%	111	27%	33	7%	CS,T1	CS,D
Denmark	IE	IE	IE	-	-	-	-	-	NA	NA
Estonia	NO	5	4	0.1%	4	∞	-1	-11%	T1	D
Finland	30	23	22	0.4%	-8	-27%	-1	-4%	CS,T2	CS,D
France	73	92	89	1.5%	16	22%	-3	-3%	T1	D
Germany	10	53	54	0.9%	43	419%	1	2%	CS,T2	CS
Greece	919	1 107	1 131	18.9%	211	23%	23	2%	CS,D	CS,D
Hungary	152	28	28	0.5%	-124	-81%	0	0%	T1	D
Ireland	IE	IE	IE	-	-	-	-	-	NA	NA
Italy	1 703	1 540	1 578	26.4%	-124	-7%	38	2%	D	D
Latvia	154	4	4	0.1%	-150	-98%	0	-1%	T1	PS
Lithuania	IE	IE	IE	-	-	-	-	-	NA	NA
Luxembourg	NO	NO	NO	-	-	-	-	-	NA	NA
Malta	IE	IE	IE	-	-	-	-	-	NA	NA
Netherlands	8	12	12	0.2%	3	42%	0	0%	T2	CS
Poland	702	310	308	5.2%	-393	-56%	-2	-1%	T1	CS,D
Portugal	290	211	211	3.5%	-79	-27%	0	0%	T2	CS,D
Romania	424	213	257	4.3%	-167	-39%	44	20%	D	D
Slovakia	33	5	5	0.1%	-28	-85%	0	5%	T1	D
Slovenia	110	9	9	0.1%	-101	-92%	0	4%	T1	CS,D
Spain	1 925	1 301	1 372	22.9%	-554	-29%	71	5%	T1	CS,D
Sweden	7	6	6	0.1%	-1	-8%	1	11%	T2	CS
EU-27	**9 569**	**5 751**	**5 978**	**100%**	**-3 591**	**-38%**	**226**	**4%**	**-**	**-**

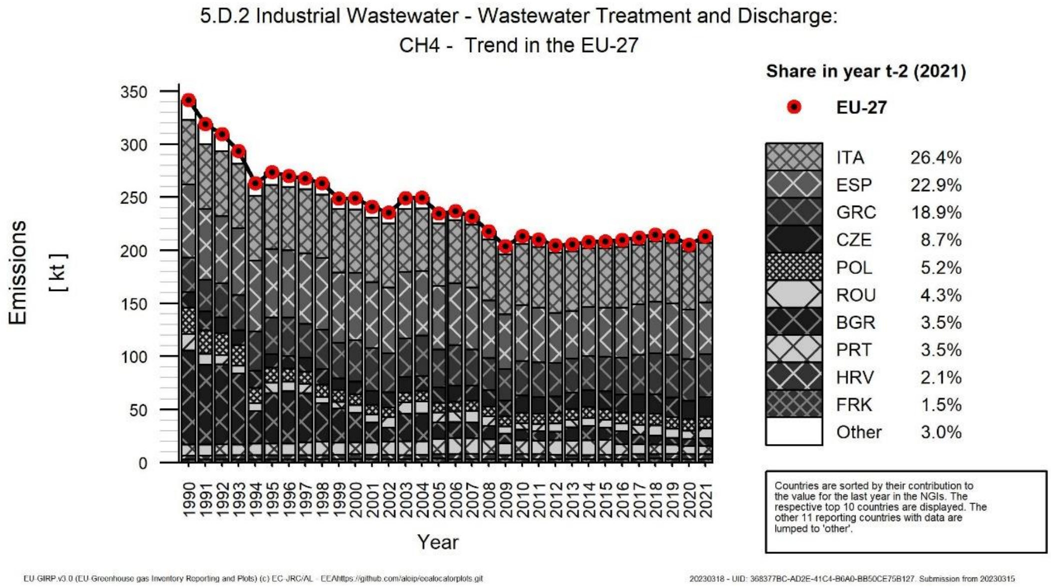
Presented methods and emission factor information refer to the last inventory year.
Abbreviations explained in the Chapter 'Units and abbreviations'.

Trends in Emissions and Activity Data

CH_4 emissions from industrial wastewater treatment and discharge decreased by 37.5 % between 1990 and 2021 *Figure 7.19* shows the trend of emissions indicating the countries contributing most to EU total.

The largest decrease in absolute terms is reported by Bulgaria, followed far below by Spain and Poland contributing together 31.6 % of EU emissions from source 5D2 in 2021, whereas Greece and Czech Republic show the largest, but moderate, absolute emission increases between 1990 and 2021 (Table 7.11). Italy is responsible for 26.4 %, Spain for 22.9 %, and Greece for 18.9 % of EU CH_4 emissions from this source in 2021. The emission trends in this sector are mainly influenced by the strong decrease in Bulgaria.

Figure 7.19 *5D2 Industrial wastewater: CH_4 emissions (Trend in relevant countries)*



Bulgaria decreased its CH_4 emissions from industrial wastewater until 2005 and remains rather constant in the following years with little annual variations. In 2003 and 2004 CH_4 emissions show a peak compared to the preceding years due to the discharge of industrial wastewater into several big tailing ponds by mining companies. The strong decrease of CH_4 emissions from industrial wastewater between 1990 and 2005 is caused by decreasing quantities of organic load inindustrial wastewater in the country, which decreased from 1769 kt COD in 1990 159 kt COD in 2021. Moreover, between 1990 and 2021 the fraction discharged in stagnant sewer decreased from 7.9 % to 1.1%. As a consequence, CH_4 emissions decreased by 91.5 % between 1990 and 2021.

In **Spain**, CH_4 emissions from industrial wastewater decreased by 22.9 % in 2021 in comparison to 1990. Industries with high organic loads that have on-site wastewater treatment are the oil refining industry and the pulp and paper production industry. Other industries with high organic loads are the food- and drink processing industry and the organic chemical industry. Due to changes in production levels CH_4 emissions from this source are also slightly fluctuating throughout the time series in Spain.

In Italy, which represents 26.4 % of EU CH_4 emissions from this source in 2021**,** CH_4 emissions from industrial wastewater decreased only slightly by 7.3 % between 1990 and 2021. This is caused by a decreasing amount of wastewater from industries. Main reductions in industrial wastewater load can be found in the pulp and paper and in the textiles industry.

CH_4 emissions from industrial wastewater in **Poland** decreased by 56.1 % between 1990 and 2021, due to a reduction in wastewater production by industries. Main reduction of wastewater production took place in the mining and quarrying industry, the iron and steel industry and in the wood and paper industry.

In **Greece**, CH_4 emissions from industrial wastewater increased by 22.3 % between 1990 and 2021 due to the increase of the organic load from organic chemical industries and other industries despite the increase of the organic load removed as sludge.

In **France,** CH_4 emissions from industrial wastewater increased only by 22.3 % between 1990 and 2021 but represents only 1.5 % of total EU CH_4 emissions from 5D2. As all in-situ wastewater treatment plants are considered to be well managed in France, only natural lagoon treatment plants have a non-zero MCF and are considered as a source of CH_4 in the French inventory. Only Food &

Beverage industry is using natural lagoon because this type of treatment is not adapted to high COD load.

Methodological information

Emissions from industrial wastewater include all wastewater that is treated/disposed on-site and not sent to public sewers. The main sources for methane emissions from industrial wastewater are:

- pulp and paper manufacture;
- food and drink processing (e.g. meat and poultry processing, alcohol/starch production and dairy products); and
- Organic chemicals production.

Activity data is based on production output from the relevant industries and a Chemical Oxygen Demand per unit of output for each industry. Default IPCC values are provided and it is good practice to use them in the absence of national data.

CH_4 emissions from industrial wastewater handling are reported by 22 countries, while Belgium reports CH_4 emissions as Included Elsewhere/Not estimated (IE/NE) because the same methodology is not applied in its 3 regions, Luxembourg reports CH_4 emissions under 5D2 as not occurring (NO) and Denmark, Ireland, Lithuania and Malta report CH_4 emissions from industrial wastewater as included elsewhere (IE).

According to the IPCC 2006 Guidelines, the emission factor for determining CH_4 emissions from wastewater is composed of the maximum methane producing potential (B0) and the methane conversion factor (MCF). There is an IPCC default value available for the maximum methane producing potential which is applied in most of the countries. In contrast, the MCF has to be determined country specifically and varies strongly among the countries depending on wastewater treatment systems used.

7.2.5 Waste – non-key categories

Table 7.12 Aggregated GHG emission from non-key categories in the waste sector

EU	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 5. Waste in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
5.A.1 Managed Waste Disposal Sites: Waste (CO_2)	0.0	0.0	0.0	0.00%	0	0%	0.0	0%
5.A.2 Unmanaged Waste Disposal Sites: Waste (CO_2)	0.0	0.0	0.0	0.00%	0	0%	0.0	0%
5.A.3 Uncategorized Waste Disposal Sites: Waste (CH_4)	1 390.9	255.6	241.1	0.22%	-1 150	-83%	-14.5	-6%
5.A.3 Uncategorized Waste Disposal Sites: Waste (CO_2)	0.0	0.0	0.0	0.00%	0	0%	0.0	0%
5.B.1 Waste Composting: Waste (N_2O)	311.4	1 749.2	1 763.8	1.61%	1 452	466%	14.6	1%
5.B.2 Anaerobic Digestion at Biogas Facilities: Waste (CH_4)	8.2	1 836.4	1 931.7	1.77%	1 924	23550%	95.3	5%
5.B.2 Anaerobic Digestion at Biogas Facilities: Waste (N_2O)	0.0	72.9	71.9	0.07%	72	100%	-1.0	-1%
5.C.1 Waste Incineration: Waste (CH_4)	2.6	1.4	1.4	0.00%	-1	-46%	0.0	0%

EU	Aggregated GHG emissions in kt CO_2 equ.			Share in sector 5. Waste in 2021	Change 1990-2021		Change 2020-2021	
	1990	2020	2021		kt CO_2 equ.	%	kt CO_2 equ.	%
5.C.1 Waste Incineration: Waste (CO_2)	3 712.4	2 654.9	2 644.3	2.42%	-1 068	-29%	-10.6	0%
5.C.1 Waste Incineration: Waste (N_2O)	194.5	129.8	126.0	0.12%	-68	-35%	-3.8	-3%
5.C.2 Open Burning of Waste: Waste (CH_4)	414.9	564.1	587.5	0.54%	173	42%	23.4	4%
5.C.2 Open Burning of Waste: Waste (CO_2)	83.4	33.3	35.3	0.03%	-48	-58%	1.9	6%
5.C.2 Open Burning of Waste: Waste (N_2O)	239.2	359.2	358.8	0.33%	120	50%	-0.4	0%
5.D.2 Wastewater Treatment and Discharge: Industrial Wastewater (N_2O)	410.9	170.3	169.9	0.16%	-241	-59%	-0.3	0%
5.D.3 Wastewater Treatment and Discharge: Other Wastewater (CH_4)	249.8	80.8	81.1	0.07%	-169	-68%	0.3	0%
5.D.3 Wastewater Treatment and Discharge: Other Wastewater (N_2O)	136.4	45.7	45.5	0.04%	-91	-67%	-0.2	0%
5.E Other Disposal: Waste (CH_4)	52.2	6.4	6.1	0.01%	-46	-88%	-0.3	-4%
5.E Other Disposal: Waste (CO_2)	21.8	23.0	21.6	0.02%	0	-1%	-1.4	-6%
5.E Other Disposal: Waste (N_2O)	0.0	29.5	29.0	0.03%	29	100%	-0.5	-2%

7.3 EU uncertainty estimates

Table 7.13 shows the total EU uncertainty estimates for the sector Waste and the uncertainty estimates for the relevant gases of each source category. The highest level uncertainty was estimated for N_2O from 5D and CO_2 and CH_4 from from 5E. Unexpectively CH_4 from 5A has one of the lower uncertainties. Regarding the uncertainty on trend, N_2O from 5D and CH_4 from 5B show the highest uncertainty estimates, followed by N_2O from 5B. For a description of the Tier 1 uncertainty analysis carried out for the EU see Chapter 1.6.

Table 7.13 Sector 5 -Waste: EU uncertainty estimates

Source category	Gas	Emissions Base Year	Emissions 2021	Emission trends Base Year-2021	Level uncertainty estimates based on MS uncertainty estimates	Trend uncertainty estimates based on MS uncertainty estimates
5.A Solid Waste Disposal	CO2	0	0	0.0%	0.0%	0.0%
5.A Solid Waste Disposal	CH4	137 074	75 450	-45.0%	43.9%	9.1%
5.A Solid Waste Disposal	N2O	0	0	0.0%	0.0%	0.0%
5.B Biological treatment of solid waste	CO2	0	0	0.0%	0.0%	0.0%
5.B Biological treatment of solid waste	CH4	391	4 411	1028.7%	51.2%	400.7%
5.B Biological treatment of solid waste	N2O	236	1 638	594.9%	64.7%	224.9%
5.C Waste Incineration	CO2	3 671	2 680	-27.0%	21.6%	4.8%
5.C Waste Incineration	CH4	156	200	28.1%	44.3%	20.9%
5.C Waste Incineration	N2O	225	145	-35.5%	32.6%	9.8%
5.D Wastewater treatment and discharge	CO2	0	0	0.0%	0.0%	0.0%
5.D Wastewater treatment and discharge	CH4	34 172	17 152	-49.8%	58.7%	9.7%
5.D Wastewater treatment and discharge	N2O	7 381	6 243	-15.4%	410.1%	344.3%
5.E Other	CO2	22	22	-0.8%	300.2%	2.4%
5.E Other	CH4	3	6	82.5%	262.8%	27.1%
5.E Other	N2O	0	29	Inf	20.1%	Inf
5 (where no subsector data were submitted)	all	852	1 308	53.5%	98.5%	131.3%
Total - 5	**all**	**184 184**	**109 284**	**-40.7%**	**40.6%**	**15.5%**

***Note**: Emissions are in Gg CO_2 equivalents; trend uncertainty is presented as percentage points; the sum of the source category emissions may not be the total sector emissions of the EU-NIR because uncertainty estimates are not available for all source categories in all countries;*

7.4 Sector-specific quality assurance and quality control

There are several activities for improving the quality of estimating and reporting GHG emissions from waste: Before and during the compilation of the EU GHG inventory, several checks are made of the countries data in particular for completeness, time series consistency of emissions and implied emission factors, comparisons of implied emission factors across countries and checks of internal consistency.

In the second half of the year, the EU internal review is carried out for selected source categories. In 2005, the EU internal review was carried out for the first time. In 2012 a comprehensive review was carried out for all sectors and all EU countries in order to Source category Gas Emissions fix the base year 2020 under the EU Effort Sharing Decision. (ESD review 2012). This review also covered the waste sector of the MS GHG inventories (peer review). In 2015, a few countries volunteered to be reviewed under step 2 of the ESD trial review for the sector waste. In 2016, again a comprehensive review was carried out for all sectors and all EU countries with a focus on the years 2005, 2008-2010, 2013 and 2014 in order to track progress of the EU countries under the EU Effort Sharing Decision. (ESD review 2016).

In March 2016, during the WG1-meeting, a note/paper on wastewater treatment and discharge was discussed with the countries. This note/paper reflects a number of concerns raised during the ESD 2015 trial review. In connection to the ESD review further capacity building activities between the ESD review team and EU sectoral experts have taken place via webinars and distribution of working papers on the main conclusions from the ESD reviews.

In September 2017 a capacity building webinar related to the waste sector was organized between the ESD review team and the countries. Several aspects on solid waste disposal, biological treatment and wastewater treatment were discussed. A second webinar took place in November 2017 in order to discuss in more detail the different interpretations when using equations 6.1-6.3 of the IPCC 2006 guidelines (Volume 5, chapter 6) for calculating emissions from wastewater treatment. An elaborated spreadsheet, along with a brief explanation of the spreadsheet was presented and explained during the webinar.

In the autumn of 2018 a capacity building webinar related to the waste sector was organized where the ESD review team informed the Countries on specific aspects that were handled and discussed during the ESD review round in 2018.

In the autumn of 2019 a capacity building webinar related to the waste sector was organized where the ESD review team informed the Countries on specific aspects that were handled and discussed during the ESD review round in 2019.

In the autumn of 2020 a capacity building webinar related to the waste sector was organized where the ESD review team informed the Countries on specific aspects that were handled and discussed during the ESD review round in 2020.

In the autumn of 2021 a capacity building webinar related to the waste sector was organized where the ESD review team informed the Countries on specific aspects that were handled and discussed during the ESD review round in 2021.

7.5 Sector-specific improvements

After the implementation of the new IPCC guidelines in 2015 and the subsequent changes to the sector, chapters had to be re-written in 2016, and certain methodological changes had to be applied, which have been reviewed in the 2016 ESD review.

Explanations for recalculations were further elaborated in 5.B Biological treatment to increase transparency.

From the year 2016 onwards, additional quality checks of the EU NIR chapter waste were carried out in order to improve the consistency between the CRF tables and the EU NIR and consistency of tables and figures with text in the EU NIR.

8 OTHER

Sector Other is not an EU key category (see Annex 1.1) and does not include any emissions in 2023

9 INDIRECT CO_2 AND N_2O EMISSIONS

9.1 Description of sources of indirect emissions in the GHG inventory

The CO_2 resulting from the atmospheric oxidation of CH_4, CO and NMVOC is referred to as indirect CO_2. Indirect CO_2 resulting from the oxidation of CH_4, CO and NMVOCs produced by fossil fuel combustion are included in the general methodological approach which assumes that all the carbon in the fuel (minus the portion that remains as soot or ash) is oxidized to CO_2 whereas a fraction of this carbon is initially emitted as CH_4, CO or NMVOC.

Total indirect CO_2 emissions at EU level are based on emission sources reported by those Member States estimating and reporting indirect CO_2, and consistent with the methodological guidance provided in the 2006 IPCC Guidelines.

For consistency with the reporting under the first commitment period of the Kyoto Protocol, indirect CO_2 emissions from solvent use, road paving with asphalt and asphalt roofing are generally reported under CRF category 2D3 ,'non-energy products from fuels and solvent use‘ according to UNFCCC Reporting Guidelines. For other sources of indirect CO_2, emissions are reported in CRF Table 6.

Indirect CO_2 only includes fossil carbon, and excludes biogenic sources and combustion-fuels where IPCC default CO_2 emission factors (i.e. full oxidation with factor equal to 1) are assumed.

Indirect N_2O emissions in the agriculture sector address nitrous oxide (N_2O) emissions that result from the deposition of the nitrogen emitted as nitrogen oxides (NO_X) and ammonia (NH_3). N_2O is produced in soils through the biological processes of nitrification and denitrification. One of the main controlling factors in this reaction is the availability of inorganic nitrogen in the soil and therefore deposition of nitrogen resulting from NO_X and NH_3 will enhance emissions.

In addition to agriculture, the 2006 IPCC Guidelines include guidance for estimating N_2O emissions resulting from nitrogen deposition of all anthropogenic sources of NO_X and NH_3 (in particular from sources in the energy and IPPU sectors). The 2006 IPCC Guidelines, Volume 5, also address indirect N_2O emissions which occur from the release of wastewater effluents into waterways, lakes or the sea.

As with indirect CO_2, indirect N_2O emissions at EU level are fully consistent with estimation methods used by Member States.

The EU GHG national total includes indirect CO_2 if these emissions have been reported by Member States. Both national totals, including and excluding indirect CO_2, are reported in the CRF tables. Indirect N_2O emissions reported in Summary 1 are not included in national GHG totals.

This chapter refers to the indirect emissions that are reported in Table 6 of the EU CRF tables. As mentioned above, indirect emissions are also included in other sectors, such as indirect CO_2 in IPPU (i.e. under ‘2D Non-energy products from fuels and solvents‘) and indirect N_2O in the agriculture and LULUCF sectors (i.e. in CRF tables 3.D and 3.B.b or table 4(IV)). These emissions are dealt with in the corresponding sectoral chapters.

9.2 Methodological issues

Table 9.1 summarizes indirect CO_2 and nitrous oxide emissions reported by EU Member States. Twelve countries provided values for indirect CO_2 emissions. The highest shares of the EU total of indirect CO_2 emissions are reported by France (30.7 %) and Czechia (19.8 %). Nine countries reported indirect N_2O emissions for the year 2021 in 2023, with Bulgaria, Romania, Italy accounting for 86 % of the total EU indirect N_2O emissions.

Indirect CO_2 is not an EU key category.

Table 9.1 Indirect CO_2 and N_2O emission for the EU in 2021

Countries	indirect CO_2 [kt CO_2 equ.]	Share in EU-27 [%]	indirect N_2O [kt CO_2 equ.]	Share in EU-27 [%]
Austria	NO,NE,IE,NA	-	11	0.2%
Belgium	NO,NE	-	NO,NE	-
Bulgaria	68	2.1%	865	18%
Croatia	NO,NA	-	NO,NA	-
Cyprus	5	0.2%	NO,NE	-
Czechia	654	19.8%	206	4%
Denmark	245	7.4%	195	4%
Estonia	NO,NE,IE	-	NO,NE	-
Finland	57	1.7%	121	3%
France	1 014	30.7%	NO,NE	-
Germany	NO,NE	-	NO,NE,IE	-
Greece	NO,NE	-	NO,NE	-
Hungary	NO,NE	-	NO,NE	-
Ireland	NO,NE,IE	-	NO,NE	-
Italy	NO,IE	-	804	17%
Latvia	13	0.4%	NO,IE,NA	-
Lithuania	40	1.2%	NO,NE	-
Luxembourg	NO,NE	-	NO,NE	-
Malta	NO,NE,NA	-	17	0%
Netherlands	503	15.2%	NO,NE	-
Poland	499	15.1%	NA	-
Portugal	164	5.0%	NO,NE,NA	-
Romania	NO,NE	-	2 453	51%
Slovakia	44	1.3%	NO,NE	-
Slovenia	NO,NE	-	NO,NE	-
Spain	NE,IE	-	NE,NA	-
Sweden	NO	-	147	3%
EU-27	**3 306**	**100%**	**4 819**	**100%**

The methodologies for the estimation of indirect emissions in EU countries are consistent with the 2006 IPCC Guidelines.

For the estimation of indirect CO_2 emissions EU countries follow the basic principle proposed by the IPCC for calculating the CO_2 inputs from the atmospheric oxidation of CH_4, CO or NMVOC (2006 IPCC Guidelines, Volume 1, Chapter 7, p. 7.6):

From CH_4: $Inputs_{CO2} = Emissions_{CH4} \bullet 44/16$

From CO: $Inputs_{CO2} = Emissions_{CO} \bullet 44/28$

From NMVOC: $Inputs_{CO2} = Emissions_{NMVOC} \bullet C \bullet 44/12$

Where C is the fraction carbon in NMVOC by mass (default = 0.6)

Some countries (i.e. CZE, DNM) explicitly mention that the precursor gases emissions (CO, NO_X and NMVOC) used in the above equations are consistent with the precursor gases emissions reported under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the CH_4 emissions reported to the UNFCCC.

In general, emissions reported in table 6 refer to indirect emissions from energy, IPPU and waste, while some countries report the indirect CO_2 emissions in other categories too (e.g. in the IPPU category 2.D.3).

9.3 Uncertainties and time-series consistency

Indirect CO_2 emissions have decreased since 1990 in all countries but Lithuania (+17 %), Poland (+76 %) and Portugal (+110 %). The highest percentage decrease has been reported by Denmark (-78 %), while in absolute terms Czechia had the biggest share in the EU reduction, decreasing its indirect CO_2 emissions by almost 1.3 Mt. The main reason for the decrease in indirect CO_2 emissions is the decrease of the precursor gases emissions. The uncertainty of the indirect emission estimates is also based on the calculation of emissions from these gases.

9.4 Category specific planned improvements

The separate reporting of indirect CO_2 and nitrous oxide emissions (from sources other than agriculture and LULUCF) to the UNFCCC under CRF Table 6 has been performed for the first time in 2015 and is in line with paragraph 29 of the UNFCCC reporting guidelines (Decision 24/CP.19). Following this reporting the EU team analysed the ways that countries reported these emissions and presented the results in Working Group 1 of the Climate Change Committee of the European Commission. The different approaches have been discussed and guidance was provided to Member States in order to improve the consistency in the reporting of these emissions.

10 RECALCULATIONS AND IMPROVEMENTS

10.1 Main recalculations

The key factors for recalculations in the EU's 2023 inventory submission under the Convention, compared to the EU 2022 submission, are (Figure 10.1):

- Emissions and removals from the UK are no longer included in the EU inventory. The EU inventory is the sum of emissions and removals of its 27 Member States.
- Based on the latest Decision on the UNFCCC Reporting Guidelines taken at COP27 in Sharm-El-Sheik, Parties shall apply the global warming potentials values set out in the IPCC Fifth Assessment Report by no later than 31 December 2024. The EU has decided to implement this Decision one year before the deadline; thus in 2023 already.
- The regular recalculations that are due to changes in activity data, emission factors and other methodological improvements.

Figure 10.1: Reasons for recalculations in 2023 EU inventory

Note: MR = methodological recalculations, GWP = impact of change from GWP AR4 to GWP AR5; Data refer to total GHG emissions including LULUCF, international aviation and indirect CO_2 emissions

10.2 Implications for emission levels

Table 10.1 provides the differences in total GHG emissions (including indirect emissions) between the latest submission and the previous submission in absolute and relative terms for the EU. The table shows that due to recalculations, total 1990 GHG emissions with indirect CO_2 including LULUCF and international aviation (Memo item) have increased in the latest submission compared to the previous submission by 24 834 kt (0.01 %). EU GHG emissions for 2020 decreased by 5 915 kt (<0.0%) due to recalculations.

Table 10.1 Overview of recalculations of EU total GHG emissions (difference between latest submission and previous submission in kt CO_2 equivalents)

		1990	1995	2000	2005	2010	2015	2020
Total CO_2 equivalent emissions including LULUCF	kt	24 719	-11 090	3274	-27 375	-25 376	-22 928	-6 145
	%	0.53	-0.26	0.08	-0.65	-0.66	-0.65	-0.20
Total CO_2 equivalent emissions excluding LULUCF	kt	20 381	12 964	8 137	4 983	4 889	-3 252	5 365
	%	0.42	0.29	0.18	0.11	0.12	-0.09	0.16
Total CO_2 equivalent emissions including LULUCF and International Aviation	kt	24 834	-10 936	3 332	-27 514	-25 395	-22 763	-5 915
	%	0.01	-0.00	0.00	-0.01	-0.01	-0.01	-0.00

Table 10.2 provides an overview of recalculations for the key categories for 1990 and 2020 (see Section 1.5 for information on identification of key categories). The table shows that the largest recalculations in absolute terms were made in the key category of the LULUCF sector, in 1990 as well as in 2020. Of the other sectors, the largest recalculations occurred in the category ‘Energy Industries’, followed by ‘Waste water treatment and discharge’ in 1990; and in 2020 in the category ‘Solid Waste Disposal’ followed by ‘Manufacturing Industries’.

Table 10.2 Recalculations for EU key source categories 1990 and 2020 (difference between latest submission and previous submission in kt of CO_2 equivalents and in percentage)

Greenhouse Gas Source Categories	Gas	Recalculations 1990		Recalculations 2020	
		(kt CO_2 equivalents)	(%)	(kt CO_2 equivalents)	(%)
1.A.1. Energy Industries	CO_2	4 407	0.3%	- 2 591	-0.3%
1.A.2. Manufacturing Industries	CO_2	2 259	0.3%	7 075	1.8%
1.A.3. Transport	CO_2	- 282	0.0%	- 269	0.0%
1.A.3. Transport	CH_4	732	13.1%	4	0.4%
1.A.3. Transport	N_2O	- 913	-13.7%	- 147	-1.9%
1.A.4. Other Sectors	CO_2	- 644	-0.1%	5 422	1.1%
1.A.4. Other Sectors	CH_4	2 543	12.0%	1 224	8.2%
1.A.5. Other	CO_2	25	0.1%	- 273	-4.3%
1.B.1. Solid Fuels	CH_4	9 701	12.8%	45	0.2%
1.B.2. Oil and Natural Gas	CH_4	6 927	13.0%	- 3 156	-16.2%
1.B.2. Oil and Natural Gas	CO2	8	0.1%	- 10	-0.1%
2.A. Mineral Industry	CO_2	- 144	-0.1%	201	0.2%
2.B. Chemical Industry	CO_2	- 161	-0.3%	- 438	-0.9%
2.B. Chemical Industry	Unspecified mix of HFCs and PFCs	- 897	-16.1%	1	1.9%
2.B. Chemical Industry	N_2O	- 9 782	-11.1%	- 6	-0.1%
2.B. Chemical Industry	HFCs	- 1 837	-12.5%	- 148	-14.6%
2.C. Metal Industry	CO_2	232	0.2%	45	0.1%
2.C. Metal Industry	PFC	- 1 927	-10.0%	- 39	-10.1%
2.F. Product uses as substitute for ODS	HFC	- 1	-8.3%	- 4 141	-5.4%
3.A. Enteric Fermentation	CH_4	25 896	12.3%	42	0.0%
3.B. Manure Management	CH_4	8 711	19.1%	3 340	8.9%
3.B. Manure Management	N_2O	- 1 477	-5.5%	1 439	7.5%
3.D. Agricultural Soils	N_2O	- 31 942	-17.7%	- 13 625	-9.3%
3.G. Liming	CO_2	78	0.8%	264	5.2%
4.A. Forest Land	CO_2	- 11 081	3.3%	9 403	-3.0%
4.B. Cropland	CO_2	4 385	7.4%	- 15 818	-43.7%
4.C. Grassland	CO_2	14 536	51.0%	5 810	57.4%
4.D. Wetlands	CO_2	241	2.4%	- 276	-1.8%
4.E. Settlements	CO_2	- 6 073	-20.7%	- 9 475	-28.0%
4.G. Harvested w ood products	CO_2	- 670	2.4%	- 5 061	14.0%
5.A. Solid Waste Disposal	CH_4	12 099	9.7%	- 10 945	-13.7%
5.B. Biological Treatment of Solid Waste	CH_4	- 61	-10.4%	- 329	-7.4%
5.D. Waste Water treatment and discharge	CH_4	- 350	-1.0%	- 137	-0.9%
5.D. Waste Water treatment and discharge	N_2O	- 125	-1.7%	918	14.8%

Note: Many of these source categories are more aggregated than the EU key source categories identified in Section 1.5.

Table 10.3 and Table 10.4 give an overview of absolute and relative changes of Member States' emissions due to recalculations for 1990 and 2020. Recalculations of more than 5 million tonnes of CO_2 equivalents were made by Finland, Germany, Portugal, Romania and Sweden in 1990, and Finland, France, Germany, Romania and Spain in 2020. For the EU this resulted in a relative change of +0.5 % in 1990 emissions and -0.2 % in 2020. On country level, recalculations in relative terms of more than 10 % were made by Finland, Portugal and Sweden for 1990 and by Finland, Romania, Slovenia and Slovakia for 2020.

Table 10.3 Contribution of countries to EU recalculations of total GHG emissions with indirect CO_2, with LULUCF and with international aviation for 1990–2020 (difference between latest submission and previous submission kt of CO_2 equivalents)

	1990	1995	2000	2005	2010	2015	2020
Austria	480	-5 826	2 810	-7 091	-15 440	-3 966	-3 651
Belgium	155	-19	-11	-144	-10	23	836
Bulgaria	2 187	1 669	1 171	830	557	-1 384	-946
Croatia	-303	-140	-148	-55	224	-8	-211
Cyprus	221	196	12	154	97	122	-249
Czechia	2 237	2 506	1 729	917	496	70	-1 126
Denmark	415	602	595	849	908	771	1 101
Estonia	-434	-562	-500	-1 495	-717	1 280	1 063
Finland	-12 294	-11 527	-9 398	-8 100	-4 364	2 099	8 229
France	2 066	81	-3 290	-4 390	-3 021	-5 878	-8 052
Germany	18 418	6 708	12 914	1 986	8 708	7 878	17 702
Greece	393	11	-462	85	296	4	-835
Hungary	-99	127	199	114	96	673	-140
Ireland	1 063	958	972	1 084	307	238	1 456
Italy	1 728	1 808	2 238	2 966	5 505	3 097	3 575
Latvia	65	49	11	-42	-94	10	191
Lithuania	491	219	40	-11	81	-223	-1 208
Luxembourg	-160	-39	-39	-69	-185	-24	-147
Malta	27	9	-40	17	17	6	-3
Netherlands	2 649	2 147	2 463	2 885	2 814	2 247	1 058
Poland	704	1 598	-173	-1 912	-2 770	-3 574	-2 104
Portugal	7 007	-4 575	4 214	1 614	3 087	5 564	2 652
Romania	6 483	2 547	1 730	2 740	-5 193	-15 046	-15 411
Slovakia	1 173	1 109	1 243	1 651	1 581	1 607	1 236
Slovenia	168	165	173	165	146	215	1 716
Spain	-297	-4 864	-8 666	-10 313	-10 936	-10 396	-11 050
Sweden	-9 710	-6 204	-6 458	-11 671	-7 586	-8 498	-1 596
EU-27	**24 834**	**-11 244**	**3 332**	**-27 235**	**-25 395**	**-23 094**	**-5 915**

Note: United Kingdom was included in the last EU submission but is no longer as the UK left the EU on 31 Jan 2020.

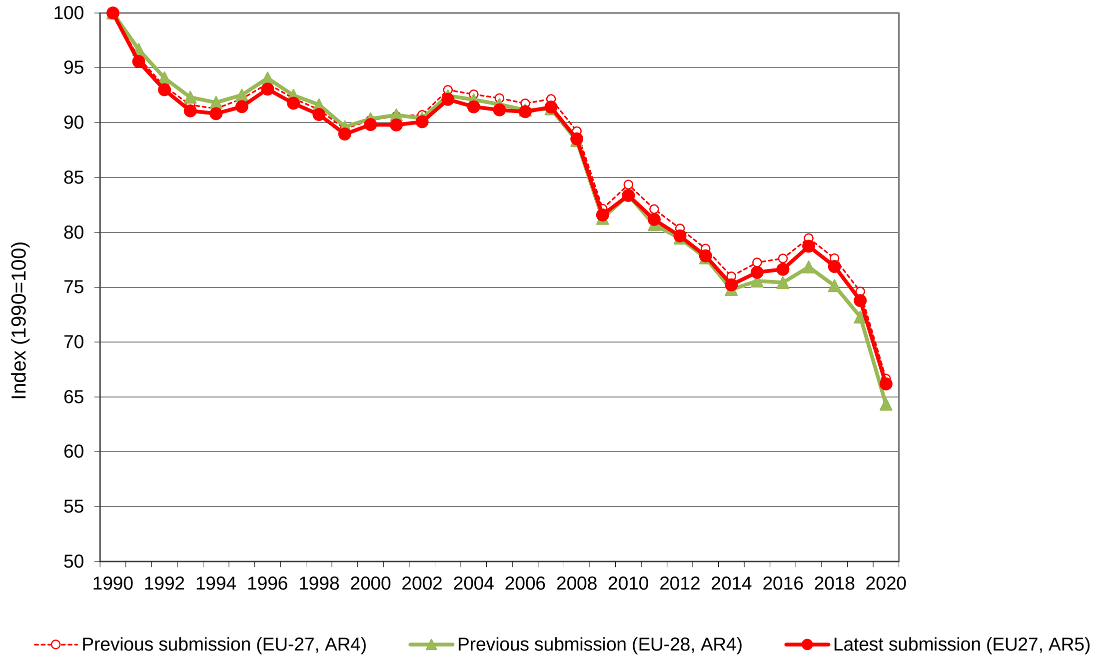
Table 10.4 Contribution of Member States to EU recalculations of total GHG emissions with indirect CO_2, with international aviation and with LULUCF for 1990–2020 (difference between latest submission and previous submission in percentage)

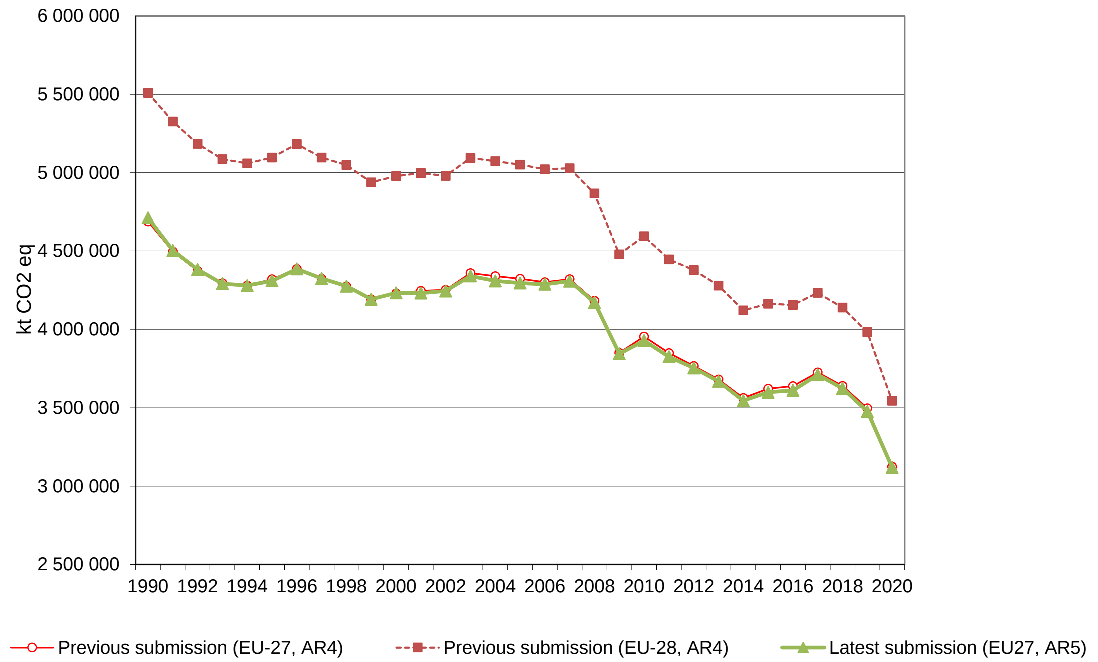
	1990	1995	2000	2005	2010	2015	2020
Austria	0.7%	-8.6%	4.3%	-8.5%	-18.7%	-5.1%	-5.0%
Belgium	0.1%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.8%
Bulgaria	2.7%	3.0%	3.0%	1.8%	1.2%	-2.5%	-2.4%
Croatia	-1.2%	-1.0%	-0.8%	-0.2%	1.0%	0.0%	-1.1%
Cyprus	3.7%	2.6%	0.1%	1.6%	1.0%	1.4%	-2.8%
Czechia	1.2%	1.7%	1.2%	0.6%	0.4%	0.1%	-0.9%
Denmark	0.5%	0.7%	0.8%	1.1%	1.3%	1.5%	2.4%
Estonia	-1.2%	-3.2%	-3.7%	-8.3%	-4.4%	8.0%	8.2%
Finland	-20.9%	-19.4%	-16.7%	-16.0%	-7.8%	5.5%	26.2%
France	0.4%	0.0%	-0.6%	-0.8%	-0.6%	-1.3%	-2.1%
Germany	1.4%	0.6%	1.2%	0.2%	0.9%	0.9%	2.4%
Greece	0.4%	0.0%	-0.4%	0.1%	0.3%	0.0%	-1.2%
Hungary	-0.1%	0.2%	0.3%	0.2%	0.2%	1.2%	-0.2%
Ireland	1.7%	1.4%	1.2%	1.3%	0.4%	0.3%	2.2%
Italy	0.3%	0.4%	0.4%	0.5%	1.1%	0.8%	1.0%
Latvia	0.5%	-2.2%	-0.7%	-0.8%	-0.9%	0.1%	1.7%
Lithuania	1.1%	1.2%	0.4%	-0.1%	0.8%	-1.8%	-8.1%
Luxembourg	-1.2%	-0.4%	-0.4%	-0.5%	-1.4%	-0.2%	-1.4%
Malta	1.0%	0.3%	-1.3%	0.5%	0.5%	0.2%	-0.1%
Netherlands	1.1%	0.9%	1.1%	1.3%	1.2%	1.1%	0.6%
Poland	0.2%	0.4%	0.0%	-0.5%	-0.7%	-1.0%	-0.6%
Portugal	11.4%	-7.0%	5.4%	1.8%	4.9%	9.0%	5.1%
Romania	2.9%	1.6%	1.6%	2.4%	-5.5%	-18.2%	-20.0%
Slovakia	1.9%	2.6%	3.2%	3.7%	4.0%	4.8%	4.4%
Slovenia	1.2%	1.2%	1.4%	1.2%	1.2%	1.2%	15.4%
Spain	-0.1%	-1.6%	-2.4%	-2.5%	-3.3%	-3.3%	-4.5%
Sweden	-26.8%	-16.2%	-22.6%	-31.7%	-31.9%	-47.6%	-21.4%
EU-27	**0.5%**	**-0.3%**	**0.1%**	**-0.6%**	**-0.6%**	**-0.6%**	**-0.2%**

10.3 Implications for emission trends, including time series consistency

Figure 10.2 shows that the overall emission trend has only marginally changed due to recalculations caused by methodoligcal changes and the new GWP used. The indexes are therefore largely overlapping. The impact of the United Kingdom no longer being a member of the EU, has influenced the emission trend especially in the early 1990ies and in recent years. In the previous submission total GHG emissions (with indirect CO_2, LULUCF and international aviation) of the EU decreased by 33.3%, and in the latest submission it decreased by 33.8%.

Figure 10.2: Comparison of EU GHG emission trends 1990–2020 (with indirect CO_2, LULUCF and International Aviation) of the latest and the previous submission, as index and in absolute values





10.4 Recalculations, including in response to the review process, and planned improvements to the inventory

10.4.1 EU response to UNFCCC review

A list of recommendations and improvements is presented in Annex V. The tables in Annex V focus on UNFCCC recommendations from the draft review report 2022.

10.4.2 Improvements planned at EU level

The following activities are planned at EU level with a view to improving the EU GHG inventory:

- Include new key categories in the NIR giving detailed information like for other key categories;
- Further implement the recommendations from the past reviews;
- Continue QA/QC activities;

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12 UNITS AND ABBREVIATIONS

t	1 tonne (metric) = 1 megagram (Mg) = 10^6 g
Mg	1 megagram = 10^6 g = 1 tonne (t)
Gg	1 gigagram = 10^9 g = 1 kilotonne (kt)
Tg	1 teragram = 10^{12} g = 1 megatonne (Mt)
TJ	1 terajoule

AWMS	animal waste management systems
AD	activity data
BEF	biomass expansion factor
BKB	lignite briquettes
C	confidential
CAPRI	Common Agricultural Policy Regional Impact Assessment model (http://www.capri-model.org/)
CCC	Climate Change Committee (established under Council Decision No 280/2004/EC)
CH_4	methane
CO_2	carbon dioxide
COP	conference of the parties
CRF	common reporting format
CV	calorific value
EC	European Community
EEA	European Environment Agency
EF	emission factor
Eionet	European environmental information and observation network
EMAS	Ecomanagement and Audit Scheme
ETC/CM	European Topic Centre on Climate Change Mitigation
ETS	European Emissions Trading System
EU	European Union

FAO	Food and Agriculture Organisation of the United Nations
GHG	greenhouse gas
GPG	good practice guidance and uncertainty management in national greenhouse gas inventories (IPCC, 2000)
GWP	global warming potential
HFCs	hydrofluorocarbons
JRC	Joint Research Centre
F-gases	fluorinated gases (HFCs, PFCs, SF_6)
IE	included elsewhere
IEF	implied emission factor
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
LULUCF	land-use, land-use change and forestry
MNP	Milieu-en Natuurplanbureau
MS	Member State
MRG	monitoring and reporting guidelines
N	nitrogen
NH_3	ammonia
N_2O	nitrous oxide
NA	not applicable
NE	not estimated
NFI	national forest inventory
NIR	national inventory report
NO	not occurring
NUTS	Nomenclature of Territorial Units for Statistics
PFCs	perfluorocarbons
QA	quality assurance
QA/QC	quality assurance/quality control
QM	quality management
QMS	quality management system
RIVM	National Institute of Public Health and the Environment (The Netherlands)

SF_6	sulphur hexafluoride
SNE	Single National Entity
UNFCCC	United Nations Framework Convention on Climate Change
VOCs	Volatile Organic Compounds

Abbreviations in the source category tables in Chapters 3 to 9 and 18-24

Methods applied	EF: methods applied for determining the emission factor	AD: methods applied for determining the activity data	Estimate: assessment of completeness	Quality: assessment of the uncertainty of the estimates
CR — Corinair	CR — Corinair	AS — associations, business organizations	All — full	H — high
CS — country-specific	CS — country-specific	IS — international statistics	F — full	M — medium
COPERT X — Copert Model X = version	D — default	NS — national statistics	Full — full	L — low
D — default	M — model	PS — plant specific data	IE — included elsewhere	
M — model	MB — mass balance	Q — specific questionnaires, surveys	NE — not estimated	
NA — not applicable	PS — plant-specific	RS — regional statistics	NO — not occurring	
OTH - other				
RA — reference approach			P — partial	
T1 — IPCC Tier 1			Part — partial	
T1a — IPCC Tier 1a				
T1b — IPCC Tier 1b				
T1c — IPCC Tier 1c				
T2 — IPCC Tier 2				
T3 — IPCC Tier 3				