European Environment Agency

European Union emission inventory report 1990-2021 — Under the UNECE Convention on Long-range Transboundary Air Pollution (Air Convention)

EEA Report 04/2023

European Environment Agency

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

More information on the European Union is available on https://european-union.europa.eu/index_en.

Luxembourg: Publications Office of the European Union, 2023

ISBN 978-92-9480-590-4
ISSN 1977-8449
doi:10.2800/68478

Cover design: EEA
Cover photo: © Karsten Wurth, Unsplash
Layout: Formato Verde/EEA

Contents

Acknowledgements

This report was prepared by the EEA and its European Topic Centre on Human Health and the Environment with the partner organisation klarFAKT.

The lead authors of the report were Marion Pinterits and Bernhard Ullrich, and they were assisted by Elisabeth Kampel. The EEA project manager was Agnieszka Griffin. The desk officer at the European Commission's Directorate-General for the Environment (DG Environment) was Viviane André. The authors gratefully acknowledge the technical support received from Sabine Schindlbacher and Robert Wankmüller of European Monitoring and Evaluation Programme's Centre on Emission Inventories and Projections.

The EEA acknowledges comments received on the draft report from the Eionet National Reference Centres in EEA member countries and the European Commission (DG Environment).

Title of report	**European Union emission inventory report 1990-2021 under the UNECE Convention on Long-range Transboundary Air Pollution (Air Convention)**
Contact names	Agnieszka Griffin (EEA) Marion Pinterits (ETC HE) Viviane André (DG Environment)
Organisation	EEA European Commission, DG Environment
Address of the EEA	Kongens Nytorv 6 1050 Copenhagen K Denmark
Email	Agnieszka.Griffin@eea.europa.eu
Address of the European Commission	European Commission DG Environment 1049 Brussels Belgium
Email	Viviane.ANDRE@ec.europa.eu

Executive summary

This document is the annual EU emission inventory report under the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (Air Convention) (UNECE, 1979). The report and its accompanying data constitute the official submission to the Air Convention from the European Commission on behalf of the EU as a Party to the UNECE Air Convention (Box ES.1). The submission to the Air Convention is done via the UNECE secretariat. The EEA compiled the report in cooperation with the EU Member States and the European Commission.

Box ES.1

The Gothenburg Protocol

The original Gothenburg Protocol to the Convention on Long-range Transboundary Air Pollution (UNECE Air Convention) was adopted in 1999. The protocol was amended in 2012, establishing new emission reduction commitments as from 2020. These are defined as percentage reductions relative to the base year 2005 for nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), sulphur oxides (SO_x), ammonia (NH_3) and fine particulate matter ($PM_{2.5}$). The European Union is a Party to the Protocol and has a specified emission reduction commitment which is the sum of the reduction commitments of the individual EU Member States.

The Air Convention obliges and invites Parties to report emission data for numerous air pollutants:

- regulated pollutants with a reduction obligation: nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), sulphur oxides (SO_x), ammonia (NH_3) and PM with a diameter of 2.5µm or less ($PM_{2.5}$; also known as fine PM);
- other: carbon monoxide (CO)
- particulate matter (PM) emitted directly to the air (primary PM):
  - PM with a diameter of 10µm or less (PM_{10});
  - total suspended particulates (TSPs);
  - black carbon (BC), the most strongly light-absorbing component of PM (additional pollutant);
- priority heavy metals (HMs): lead (Pb), cadmium (Cd) and mercury (Hg);
- additional HMs: arsenic (As), chromium (Cr), copper (Cu), nickel (Ni), selenium (Se) and zinc (Zn);
- persistent organic pollutants (POPs): polychlorinated dibenzodioxins/dibenzofurans (PCDD/Fs), polycyclic aromatic hydrocarbons (PAHs), hexachlorobenzene (HCB) and polychlorinated biphenyls (PCBs);

- additional reporting of the individual PAHs, benzo(a)pyrene (B(a)P), benzo(b) fluoranthene (B(b)F), benzo(k)fluoranthene (B(k)F) and indeno(1,2,3-cd) pyrene (IP), and the sum of all four.

These pollutants harm human health and the environment. Certain pollutants also contribute to the formation of ground-level ozone (O_3) and secondary PM in the atmosphere. Some pollutants have both an indirect and a direct effect on the sunlight absorbed by the Earth and reflected back to space (radiative forcing) and hence on the climate (EEA, 2014, 2019a).

Box ES.2

EU country groupings in this report

The data reported by the EU to the Air Convention in 2023 (Gothenburg Protocol, please see Box ES.1) include those up to and including 2021.

In the submission year 2023, the EU has 27 Member States (EU-27) and reports emission data for these 27 Member States.

- In addition to the EU-27 data, this report includes the 2021 sulphur emission (SO_x) data for the EU-11 (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain), in accordance with the EU's reporting obligations under the Air Convention's Protocol on Further Reduction of Sulphur Emissions (Oslo Protocol).

This report addresses:

- the institutional arrangements and preparation processes behind the EU's emission inventory, methods and data sources, reporting, key category analyses (KCAs), information on quality assurance and quality control (QA/QC), general uncertainty evaluation, and information on completeness and underestimations (Chapter 1);
- information on approved adjustments and adjustment applications under the Gothenburg Protocol (Chapter 2);
- emission trends for the EU as a whole and for individual EU Member States, and the contribution of key categories to total emissions (Chapter 3);
- sectoral analyses and emission trends for key pollutants (Chapter 4);
- information on recalculations and on planned and implemented improvements (Chapter 5);
- brief information on the status of the (not mandatory) reporting of the condensable component of PM_{10} and $PM_{2.5}$ (Section 1.5.5).

Emission data used in this report are presented in the accompanying annexes and are also available for direct download from the EEA's data service (EEA, 2022a). The following sections summarise the main findings.

Box ES.3

Status of reporting by EU Member States

In 2023, EU Member States were requested to report to the EEA emission inventory data and an informative inventory report (IIR) for the Air Convention reporting. Twenty-six EU Member States provided air emission inventories and activity data, but, for those for which emission data were missing for certain years or pollutants, a gap-filling procedure was applied to obtain a European inventory that was as complete as possible. Croatia did not submit data on time, and hence the data for this Member State have entirely been gap filled.

The EU should deliver emission inventories and projections by 30 April, its IIR (i.e. this report) by 30 May and its gridded and large point source (LPS) data by 15 June.
By 5 May 2023, 25 EU Member States had provided IIRs. Twenty three Member States had provided projections. The year 2023 is not a reporting year for gridded data or LPS data. Detailed information on EU Member States' submissions is given in Appendix 3 ([1]).

In 2012, the Executive Body of the Air Convention decided that adjustments to emission reduction commitments, or to inventories for the purposes of comparing them with total national emissions, may be applied in some circumstances if such a circumstance keeps a Party from being able to meet one of its reduction commitments (UNECE, 2012a). Under the provisional application of the amended Gothenburg Protocol, the European Monitoring and Evaluation Programme Steering Body accepted inventory adjustment applications for emissions from 10 countries in 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022.

Circumstances that allow adjustments to emission inventories are defined as follows:

- There are additional categories of emission sources that were not accounted for when the emission reduction commitments were made.
- Emission factors used to determine emission levels for particular source categories for the year in which emission reduction commitments are to be attained are significantly different from the emission factors applied to these categories at the time the emission reduction commitments were made.
- The methods for determining emissions from specific source categories changed significantly between when emission reduction commitments were made and the year they are to be attained.

EU emission trends

Figures ES.1-ES.3 present the trends in the emissions of air pollutants between 1990 and 2021([2]). They are aggregated across the EU.

Emission trends for regulated pollutants with a reduction obligation between 1990 and 2021

With reference to regulated pollutants with a reduction obligation, SO_x registered the greatest reduction in emissions across the EU. In 2021, SO_x emissions were 93% lower than in 1990 (Figure ES.1). This reduction is the result of a combination of measures:

- fuel switching in energy-related sectors, moving away from solid and liquid fuels with high sulphur contents to low-sulphur fuels such as natural gas;

([1]) For detailed information on LPS and gridded data reporting, please see the Member State submissions on the Central Data Repository (https://cdr.eionet.europa.eu).
([2]) Each year, by 15 February, Member States must report emission data for the years up to and including the last calendar year but one. Thus, by 15 February 2023, Member States were obliged to report data for the years up to 2021. Typically, it takes countries about 12-15 months to compile and report emission inventory data (for both air pollutants and greenhouse gases). This delay is mainly because of the time needed for official national and/or trade statistics to become available (typically up to 12 months after the end of the calendar year), together with the time needed for subsequent data processing, calculations, and quality assurance and quality control (QA/QC) checks.

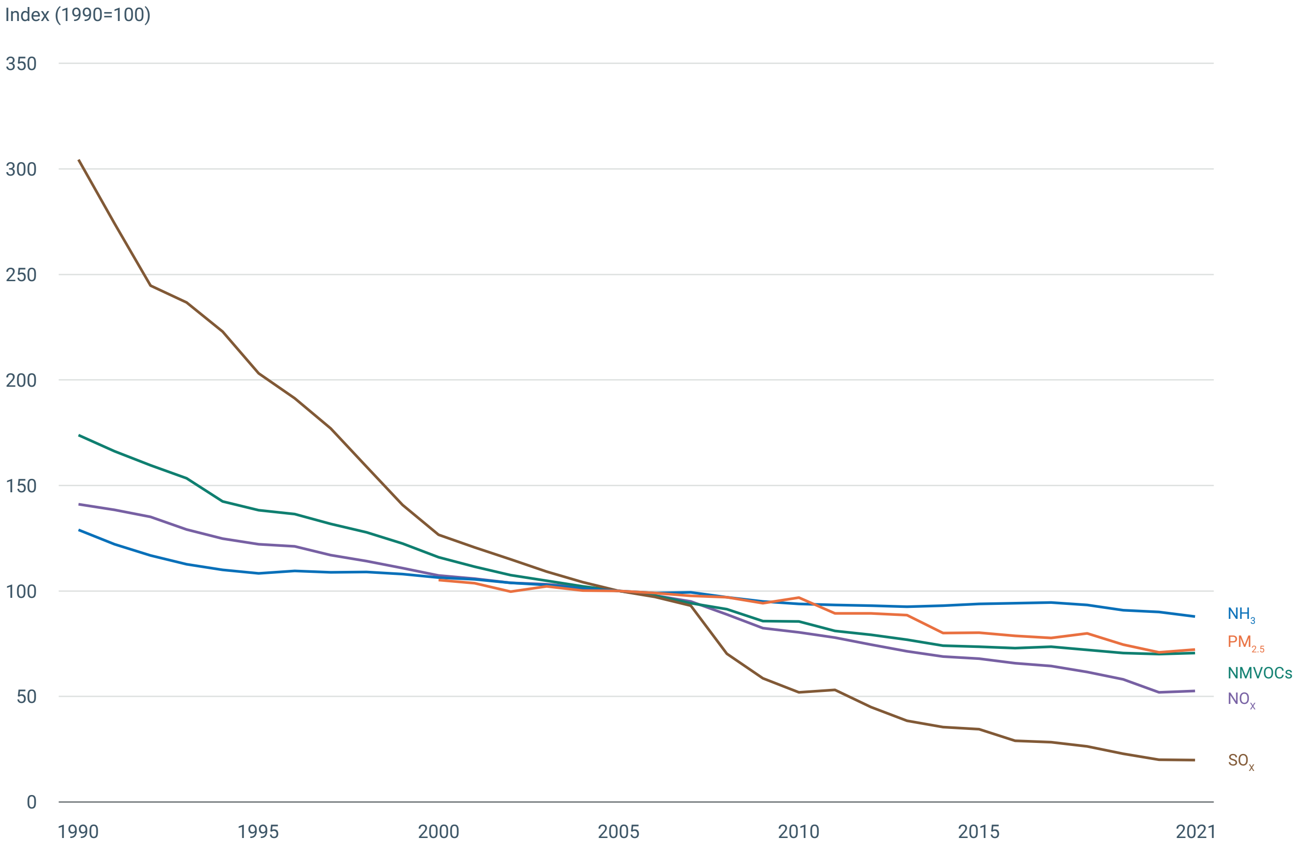
- applying flue gas desulphurisation (FGD) techniques in industrial facilities;
- implementing EU directives relating to the sulphur content of certain liquid fuels.

Emissions of the other regulated pollutants with a reduction obligation have dropped considerably since 1990: $PM_{2.5}$ (31% reduction), NMVOCs (59% reduction) and NO_X (63% reduction).

For most main air pollutants, emissions decreased more slowly from 2007 to 2021. NH_3 emissions have not fallen to the same extent as those of other pollutants. NH_3 emissions decreased between the years 1990 and 1995, but since then emissions have remained stable with minor fluctuations.

Emission reduction measures in the road transport sector have led to a reduction in NMVOC emissions since 1990, and NO_X since 1992. The sector has achieved this primarily through legislative measures requiring the abatement of vehicle exhaust emissions.

Figure ES.1 EU-27 emission trends for regulated pollutants with a reduction obligation



EU legislation sets progressively stricter emission limits for air pollutants from cars and vans, trucks, and buses and coaches, known as the 'Euro standards'. The standards apply to exhaust emissions of NO_x, determined by laboratory-based tests. These official tests fail to measure the actual level of emissions that vehicles are producing under real driving conditions, i.e. actual NO_x emissions are often higher than EU limits permit. This has contributed significantly to exceedances of the nitrogen dioxide (NO_2) air quality daily limit value at urban traffic stations ([3]) (EEA, 2019b). New tests under real driving conditions now complement laboratory-based testing. Such tests became mandatory for all new cars and vans in September 2019 (EU, 2016a).([4])

NO_x emissions declined considerably in the electricity/energy generation sectors as a result of certain technical measures, mainly:

- the introduction of combustion modification technologies (e.g. use of low-NO_x burners);
- the implementation of flue gas abatement techniques (e.g. NO_x scrubbers and selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) techniques);
- fuel switching from coal to gas.

Box ES.4

Changes in the emissions of regulated pollutants with a reduction obligation in the EU Member States between 2020 and 2021

Between 2020 and 2021, emissions of nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOCs) $PM_{2.5}$ increased by 1.0%, 0.6% and 2.1%, respectively. Sulphur oxides (SO_x) and ammonia (NH_3) dropped by 0.3% and 2.4%, respectively.

NO_x emissions increased in 16 EU Member States. The main contributors were Spain, France, Italy and Romania (in order of the largest absolute emission changes).

NMVOC emissions increased in 21 EU Member States between 2020 and 2021. France, Italy and Germany (in order of the largest absolute emission changes) were responsible for the highest increases. The main emitter of NMVOCs is the 'industrial processes and product use' sector.

From 2020 to 2021, the largest reductions in SO_x emissions in absolute terms were reported by Bulgaria, Italy and Spain (in order of the largest absolute emission changes). The 'energy production and distribution' sector was the main contributor to the reduction in SO_x emissions.

NH_3 emissions decreased in 20 EU Member States. Poland, Germany, France and Spain reported the highest decreases (in order of the largest absolute emission changes).

Between 2020 and 2021, $PM_{2.5}$ emissions increased in 18 EU Member States. The main contributors to this increase were France, Romania, Italy and Germany (in order of the largest absolute emission changes).

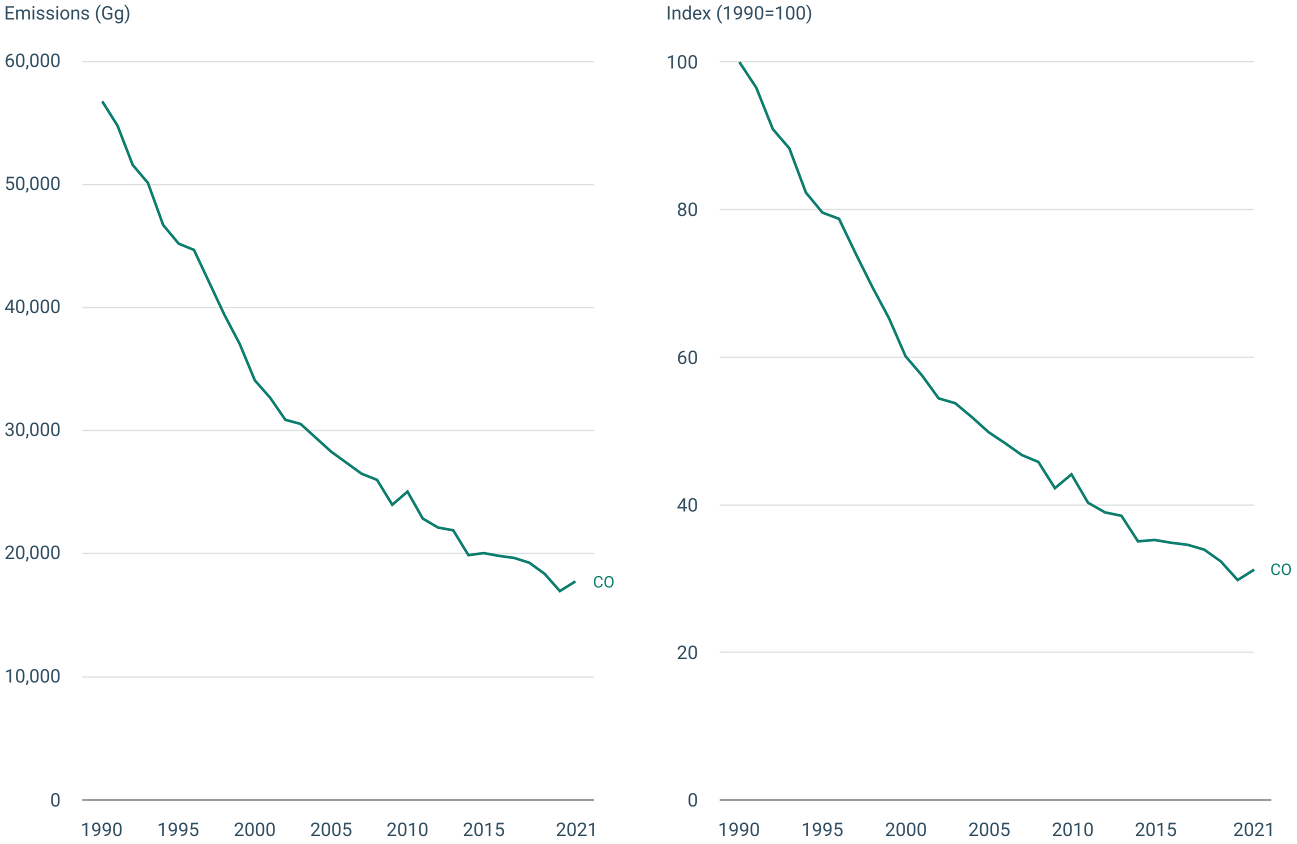
([3]) Stations in urban areas (mainly cities) close to main roads.
([4]) The Commission adopted on 10 November 2022 a proposal for a new Euro 7 emission standard for light and heavy vehicles, proposing further strengthening of testing conditions and monitoring of compliance (COM(2022) 586).

Emission trends for CO

Between 1990 and 2021, CO emissions decreased by 69% (Figure ES.2). The 'road transport' sector contributed most to the decrease in CO emissions. Emission reduction measures in this sector have led to a reduction in CO emissions since 1990.

EU CO emissions increased between 2020 and 2021, mainly due to increased emissions reported by France, Italy, Germany and Spain (in order of the largest absolute emission changes).

Figure ES.2 EU-27 emission trends for CO



Emission trends for particulate matter between 2000 and 2021

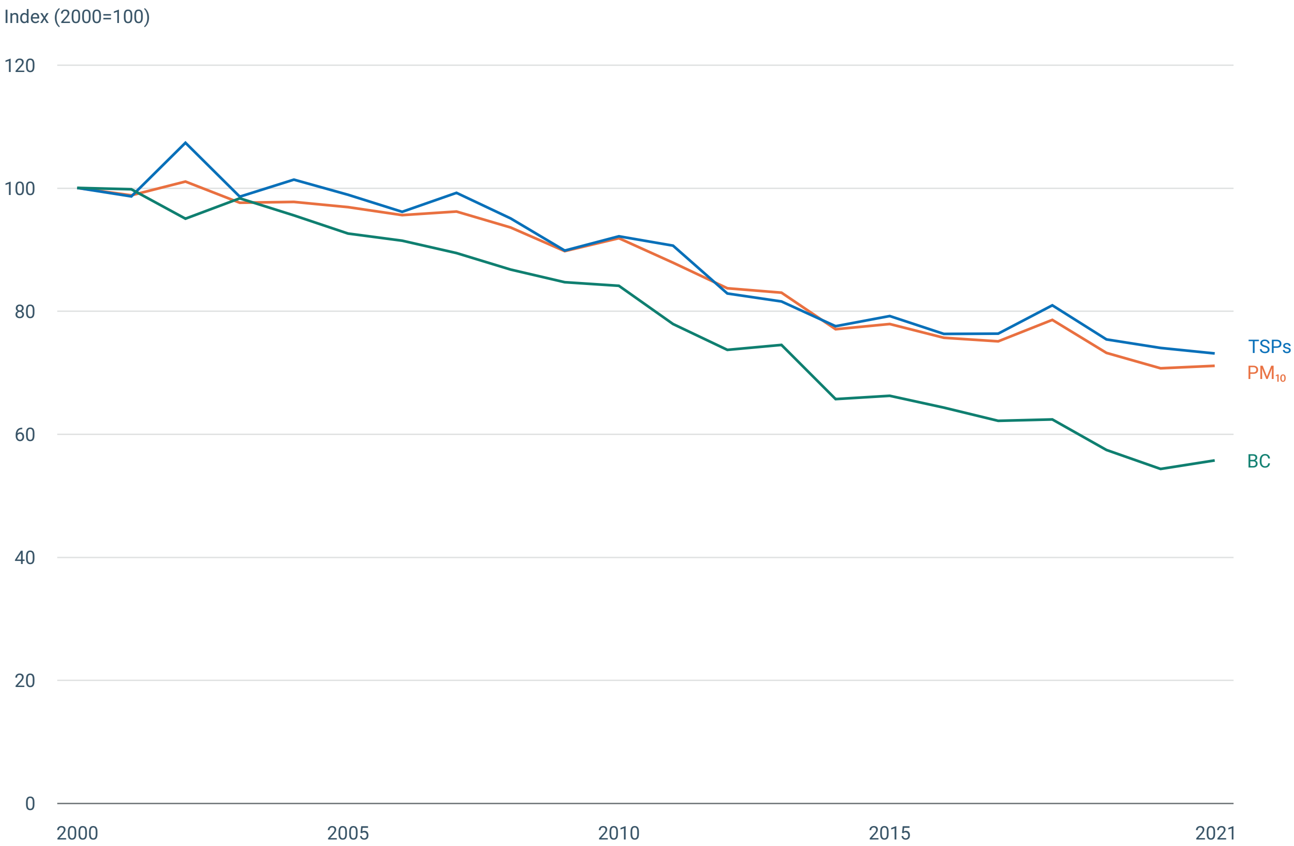
The Air Convention formally requests Parties to report emissions of PM from the year 2000 onwards; hence, emission trends are shown for 2000 and the subsequent years only. Aggregated emissions of TSPs fell by 27% across the EU between 2000 and 2021 (Figure ES.3). Emissions of primary PM_{10} and BC fell by 29% and 44%, respectively.

The reporting of condensable components is not mandatory, and in recent years there has been no clear definition of whether PM emission reporting includes or excludes the condensable component. However, the reporting table on condensable components within Annex II was provided by 16 EU Member States in 2023. The level of information is rather heterogeneous, and for many categories no information is available at all.

Total PM emissions dropped, mainly thanks to the introduction or improvement of abatement measures across the energy, road transport and industry sectors. This has been coupled with other developments in industrial sectors, such as switching from fuels containing high levels of sulphur to those with low levels. SO_x, NO_x and NH_3 play an important role in the formation of secondary PM. Thus, if emissions of these pollutants decrease, this also influences PM formation (EEA, 2022d).

NH_3 emissions from agriculture contribute to episodes of high secondary inorganic PM concentrations being experienced across certain regions of Europe each spring. Such episodes contribute to exceedances of the PM_{10} daily limit values set in the EU's Ambient Air Quality Directive (e.g. CAMS, 2021).

Figure ES.3 EU-27 emission trends for PM



Emission trends for heavy metals and persistent organic pollutants between 1990 and 2021

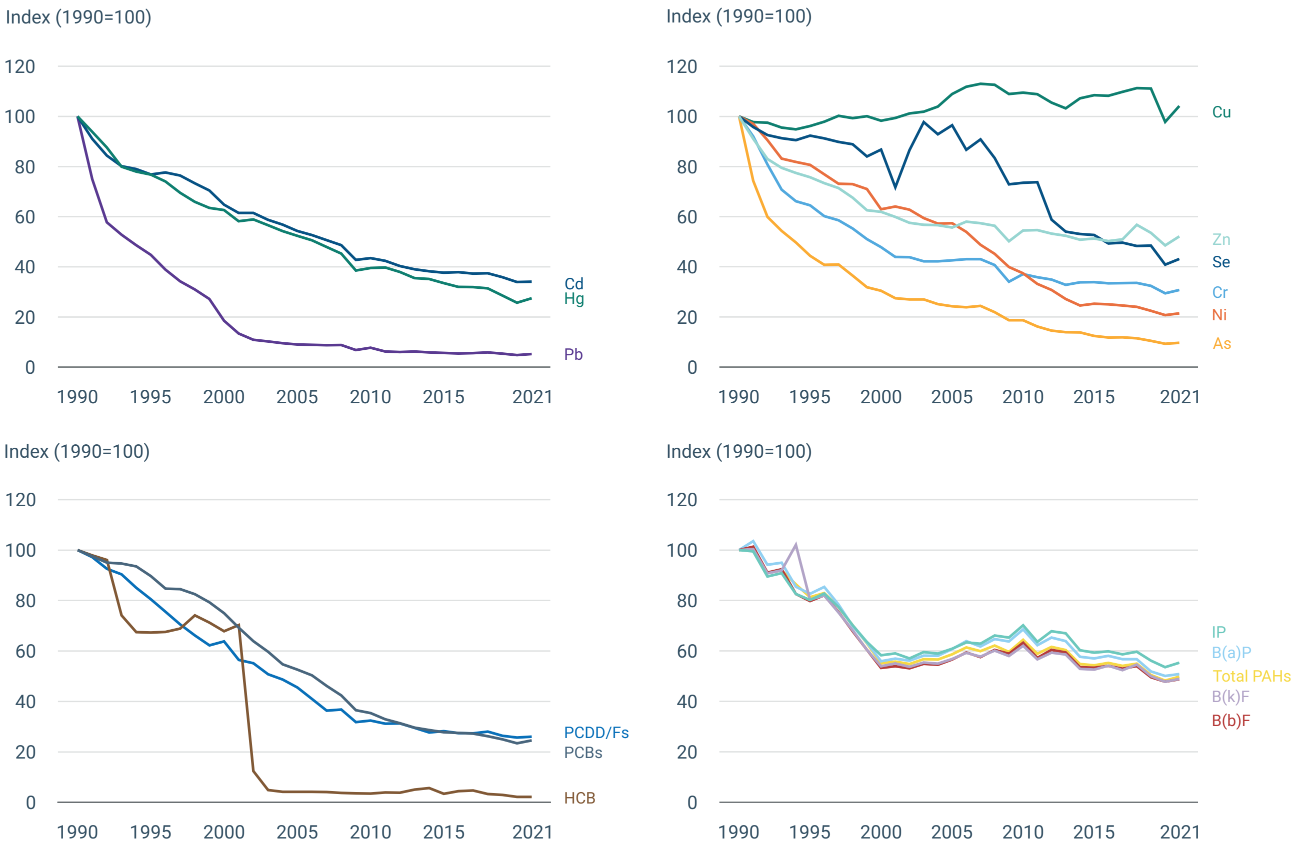
Since 1990, emissions of the main HMs (Pb, Cd, Hg), dioxins and furans, total PAHs, HCB and PCBs have also dropped substantially, by at least 50% (Figure ES.4).

Much progress has been made since the early 1990s in reducing point source emissions of these substances, particularly from industrial facilities. This has been achieved partly through improved abatement techniques for wastewater treatment and incinerators in the metal-refining and smelting industries. In some countries, the reduction in emissions follows the closure of older industrial facilities as a result of economic restructuring. Total emissions fell faster between 1990 and 2000 than in the next decade.

Emissions of all HMs except Cu fell between 1990 and 2021: Pb by 95%, Cd by 66%, Hg by 73%, As by 90%, Cr by 69%, Ni by 78%, Se by 58% and Zn by 48%. Cu emissions increased by 4%.

Total PAHs decreased by 50% from 1990 to 2021([5]). For individual PAHs, the reductions from 1990 to 2021 were 49% for B(a)P, 51% for B(b)F, 51% for B(k)F and 45% for IP. Dioxins and furans decreased by 74% between 1990 and 2021. The reductions in HCB and PCB emissions were 98% and 75%, respectively. Although there have been clear decreases over the last 25 years, emissions of POPs have remained relatively stable since 2003 (Figure ES.3).

Figure ES.4 EU-27 emission trends for HMs and POPs



Note: The decrease in HCB emissions between 2003 and 2004 is caused by reductions reported by Germany.

The peak in B(k)F emissions in 1994 is caused by a large increase reported by Bulgaria.

For certain pollutants, not all Member States reported data.

([5]) It is difficult to compare reductions in total PAHs with reductions in the other PAHs. The reporting completeness for the EU (the sum of reporting/gap filling of the Member States) differs strongly between total PAHs and the other PAHs.

Box ES.5

Effects of recalculating data for previously reported emissions in the EU Member States

In 2023, all EU Member States except Croatia (which did not provide a submission on time) reported recalculations for one or more years. This meant changes in emission inventories for all pollutants up to 2020 (see Chapter 5.1), whereby the changes for regulated pollutants with a reduction obligation (NO_x, NMVOCs, SO_x, NH_3 and $PM_{2.5}$) were up to 12%. In their informative inventory reports (see Appendix 5), EU Member States gave an account of their reasons for recalculating parts of their time series or whole time series. Explanations included methodological improvements, revision of emission factors or newly implemented emission factors, reallocations, availability of new data, and revision of activity data and correction of errors. Information on the rationale for carrying out recalculations is not always provided.

EU key categories and main emission sources

EU key categories refer to the individual sources that contributed the most to total emission levels in 2021. These have been determined by a level assessment ([6]) for NO_x, NMVOCs, SO_x, NH_3, CO, $PM_{2.5}$, PM_{10}, BC, Cd, Pb, Hg, PCDD/Fs, total PAHs, B(a)P, HCB and PCBs.

A total of 57 different emission inventory source categories were identified as being key for at least one pollutant. Several emission categories were identified as being key for more than 1 of the 16 pollutants assessed. Table ES.1 lists the most relevant key categories.

Table ES.1 Most relevant key categories for air pollutant emissions

Name of key category	Number of occurrences as a key category
Residential: Stationary (combustion) (NFR 1A4bi)	14 (NO_x, NMVOCs, SO_x, CO, $PM_{2.5}$, PM_{10}, BC, Pb, Cd, Hg, PCDD/Fs, total PAHs, B(a)P, HCB)
Public electricity and heat production (NFR 1A1a)	10 (NO_x, SO_x, $PM_{2.5}$, PM_{10}, CO, Pb, Cd, Hg, HCB, PCBs)
Iron and steel production (NFR 2C1)	9 (SO_x, CO, Pb, Cd, Hg, PCDD/Fs, total PAHs, HCB, PCBs)
Road transport: Passenger cars (NFR 1A3bi)	7 (NO_x, NMVOCs, CO, $PM_{2.5}$, PM_{10}, BC, Hg)
Waste: Open burning of waste (NFR 5C2)	6 (CO, PM_{10}, $PM_{2.5}$, BC, Cd, PCDD/Fs)

Note: NFR, nomenclature for reporting.

Figure ES.5 shows the share of total EU emissions in 2021 by sector group. As observed in previous years, each main air pollutant has one main source category:

1. For NO_x, this is 'road transport'.

2. For SO_x, this is 'energy production and distribution'.

([6]) A key category-level assessment identifies those source categories that have a significant influence on a country's total inventory in terms of its absolute level of emissions. In this report, key categories refer to those that are collectively responsible for 80% of the total emissions of a given pollutant (EMEP/EEA, 2019).

3. For NH_3, this is 'agriculture'.

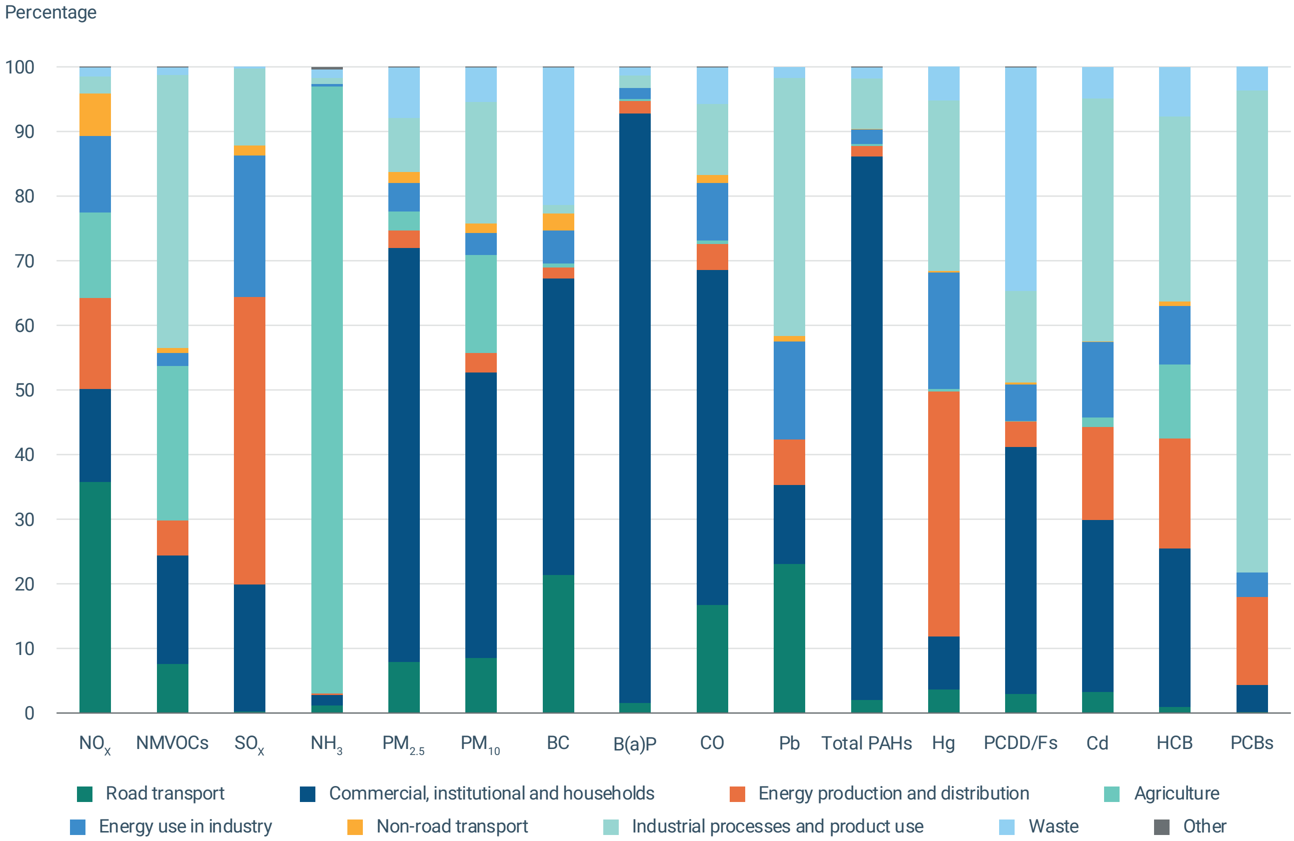
4. For NMVOCs, this is 'industrial processes and product use'.

5. For CO and PM, this is 'commercial, institutional and households'.

Emissions of NO_X from the road transport sector fell by 67% between 1990 and 2021. Nevertheless, in the EU, this sector is a major source of the ground-level O_3 precursors NO_X, CO and NMVOCs. In 2021, this sector contributed 36% (NO_X), 17% (CO) and 8% (NMVOCs) to the total emissions of these pollutants in the EU. Passenger cars, heavy duty vehicles and buses are the principal contributors to CO emissions from this sector; in 2021, passenger cars alone contributed around 71% of CO emissions from the road transport sector.

The commercial, institutional and households sector is the most significant source of primary PAHs, $PM_{2.5}$, CO, BC, PM_{10} and PCDD/Fs. Energy- and process-related emissions from industry contribute considerably to the overall emissions of a number of NMVOCs, HMs and POPs.

Figure ES.5 Share of sector groups in EU emissions of the main air pollutants in 2021



Adjustments to emission inventories under the Gothenburg Protocol

Following the adoption of the amended Gothenburg Protocol and the decision on its provisional application from 2012, Parties to the Air Convention were able to 'adjust' their emission inventories downwards if non-compliance with the ceilings set in the Gothenburg Protocol was caused by the application of improved emission inventory methods in accordance with updated scientific knowledge since the 2010 ceilings were originally set. This was to avoid countries being disadvantaged by applying improved emission inventory methodologies. Emission reduction commitments are in place and the same approach applies (though inventory adjustments now have to be applied to both the year for which the compliance is checked and the base year 2005) — see below.

Table ES.2 lists inventory adjustment applications that the European Monitoring and Evaluation Programme (EMEP) Steering Body accepted in 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022.

Table ES.2 Accepted inventory adjustment applications

Country	Pollutant	NFR
Belgium	NO_x	Road transport (1A3bi-iv), Agriculture (3B, 3Da1, 3Da2a)
	NMVOCs	Agriculture (3B, 3De)
Czechia	NMVOCs	Agriculture (3B)
Denmark	NMVOCs	Agriculture (3B, 3B1a)
	NH_3	Agriculture (3Da1, 3De)
Finland	NH_3	Energy use in industry (1A2gviii), Commercial, institutional and households (1A4ai, 1A4bi, 1A4ci), Road transport (1A3bi-iv)
France	NO_x	Road transport (1A3bi-iv), agriculture (3B, 3D)
	NMVOCs	Agriculture (3B, 3D)
Germany	NMVOCs	Agriculture (3B, 3De)
	NH_3	Agriculture (3Da2c, 3I)
Hungary	NMVOCs	Agriculture (3B, 3De)
Luxembourg	NO_x	Road transport (1A3bi-iv), agriculture (3B, 3De)
	NMVOCs	Agriculture (3B, 3De)
Netherlands	NMVOCs	Agriculture (3B1a, 3B4h, 3B4d, 3B4e, 3B4giii, 3B4giv, 3B2, 3B4h, 3B4f, 3B1b, 3Da2a, 3Dc, 3B3, 3B4gii, 3B4gi, 3De, 3Da3)
	NH_3	Agriculture (3Da4, 3De, 3B3)
Spain	NO_x	Road transport (1A3bi, 1A3biii), agriculture (3B)

Note: For NFR (nomenclature for reporting) codes, see Appendix 4.

Sources: UNECE (2014b, 2015, 2016, 2017, 2018, 2019a, 2020, 2021, 2022a).

Progress towards meeting the EU's emission reduction commitments for 2021 under the Gothenburg Protocol

The Gothenburg Protocol (1999) set emission ceilings for the European Community, at the time comprising 15 EU Member States (EU-15). The Gothenburg Protocol was amended in 2012 to set emission reduction commitments for 2020 and beyond. The reduction commitment for the EU is the sum of the reduction commitments of the EU Member States ([7]).Table ES.3 shows the aggregated EU-27 emissions for 2021 and 2005, as well as the actual reduction compared with the emission reduction commitment the protocol specified for the EU in 2020 and beyond. In 2021, the EU-27 emissions of NO_x, NMVOCs, SO_x, NH_3 and $PM_{2.5}$ were below the reduction commitments set.

Figure ES.6 shows whether or not EU Member States met their respective Gothenburg Protocol national emission reduction commitments in 2021. The reduction commitment for SO_x was met by all Member States except Cyprus.

Several Member States ([8]) did not meet their reduction commitment for NO_x emissions (Lithuania and Romania), NH_3 emissions (Austria, Bulgaria, Denmark, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Portugal, Sweden), NMVOC emissions (Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Poland) and $PM_{2.5}$ emissions (Hungary, Poland, Romania).

Table ES.3 Emissions reported for 2021 by EU-27 Member States compared with the EU reduction commitment for 2020 and beyond set under the Gothenburg Protocol

Pollutant	EU-27 emissions 2021 (Gg)	EU-27 emission levels 2005 (Gg)	Reduction commitment from 2005 level (%)	Current difference (%)
NO_x	4,993	10,011	-40	-51
NMVOCs	6,078	8,811	-28	-31
SO_x	1,399	7,015	-59	-80
NH_3	3,336	3,799	-6	-12
$PM_{2.5}$	1,333	1,844	-22	-28

Notes: For Spain, data for emission comparisons exclude emissions from the Canary Islands, i.e. data comprise the EMEP domain only.

For Portugal's reduction commitments, emissions from the Azores and Madeira are excluded.

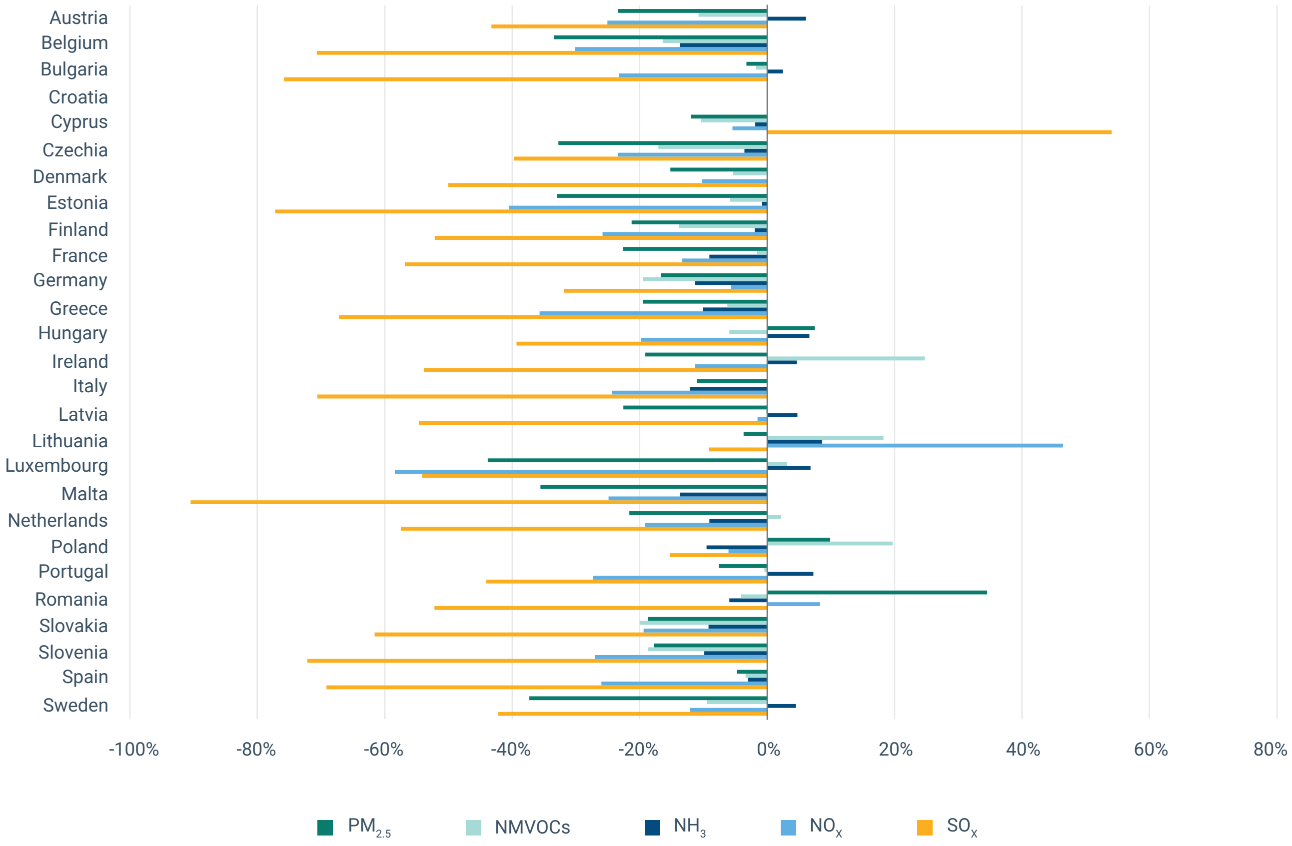
Under the Gothenburg Protocol, the EMEP Steering Body accepted applications from Belgium, Czechia, Denmark, Finland, France, Germany, Hungary, Luxembourg, the Netherlands and Spain for emission inventory adjustments in 2014, 2015, 2016, 2017, 2018, 2019, 2020 and 2021. This table takes these adjusted data into account.

Emission reduction commitments are also specified for individual EU-27 Member States.

([7]) Annex II of the amended Gothenburg Protocol shows the EU reduction commitment as the sum of the 27 countries who were Member States in 2012; the applicable reduction commitment for the EU is updated by technical correction when the membership of the EU changes (see EB Decision 2021/3 on the methodology for such technical corrections).

([8]) Austria, Italy and Poland have signed the Gothenburg Protocol but have not ratified it. For this reason, the targets are not binding for these countries.

Figure ES.6 **Distance to Gothenburg Protocol reduction commitment for the EU-27 and the single EU Member States in 2021**



Note: Croatia is not included due to missing submissions.

Actions and recommendations for improving the EU emission inventory

Although reporting has become more complete in recent years, several data gaps remain in the official data sets received from EU Member States. Thus, the completeness of submissions can be further improved, particularly for historical data for the period 1990-2000 and for certain pollutants such as HMs and POPs. To compile as complete an EU inventory as possible, missing emission data are gap filled as far as feasible and reasonable (for details see Section 1.4.5).

This report also includes several recommendations that may further improve the quality of the EU inventory in the future. EU Member States should submit complete inventories and use proper notation keys, for instance when no values are available. They should recalculate emission data for past years when new methods or new scientific knowledge become available. In this context, it is recommended that EU Member States review and apply the information included in the updated *EMEP/EEA air pollutant emission inventory guidebook — 2019* (inventory guidebook for short; EMEP/EEA, 2019) when compiling their emission inventory data sets.

EU Member States are encouraged to consider the findings of the annual quality checks performed by the EEA and its European Topic Centre on Human Health and the Environment (ETC HE) have been performing QA/QC procedures during the compilation of the EU inventory. Where necessary, EU Member States are invited to either resubmit inventory data (in the nomenclature for reporting 19 (NFR19) format for reporting of air pollutants) or update the following year's inventory to reflect new insights gained or errors identified. In 2023, several EU Member States were contacted by the EEA regarding potential errors identified during the QA/QC procedures carried out by the ETC HE.

1. Introduction

The European Commission provides this report and its accompanying data (on behalf of the EU[9]) as an official submission to the Convention on Long-range Transboundary Air Pollution (Air Convention) via the Convention secretariat at the United Nations Economic Commission for Europe (UNECE).

The report covers the following subjects: the formal institutional arrangements that underpin the EU's emission inventory, the inventory preparation process, methods and data sources, key category analyses (KCAs), information on quality assurance and quality control (QA/QC), general uncertainty evaluation, general assessment of completeness and information on underestimations (see this chapter); adjustments under the Gothenburg Protocol (Chapter 2); emission trends and the contribution of key categories to total emissions (Chapter 3); sectoral analysis and emission trends for key pollutants (Chapter 4); and information on recalculations and planned improvements (Chapter 5).

EU emission totals are estimated for the pollutants for which data should be reported under the Air Convention (see Appendix 2), i.e. emissions of:

- **regulated pollutants with a reduction obligation:**
  - nitrogen oxides (NO_X)
  - non-methane volatile organic compounds (NMVOCs)
  - sulphur oxides (SO_X)
  - ammonia (NH_3)
  - fine PM with a diameter of 2.5µm or less ($PM_{2.5}$)

- **other**
  - carbon monoxide (CO);

- **particulate matter (PM):**
  - PM with a diameter of 10µm or less (PM_{10})
  - total suspended particulates (TSPs)
  - black carbon (BC);

- **priority heavy metals (HMs):**
  - lead (Pb)
  - cadmium (Cd)
  - mercury (Hg);

- **additional HMs:**
  - arsenic (As)
  - chromium (Cr)
  - copper (Cu)
  - nickel (Ni)
  - selenium (Se)
  - zinc (Zn);

- **persistent organic pollutants (POPs):**
  - polychlorinated dibenzodioxins/polychlorinated dibenzofurans (PCDD/Fs)
  - polycyclic aromatic hydrocarbons (PAHs)
  - hexachlorobenzene (HCB)
  - polychlorinated biphenyls (PCBs);

---

(9) This report refers to the air pollutant emission totals of the EU-27.

- **additional reporting of PAHs:**
    - benzo(a)pyrene (B(a)P)
    - benzo(b)fluoranthene (B(b)F)
    - benzo(k)fluoranthene (B(k)F)
    - indeno(1,2,3-cd)pyrene (IP).

Emission estimates are not always available for all pollutants every year, because there are gaps in the data reported in 2023 by the EU Member States. A gap-filling process was developed in 2010 for compiling the EU inventory and was refined in 2011 and 2017 (see Section 1.4.5). Nevertheless, for certain pollutants (additional HMs, BC, individual PAHs), some EU Member States did not report data for any year, which made it impossible to apply such gap-filling techniques. Thus, for these pollutants, the EU total remains incomplete.

Several annexes accompany this inventory report:

- Annex A provides a copy of the EU's formal Air Convention data submission for the period 1990-2021 in the required UNECE format for the reporting of air pollutants (nomenclature for reporting 19 (NFR19)).

- Annex B provides the updated EU NO_X emission data for the period 1987-1989, as required by the 1988 NO_X protocol of the Air Convention (see Sofia Protocol in Table 1.1).

- Annex C provides results of the key category analyses (KCAs for the EU, showing the main emitting sectors for each pollutant.

- Annex D presents the EU's gap-filled inventory, colour-coded for the different data sources used and the various additional gap-filling methods applied.

- Annex E provides EU Member States' projections for NO_X, NMVOCs, SO_X, NH_3, $PM_{2.5}$ and BC emissions for 2020, 2025, 2030, 2040 and 2050.

- Annex F presents the EU's Air Convention data submission for the period 1990-2021 for the EU-11. Box ES.2 and Table A2.2 (in Appendix 2) provide information on the country groupings.

- Annex G gives an overview of the sources of data on emissions of the individual pollutants used when compiling the 2023 EU inventory.

- Annex H provides an overview of the completeness of the gap-filled inventory concerning the notation key 'NE' (not estimated).

1.1 Background

The EU ratified the UNECE Air Convention (UNECE, 1979) in 1982. Since 1984, eight protocols have come into force. Table 1.1 presents the ratification status of each protocol for the EU as a whole. The status differs across individual EU Member States.

Table 1.1 EU ratification status of the Air Convention and related protocols

Year	Air Convention and its protocols	Ratification status
1979	'Geneva Convention': Convention on Long-range Transboundary Air Pollution (UNECE, 1979)	Signed and ratified (approval)
1984	'Geneva Protocol': Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (UNECE, 1984)	Signed and ratified (approval)
1985	'Helsinki Protocol': Protocol on the Reduction of Sulphur Emissions or Their Transboundary Fluxes by at Least 30 Per Cent (UNECE, 1985)	Not signed
1988	'Sofia Protocol': Protocol Concerning the Control of Emissions of Nitrogen Oxides or Their Transboundary Fluxes (UNECE, 1988)	Ratified (accession)
1991	'Geneva Protocol': Protocol Concerning the Control of Emissions of Volatile Organic Compounds or Their Transboundary Fluxes (UNECE, 1991)	Signed
1994	'Oslo Protocol': Protocol on Further Reduction of Sulphur Emissions (UNECE, 1994)	Signed and ratified (approval)
1998	'Aarhus Protocol': Protocol on Persistent Organic Pollutants (UNECE, 1998a)	Signed and ratified (approval)
1998	'Aarhus Protocol': Protocol on Heavy Metals (UNECE, 1998b)	Signed and ratified (approval)
1999	'Gothenburg Protocol': Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (UNECE, 1999)	Ratified (accession)
2009	Amendments to the Aarhus POPs Protocol	Ratified (acceptance)
2012	Amendments to the Gothenburg Protocol (UNECE, 2012b)	Ratified (acceptance)
2012	Amendments to the Aarhus Heavy Metals Protocol	Ratified (acceptance)

Note: For NFR (nomenclature for reporting) codes, see Appendix 4.

Sources: UNECE (2014b, 2015, 2016, 2017, 2018, 2019a, 2020, 2021, 2022a).

On 4 May 2012, the Executive Body for the UNECE Air Convention adopted amendments to the Gothenburg Protocol. Now the protocol's text includes national emission reduction commitments for the major air pollutants NO_X, NMVOCs, SO_X NH_3 and $PM_{2.5}$ (and BC as a component of PM). Countries are to meet the reduction commitments in 2020 and beyond. For the EU, the emission reduction commitments relative to 2005 levels for 2020 and beyond are (UNECE, 2012b):

- 59% for sulphur dioxide (SO_2);
- 40% for NO_X (change from original Gothenburg Protocol annex II table following the change in EU membership after 2012);
- 6% for NH_3;
- 28% for NMVOCs;
- 22% for $PM_{2.5}$.

The EU ratified the amended Gothenburg Protocol on 30 August 2017.

The Executive Body of the Air Convention adopted revised *Guidelines for reporting emissions and projections data under the Convention on Long-range Transboundary Air Pollution* (reporting guidelines) at its 32nd session, in March 2014 (UNECE, 2022c). Parties were to apply the revised guidelines in 2015 and subsequent years. These guidelines were updated in December 2022 at the 42nd session of the Executive Body (UNECE, 2022b). A summary of the reporting requirements is presented in Appendix 2.

The deadline for individual Parties to submit data to the Air Convention is 15 February each year. There is a separate deadline of 15 March for submitting the accompanying inventory reports. The reporting guidelines specify separate reporting dates for the EU. They allow time to compile an aggregated inventory based on the individual submissions from EU Member States. The EU should submit EU inventory data to the Executive Secretary of UNECE by 30 April each year and the accompanying inventory report by 30 May. The reporting guidelines also request that Parties report emission inventory data using the new European Monitoring and Evaluation Programme (EMEP) NFR19 format.

In 2012, the Executive Body of the Air Convention decided that adjustments to emission reduction commitments, or to inventories for the purpose of comparing them with total national emissions, may be applied in certain circumstances if such a circumstance keeps a Party from meeting one of its reduction commitments (UNECE, 2012a; see also Chapter 2).

The EMEP Steering Body reviews any supporting documentation and assesses whether or not the adjustment is consistent with the circumstances and guidance for adjustments (UNECE, 2012c). It makes the review available to the Parties, which have the option of making a submission to the Implementation Committee under Decision 2006/2 (UNECE, 2006).

In 2014, the EMEP Steering Body accepted inventory adjustment applications for emissions from Denmark and Germany; in 2015, from Belgium, Denmark, Finland, France, Germany, Luxembourg and Spain; in 2016, from Germany and Luxembourg; in 2017, from Spain; in 2018, from Hungary, in 2019, from the Netherlands; in 2020, from Czechia; in 2021, from France; and in 2022, from Denmark, France and the Netherlands (UNECE, 2014b, 2015, 2016, 2017, 2018, 2019, 2020, 2021). More information and the adjusted emission data can be found in Chapter 2.

1.2 Institutional arrangements

1.2.1 EU Member States

EU Member States are responsible for selecting the activity data, emission factors and other parameters used for their national inventories. EU Member States should also follow the reporting guidelines (UNECE, 2022c) and apply the methodologies in the latest version of the EMEP/EEA inventory guidebook (EMEP/EEA, 2019).

EU Member States are also responsible for establishing QA/QC programmes for their inventories. Each inventory report should include a description of the QA/QC activities and recalculations.

EU Member States submit their national inventories and inventory reports by participating in Eionet (European Environment Information and Observation Network) (see Section 1.2.2). In addition, they take part in the annual review and commenting phase of the draft EU inventory report. EU Member States check their national data and information used in the inventory report and, if necessary, send updates. They also provide general comments on the inventory report.

1.2.2 The EEA, European Commission, Eionet and ETC HE

European Environment Agency
The EEA helps the European Commission's Directorate-General (DG) for Environment to compile the annual EU Air Convention inventory.

EEA activities include:

- overall coordination and management of the inventory compilation process;
- coordinating the activities of the EEA's European Topic Centre on Human Health and the Environment (ETC HE)([10]), which checks the data, compiles the inventory and writes the draft report;
- communication with the European Commission;
- communication with EU Member States;
- circulation of the draft EU emission inventory report;
- hosting the official inventory database and disseminating the data and inventory report online.

Since 2004, the EEA and EMEP have supported a separate annual quality review of emission data submitted by the countries. It provides findings each year to help the countries improve the quality of the emission data they report. Each year, EMEP publishes a joint report summarising the review's findings. Section 1.7 provides further details of the annual data review process.

European Commission
The European Commission formally submits the EU emission inventory data and this informative inventory report (IIR) to EMEP via the Executive Secretary of UNECE.

European Topic Centre on Human Health and the Environment

The main activities of the ETC HE([11]) regarding the EU's Air Convention emission inventory include:

- initial checks, tests and a centralised review of Member State submissions in cooperation with the EMEP Centre on Emission Inventories and Projections (CEIP) and compiling results from those checks (status reports, country synthesis and assessment reports, country review reports);
- consulting with EU Member States (via the EEA) to clarify issues with the data and other information provided;
- preparing the gap-filled EU emission inventory by 30 April, based on Member State submissions (which the European Commission subsequently submits to UNECE);
- preparing the updated EU emission inventory and inventory report by 30 May.

([10]) The current ETC HE started its operations on 1 January 2022. Until the end of 2021, the EEA cooperated with the European Topic Centre on Air Pollution, Transport, Noise and Industrial Pollution (ETC/ATNI).

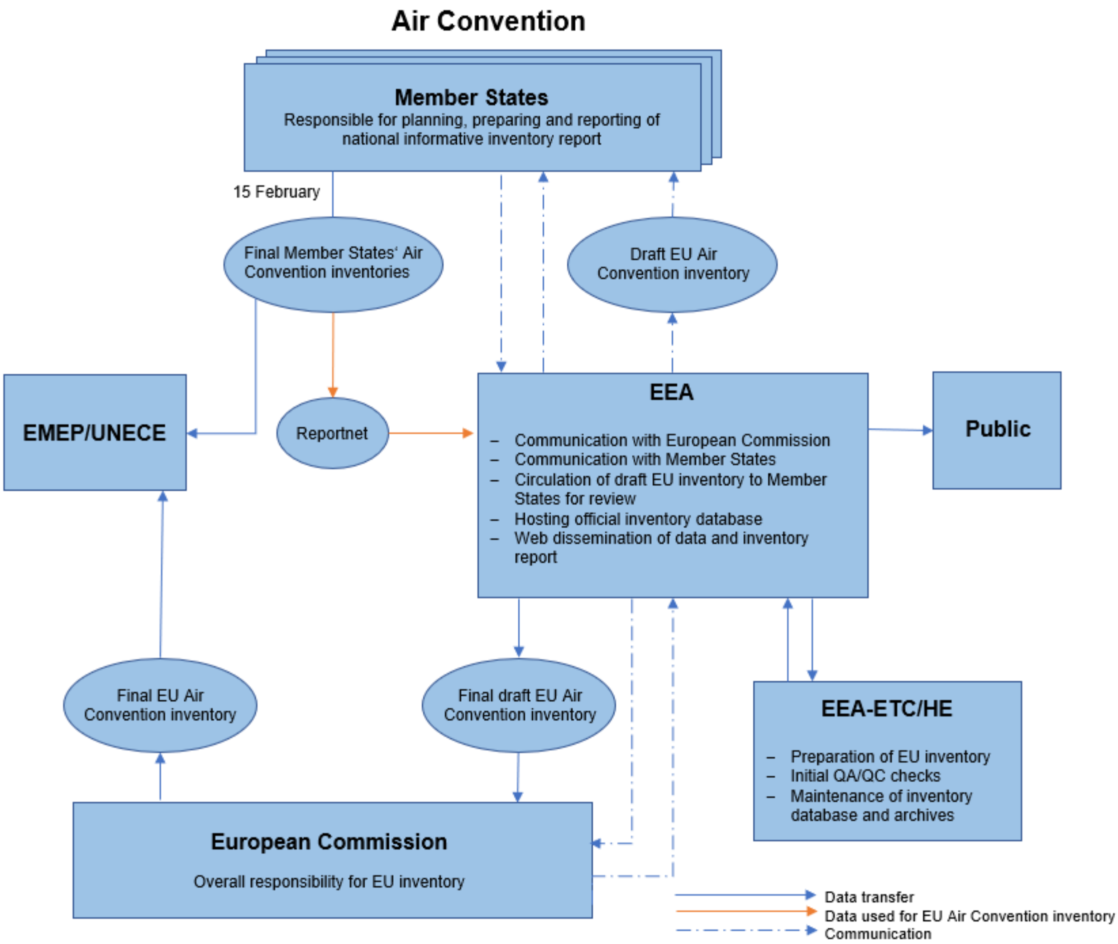
([11]) The current ETC HE was established in 2021 via a contract between the EEA and the lead organisation, the Stiftelsen Norsk Institutt for Luftforskning (Norwegian Institute for Air Research), and started its operations on 1 January 2022. It works with 10 organisations and institutions across nine European countries.

European Environment Information and Observation Network
Eionet facilitates the work of the EEA and the respective European topic centres (ETCs) (EU, 1999)([12]). It comprises the EEA (supported by its ETCs) and a supporting network of experts from national environment agencies and other bodies that deal with environmental information (Eionet, 2023a). EU Member States are requested to use the tools of the Central Data Repository (Eionet, 2023b) of Eionet's Reportnet to make their Air Convention submissions available to the EEA.

1.3 Inventory preparation process

The basis for reporting by individual EU Member States and the EU is the Air Convention (UNECE, 1979), its protocols (Table 1.1) and subsequent decisions taken by the Executive Body. The reporting guidelines describe the data that Parties should report under the Air Convention and its protocols. Under the agreement between Eionet countries and the EEA concerning priority data flows, EU Member States are requested to post a copy of their official submission to the Air Convention in the CDR by 15 February each year. The ETC HE subsequently collects the data from the CDR, performs a QA/QC procedure, compiles the gap-filled EU Air Convention emission inventory database and produces an EU Air Convention emission inventory and inventory report. The European Commission formally submits the EU's emission inventory data and IIR to EMEP through the Executive Secretary of UNECE. The inventory and accompanying documentation are then made publicly available through the EEA's website (see summary in Figure 1.1).

Figure 1.1 Data flow for compiling the EU Air Convention emission inventory



([12]) A brochure describing the structure, working methods, outputs and activities of Eionet is available (EEA, 2012).

1.4 Methods and data sources

1.4.1 Reporting obligations under the National Emission reduction Commitments Directive and the EU Greenhouse Gas Monitoring Mechanism Regulation

EU Member States report their emissions of NO_X, NMVOCs, SO_2, NH_3, CO, PM, BC, HMs and POPs under Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC (EU, 2016b). The EU 2016/2284 National Emission reduction Commitments (NEC) Directive, which entered into force on 31 December 2016, sets emission reduction commitments for five main air pollutants for the period 2020-2029 and from 2030 onwards. The reduction commitments agreed for 2030 onwards are more ambitious and are designed to reduce the health impacts of air pollution by half compared with 2005.

EU Member States also report emissions of NO_X, SO_2, NMVOCs and CO under EU Regulation No 525/2013, known as the EU Greenhouse Gas Monitoring Mechanism Regulation (MMR) (EU, 2013). EU Member States should also copy this information to the CDR (Eionet, 2023b). Table 1.2 provides an overview of the various reporting obligations for EU Member States.

Table 1.2 Overview of air emission reporting obligations in the EU, 2023

Legal obligation	Emissions to report	Annual reporting deadline for EU Member States	Annual reporting deadline for the EU([a])
Air Convention([b])	NO_X (as nitrogen dioxide — NO_2), NMVOCs, SO_X (as SO_2), NH_3, CO, HMs, POPs and PM	15 February 2023	30 April 2023
NEC Directive	NO_X (as NO_2), NMVOCs, SO_X (as SO_2), NH_3, CO, HMs, POPs and PM	15 February 2023	Not applicable
EU MMR/United Nations Framework Convention on Climate Change (UNFCCC)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride, NO_X, CO, NMVOCs and SO_2	15 January 2023 to the European Commission and 15 April 2023 to the UNFCCC	15 April 2023

Notes: ([a]) Over the years, the European Community and the EU have signed a number of protocols. The commitments include varying numbers of EU Member States. In addition to the EU-27 data, this report includes the 2021 sulphur emission (SO_X) data for the EU-11 (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain), in accordance with the EU's reporting obligations under the Air Convention's Protocol on Further Reduction of Sulphur Emissions (see Box ES.2 and Table A2.2 (in Appendix 2) for more information on EU country groupings).

([b]) Parties are formally required to report only on the substances and for the years set forth in protocols that they have ratified and that have entered into force.

Reporting obligations under the Air Convention and NEC Directive have been harmonised since the adoption of the updated reporting guidelines (UNECE, 2022c) and the adoption of the NEC Directive (EU) 2016/2284 (EU, 2016b). Minor differences still occur between reporting under the Air Convention and the NEC Directive:

- Reporting of emission data for B(a)P, B(b)F, B(k)F and IP is voluntary under the Air Convention but is obligatory under the NEC Directive.
- Under the Air Convention, Parties are invited to report their emissions for the EMEP domain. For Portugal, this means that emissions from the Azores and Madeira are included. This differs from reporting under the NEC Directive, for which the Azores and Madeira are excluded.
- Under the NEC Directive, some emissions are not counted for the purpose of compliance (see Directive 2016/2284/EU, Article 4(3)) but do need to be reported.
- While reporting of projections is required biennially under the NEC Directive, it is only obligatory every 4 years under the Air Convention.

The NEC Directive and Air Convention reporting obligations differ from the United Nations Framework Convention on Climate Change (UNFCCC) obligations by including domestic and international aviation and navigation in the reported national totals. Table 1.3 summarises the main differences between the reporting instruments, the overall impact of which is small for most EU Member States.

Table 1.3 Comparison of air pollutant reporting obligations: the Air Convention, NEC Directive and UNFCCC/MMR

Reporting item	NEC	Air Convention	UNFCCC/MMR
Domestic aviation (LTO)	Incl.	Incl.	Incl.
Domestic aviation (cruise)	Not incl.	Not incl.	Incl.
International aviation (LTO)	Incl.	Incl.	Not incl.
International aviation (cruise)	Not incl.	Not incl.	Not incl.
National navigation (domestic shipping)	Incl.	Incl.	Incl.
International inland shipping	Incl.	Incl.	Not incl.
International maritime navigation	Not incl.	Not incl.	Not incl.
Road transport (fuel sold)([a])	Incl.	Incl.	Incl.

Notes: International inland shipping refers to shipping activity in continental waters and international maritime navigation to shipping activity in marine waters. Air emissions resulting from inland shipping are included, as they are more relevant to air quality for the surrounding environment.

([a]) Parties may also report emission estimates based on fuel used as an additional 'memo item'. Austria, Belgium, Ireland, Lithuania, Luxembourg, the Netherlands and Switzerland may choose to use the national emission total calculated on the basis of fuel used in the relevant geographical area as a basis for compliance (UNECE, 2022c).

Incl., included in national totals; LTO, landing/take-off; Not incl., not included in national totals: memo item.

Under the Air Convention, the EU may deliver its emission and projections report by 30 April, its IIR by 30 May, and its gridded data and large point source (LPS) data by 15 June.

1.4.2 General methods

The EU Air Convention emission inventory is based on an aggregation of data reported by EU Member States. The methods that they use should follow those described in the inventory guidebook (EMEP/EEA, 2019). Overall, EU Member States do follow this recommendation, which ensures that they use the best methods available to estimate national emissions and that inventories are improved continuously. Moreover, the technical review procedures set up by the EMEP CEIP check and assess Parties' data submissions, as per the review guidelines. The aim is to improve the quality of emission data and associated information reported to the Air Convention.

The recommended structure for an IIR involves a general description of the methodologies and data sources used. This includes an overview of the emission factors used in the national inventory — country specific or default — given in the inventory guidebook (EMEP/EEA, 2019) and the specification of the sources of default emission factors and methods. It also provides a detailed description of activity data sources where data differ from national statistics. The following two sub-sections summarise the information that EU Member States provide in their IIRs. This should help readers to understand the basis of the EU inventory. For detailed descriptions of methodologies and data sources, see EU Member States' IIRs (see Appendix 5 for IIR references).

1.4.3 Data sources

The data source for the EU inventory is EU Member States' emission inventories. The IIRs should document detailed information on the data sources used by EU Member States. The level of detail varies widely across EU Member States, although the main data sources are official national statistics. Table 1.4 summarises data sources commonly used for the various sectors.

Table 1.4 Data sources commonly used for inventory sectors

Sector	Sources
Energy	Energy balances, EU Emissions Trading Scheme (ETS) data, large combustion plant data and LPS surveys
Transport	Energy balances, vehicle fleet statistics
Industrial processes and product use	National production statistics, trade statistics, data from plant operators (facility reports), reporting under the European Pollutant Release and Transfer Register (E-PRTR) and its predecessor, the European Pollutant Emission Register (EPER)
Agriculture	National agricultural statistics, specific studies
Waste	Landfill databases, national studies, national statistics, information from municipalities

Sources for emission factors vary according to the tier method used. One main source is the inventory guidebook (EMEP/EEA, 2019), but emission factors can also be country or even plant specific. It is impossible to survey the emission factors used by the EU Member States for all emission sources, as this information is not uniformly available: some countries report details of their methodologies, while others do not. Detailed information is available in EU Member States' IIRs (see Appendix 5).

1.4.4 Comparison of EU Member States' emissions calculated on the basis of fuel sold versus fuel consumed in road transport

In Article V/A, paragraph 22, the reporting guidelines (UNECE, 2022c) specify how to report emissions from transport:

> *For emissions from transport, all Parties should calculate emissions consistent with national energy balances reported to Eurostat or the International Energy Agency. Emissions from road vehicle transport should therefore be calculated on the basis of the fuel sold in the Party concerned. In addition, Parties may voluntarily calculate emissions from road vehicles based on fuel used or kilometres driven in the geographical area of the Party. The method for the estimate(s) should be clearly specified in the IIR.*

Paragraph 23 of the guidelines provides detailed information on the basis of compliance checking:

> *For Parties for which emission ceilings are derived from national energy projections based on the amount of fuel sold, compliance checking will be based on fuels sold in the geographical area of the Party. Other Parties within the EMEP region (i.e. Austria, Belgium, Ireland, Lithuania, Luxembourg, the Netherlands, Switzerland and the United Kingdom of Great Britain and Northern Ireland) may choose to use the national emission total calculated on the basis of fuels used in the geographic area of the Party as a basis for compliance with their respective emission ceilings (UNECE, 2022c).*

Parties can estimate transport emissions using the amount of fuel sold within the country or the amount of fuel consumed. When fuel purchased within a country is used outside that country (and vice versa), these estimates can differ significantly. The EU inventory compiled in 2023 estimates emissions from road transport based on the fuel sold for all EU Member States.

1.4.5 Data gaps and gap filling

Ideally, there should be no need to fill gaps in the inventory data reported, as it is the responsibility of EU Member States to submit full and accurate inventory data sets. However, EU Member States' submissions include a few data gaps for particular pollutants or years in the time series. Frequently, whole national inventories, emissions of some pollutants or sectoral emission data are missing.

The EMEP reporting guidelines (UNECE, 2022c) require that submitted emission inventories are complete. The 2023 gap-filling procedure was identical to that in 2022 and follows a methodology paper by the EEA and the European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM) (EEA, 2009) and some changes agreed at the meeting of the Task Force on Emission Inventories and Projections (TFEIP) in 2016([13]). This procedure is also consistent with the techniques used to fill emission data gaps proposed by the inventory guidebook (EMEP/EEA, 2019). It applies a stepwise approach using emission data from other reporting obligations to fill gaps in the national data sets, followed by further gap-filling procedures such as interpolation or extrapolation and manual changes. For further information on the gap-filling procedure, please see Box 1.1.

Box 1.1 Unified Air Convention gap filling for EU and EMEP inventories (ETC/ACM, 2015)

A stepwise approach was used to fill gaps in the national data sets:

1. Emission trends for all pollutants have been compiled from 1990 onwards, using the Convention on Long-range Transboundary Air Pollution (Air Convention) emission inventories provided by the EU Member States to the EEA in 2023.
2. Air Convention data submitted to the European Monitoring and Evaluation Programme (EMEP) Centre on Emission Inventories and Projections (CEIP) in 2023 are the next source used to fill remaining gaps. All reported data (i.e. values and notation keys) are used. In fact, there should be no difference between the EU Member States' Air Convention emission inventories provided to the EEA and the data submitted to the EMEP CEIP.
3. For those EU Member States not reporting complete data, emission data officially reported in the current reporting year by EU Member States under the EU Greenhouse Gas Monitoring Mechanism Regulation (MMR) are used to fill gaps. In this step, notation keys are not used.
4. Next, emission data reported officially by EU Member States under the 2016 National Emission reduction Commitments (NEC) Directive in the current reporting year are used to fill gaps. Notation keys are not used in this step.
5. In a further step, notation keys reported in the current reporting year by EU Member States under the MMR are used to fill any remaining gaps.
6. Subsequently, notation keys reported in the current reporting year by EU Member States under the NEC Directive are used to fill any remaining gaps.
7. Next, Member State Air Convention emission inventories provided to the EEA in previous years are used to fill any gaps still remaining (values and notation keys).

([13]) TFEIP/Eionet meeting and workshop, 16-18 May 2016, in Zagreb.

8. Older Air Convention data submitted to the EMEP CEIP are the next source of official information used to fill gaps (values and notation keys).

9. The gap filling continues with emission data reported in previous years under the MMR (values and notation keys).

10. For all remaining cases of missing data, further gap-filling procedures are applied:

    a. Linear interpolation is performed if one or several years are missing in the middle of a time series.

    b. Linear extrapolation is performed if one or several years are missing, either at the beginning or at the end of a time series, and if at least 5 consecutive years showing a clear trend ($r^2 \geq 0.6$) are available. Extrapolation 'backwards' is never allowed to result in negative values.

    c. If fewer than 5 consecutive years are available as a basis for extrapolation, or if years do not show a clear trend (as is the case when $r^2 < 0.6$), the value of the previous or next year is used to fill the gaps.

    d. If the notation key 'NA' (not applicable) or 'NO' (not occurring) is used as a basis for gap filling, it is treated as '0' and is not gap filled.

    e. When both national total and sectoral data are unavailable, sectors are first gap filled and then summed to determine the total.

    f. When the national total is available but there are no sectoral data, the sectoral split of the previous or following year is used to fill the gaps.

11. After this automated gap-filling procedure, some manual corrections are made to the gap-filled data in all cases in which total suspended particulate (TSP) emissions are lower than particulate matter (PM) with a diameter of 10µm or less (PM_{10}) emissions, PM_{10} emissions are lower than PM with a diameter of 2.5µm or less ($PM_{2.5}$) emissions, or $PM_{2.5}$ emissions are lower than black carbon (BC) emissions. In these cases, PM_{10} data are equated with TSP data, $PM_{2.5}$ data with PM_{10} data, and BC data with $PM_{2.5}$ data.

However, gap filling is applied only where national total and sectoral data are unavailable or where a national total was available but there were no sectoral data. In the former instance, sectors were first gap filled and then summed to determine the total. In the latter instance, the sectoral split of the previous or following year was used to fill the gaps. If a national total was available, but the sectoral data were incomplete, no gap filling was carried out. For BC and additional HMs, some EU Member States lacked data for all years, making gap filling impossible. In such instances, the EU emission totals for these pollutants are considered incomplete (i.e. they are underestimated). Furthermore, inventories cannot be considered complete if the notation keys 'NE' and in some cases 'NR' (not relevant), or the value 0, are reported or are used for gap filling. For further information on the effect of gap filling on the EU inventory, see Section 1.9 and Figure 1.5 and Figure 1.6.

Annex G shows how the various officially reported data sets were used to supplement the Air Convention data submissions for those EU Member States for which gap filling was required. Annex D offers a more detailed overview, showing each Member State for which data were gap filled and how this was performed. The trend tables in Chapter 3 (Table 3.3-Table 3.28) also provide an initial overview, indicating which data have been derived by gap filling.

1.5 Reporting

1.5.1 Emission reporting

The deadline for EU Member States to report by was 15 February 2023. In the 2023 reporting cycle, 26 EU Member States submitted their inventories and time series on time. Croatia did not submit their inventory (see Appendix 3, Figure A3.1). All 26 Member States provided a complete time series in 2023. , using the new NFR19 templates. Appendix 3 presents detailed information on EU Member States' submissions.

1.5.2 Projection data

In 2023, reporting of projection data was mandatory, and the deadline for EU Member States to report by was 15 March 2023. Twenty-four EU Member States have submitted information on their projections so far, fifteen of them before the deadline. The data submitted are available in Annex E of this report.

1.5.3 Gridded data

In accordance with the revised reporting guidelines, Parties within the geographical scope of EMEP should report gridded data at a resolution of 0.1°×0.1° longitude-latitude every 4 years, starting in 2017. Since gridded data for the EU were last submitted in 2021 (EEA, 2022d), there is no obligation to report gridded data this year. Thus far, only Spain has provided gridded data on a voluntary basis.

1.5.4 Large point sources

Parties within the geographical scope of EMEP are also required to provide data on LPSs every 4 years, commencing in 2017. LPS data for the EU were last submitted in 2021 (EEA, 2022d), and therefore there is no obligation to report LPS data this year. Only Spain has provided LPS data in 2023.

1.5.6 Reporting on condensable components from $PM_{2.5}$ and PM_{10}

PM consists of a filterable fraction and a condensable fraction, which reacts on cooling and dilution, shortly after release, to form solid or liquid PM. The reporting of condensable components is not mandatory, and in recent years there has been no clarity about whether PM emission reporting includes or excludes the condensable component. However, in 2019, a new reporting table within Annex II to the reporting guidelines (EMEP CEIP, 2023a), Table A6.1, 'Inclusion/exclusion of the condensable component from PM_{10} and $PM_{2.5}$ emission factors', was established. In 2023, 16 EU Member States provided information using this table. The Netherlands has not provided information using this table but has reported information on condensable components in its IIR. The level of information provided by the Member States is rather heterogeneous and for many categories no information is available at all.

1.6 Key category analyses

A key category is an emission source category that has a significant influence on an inventory. It may affect the absolute level of emissions, the trend in emissions or both. This report classifies categories jointly responsible for 80% of the national total emissions of a given pollutant as key categories (see EMEP/EEA, 2019).

An analysis of the levels of the 2021 emissions of each pollutant (following any necessary gap filling) determined EU key categories. When a Member State used the notation 'IE' (included elsewhere) for a particular source/pollutant combination, the KCA is likely to have underestimated the category concerned and overestimated the one in which emissions were reported instead.

Chapter 3 provides a summary of the top five EU key categories in 2021, for NO_X, NMVOCs, SO_X, NH_3, $PM_{2.5}$, PM_{10}, CO, HMs (Pb, Cd and Hg) and POPs (PCDD/Fs, total PAHs, HCB and PCBs). A complete list of all EU key categories for the emissions of these pollutants is also given in Figure 1.2. Additional HMs, TSPs, BC and the remaining POPs are not considered here.

A total of 57 different emission inventory source categories were identified as being key categories for at least one pollutant. '1A4bi — Residential: Stationary' was identified as being a key category for 14 pollutants assessed. Categories '1A1a — Public electricity and heat production' and '2C1 — Iron and steel production' were identified as being important emission sources for 10 and 9 pollutants, respectively. Categories '1A3bi — Road transport: Passenger cars' and '5C2 — Waste: Open burning of waste' were identified as being key categories for seven and six pollutants, respectively.

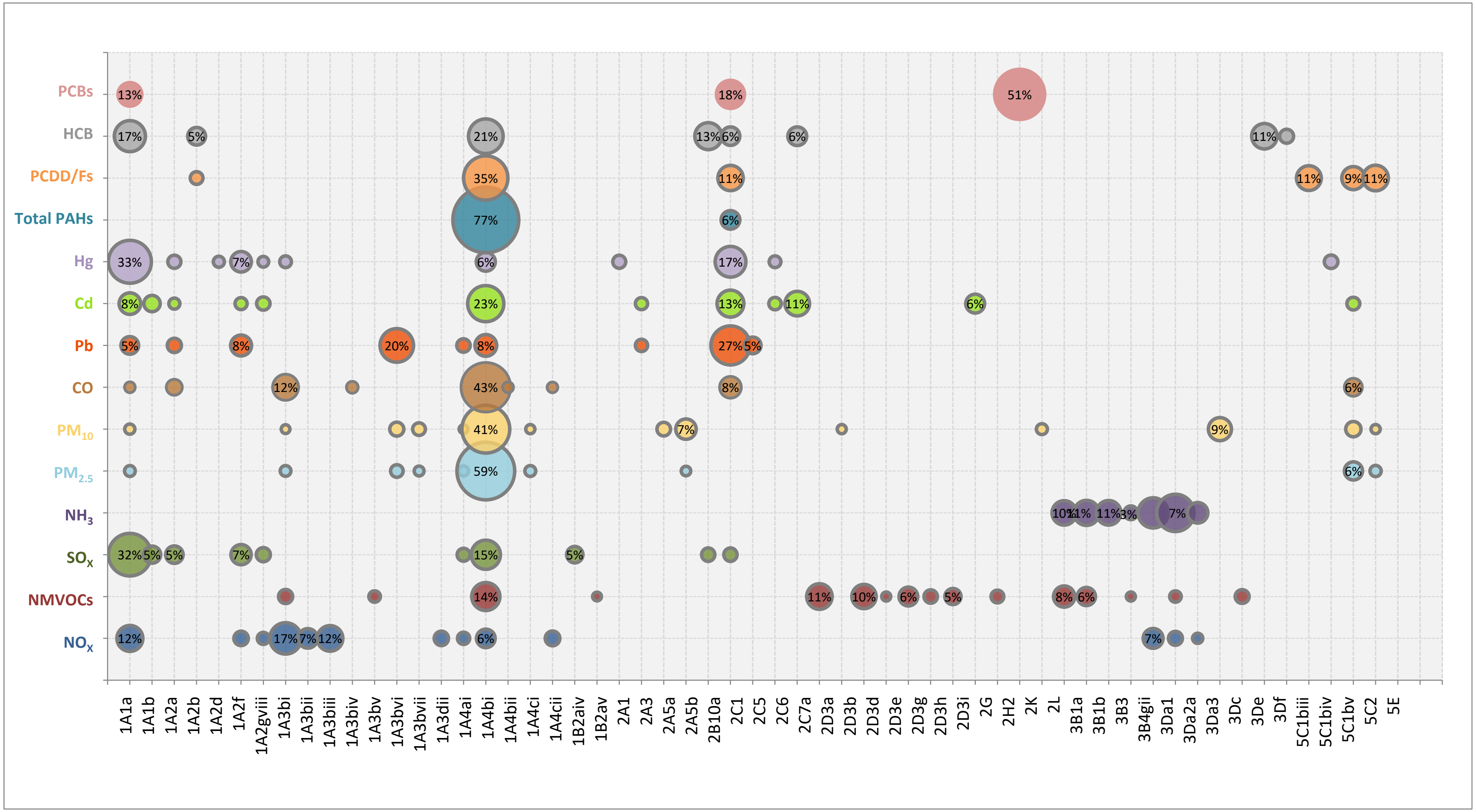
For NO_X and CO, 13 and 9 key categories were identified, respectively; as expected for both pollutants, the key categories with a large share of total emissions reported mainly involve fuel combustion. Nine key categories were identified for SO_X (mainly energy-related sectors) and six were identified for NH_3 (all from the agriculture sector). PM_{10}, $PM_{2.5}$ and NMVOC emission sources are more diverse and so larger numbers of source categories make up the key category threshold of 80% of total emissions. For the PM pollutants, key categories comprise all sectors and '1A4bi — Residential: Stationary' is an important key source for all of them. A key aspect for NMVOCs was high activity levels associated with the industrial processes and product use sector.

For the HMs, 12 key categories were identified for Cd, 10 for Pb and 13 for Hg. Emissions from these key categories were mostly related to the energy sectors and industrial processes and product use, resulting particularly from processes associated with metal production.

For the POPs, source categories from all sectors except 'Non-road transport' were identified as key categories. Overall, metal production and 'Residential: Stationary' were quite important key sources of POP emissions.

Several factors may influence the determination of key categories at the EU level. The notation key 'IE' (see Appendix 1) means that a Member State can include emission estimates from one NFR sector in those of a different sector. In addition, EU Member States have different ways of allocating emissions to the sub-sector 'other', which might lead to inconsistencies. Given such issues, the EU KCA may not always accurately reflect the share of all main emission sources. It is also crucial to note that the results of a similar analysis of individual EU Member States will differ from the key sources determined for the EU.

Figure 1.2 EU KCA results for 2021



Note: Bubble size indicates the share of the respective category to the national total of the particular air pollutant.

All values >5% are indicated. For NFR codes, see the list of source sector abbreviations in Appendix 4.

1.7 Quality assurance, quality control and verification methods

EU Member States are encouraged to use appropriate QA/QC procedures to ensure data quality and to verify and validate their emission data. These procedures should be consistent with those described in the inventory guidebook (EMEP/EEA, 2019).

The main activities improving the quality of the EU inventory, which is based on quality-assured data officially reported by the EU Member States, are the checks that the EEA's ETC HE performs on the status of each Member State's submission. Because the emission inventories reported under Air Convention and the NEC Directive are almost the same, checks are compared with those run by the EEA under the NEC Directive.

In addition, the ETC HE checks the internal consistency of EU Member States' data tables before compiling the EU tables. The ETC checks Member State data at national total and sectoral levels, and when it finds outliers it identifies the categories responsible. When the ETC HE does not find any explanation for a notable trend in a country's IIR, the EEA contacts the relevant Member State. The checks focus on data that significantly affect EU trends. An overview of the checks performed is given in Table 1.5 and an overview of the findings is given in Table 1.6.

Table 1.5 Overview of quality checks carried out during the preparation of the EU Air Convention inventory and report

Check								First checks	Sub-sequ-ent checks (after gap-filling)	Checks within the draft report	Member States will be informed on the finding	changes/ corrections
	Completeness	Consistency	Comparability	Accuracy	Transparency	level	years					
Reporting overview	✓		✓		✓	Submissions	1990-2021	×			if submission is missing or in wrong format	gap-filling of missing data as far as possible
Adjustment overview	✓		✓		✓	Submissions	2010-2021	×			if a document is missing or in wrong format	
Completeness	✓				✓	Submissions	1990-2021	×			yes	only in case of resubmissions of the Member State
Time series checks	✓	✓				National Totals, Sectors	1990-2021	×			yes	only in case of resubmissions of the Member State
NFR template line 144 check			✓		✓	National Totals	1990-2021	×			yes	only in case of resubmissions of the Member State
Total PAHs = Sum of PAHs				✓		National Totals	1990-2021	×			yes	only in case of resubmissions of the Member State
TSP-PM_{10} ratio, PM_{10}-$PM_{2.5}$ ratio checks				✓		National Totals	1990-2021	×			yes	only in case of resubmissions of the Member State
TSP ≥ PM_{10}, PM_{10} ≥ $PM_{2.5}$, $PM_{2.5}$ ≥ BC checks				✓		National Totals, Categories	1990-2021	×			yes	only in case of resubmissions of the Member State
National Total = Sum of Sectors	✓			✓		National Totals, Sum of Sectors	1990-2021		×		if difference is more than 5%	only in case of resubmissions of the Member State
'NE' analysis	✓					National Totals, Categories	2021		×	×	within the review of the draft version of the report	only in case of resubmissions of the Member State
'NA' and 'NO' checks				✓	✓	National Totals, Categories	2021		×		yes	only in case of resubmissions of the Member State
Recalculations		✓				National Totals	1990-2020			×	within the review of the draft version of the report	no
Effect of gap-filling	✓				✓	Whole EU inventory	1990, 2021			×	within the review of the draft version of the report	no
Completeness of the EU inventory	✓				✓	Whole EU inventory	1990, 2021			×	within the review of the draft version of the report	no

Table 1.6 Findings of the quality checks carried out during preparation of the EU Air Convention inventory and report in 2023

Test/check	Findings	Number of EU Member States concerned
Completeness	0	0
Time series checks	15	10
NFR template line 152 check	1	1
Total PAHs=sum of PAHs	15	15
TSP to PM_{10} ratio, PM_{10} to $PM_{2.5}$ ratio checks	4	2
TSP≥PM_{10}, PM_{10}≥$PM_{2.5}$, $PM_{2.5}$≥BC checks	27	12
National total=sum of sectors[a]	4	3
'NE' analysis	647	27
'NA' and 'NO' checks	139	18

Notes: ([a]) The check was performed on the gap-filled EU inventory.
NA, not applicable; NO, not occurring.

EU Member States also provide external checks through an Eionet review before the EU submits the final version of the EU inventory to the Air Convention Secretariat. In addition, an important element in improving the quality of national and EU Air Convention inventories is the annual meeting of the TFEIP. This expert meeting discusses quality issues concerning all Air Convention Parties emission reporting (including EU Member states) and was held on 18 and 19 April 2023 (TFEIP, 2023).

The agreed gap-filling procedure is one of the instruments used to ensure and improve the quality of the EU inventory. It analyses and, where possible, fills gaps in reporting of sectoral emissions and total emissions for any year. This improves the key features of completeness, comparability and consistency over the years and motivates EU Member States to report their data in the following reporting cycle (further details on gap filling are available in Section 1.4.5).

All inventory documents (submissions, inventory master files, inventory reports, status reports and related correspondence) are archived electronically on the EEA ETC HE forum data portal. Revisions of data sets are recorded.

The EMEP CEIP performs more detailed QA activities in an annual review process (EMEP CEIP, 2023b). It reviews Member State Air Convention emission inventories at the same time as the European Commission, assisted by the EEA, and reviews those reported under the NEC Directive (EU, 2016b). The EMEP CEIP technical review of inventories is carried out in three stages. Stages 1 and 2 include checks on timeliness, formats, consistency, accuracy, completeness and comparability of existing Member State inventory submissions. Test results, provided to EU Member States or to the EU as a whole, are used to improve the quality of the national emission inventories. Each year, the EMEP review report publishes summary results of the review (stages 1 and 2)([14]).

Stage 3 is a technical in-depth review of selected countries. It checks if submitted emission inventories are complete, consistent over time, properly documented and accurate. The annual in-depth review aims to be consistent across the Parties. The process should ensure that the Parties follow the same approach each year. The CEIP selects the countries in cooperation with the EEA and EMEP. In 2022, the CEIP reviewed all EU Member States with a focus on the condensable component of PM emissions. The results are included in individual country-specific reports (EMEP CEIP, 2023c). In 2023, the CEIP plans to review all EU Member States with a focus on the agriculture sector.

([14]) EMEP publishes a summary of the results of the stages 1 and 2 reviews performed in 2023 (EMEP, forthcoming).

1.8 General uncertainty evaluation

To quantify uncertainty in the EU Air Convention emission inventory, EU Member States first need to provide detailed information on emission uncertainties. Out of 25 EU Member States([15]), 19 (Austria, Belgium, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Latvia, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden) provided detailed tables quantifying uncertainty in their 2021 emission inventories for at least the main pollutants and PM emissions. The pollutants that they consider and the assumptions behind the uncertainty analysis vary across EU Member States. As not all countries provided an uncertainty estimate, the overall uncertainty of the EU Air Convention inventory cannot be estimated.

1.9 Completeness and underestimations

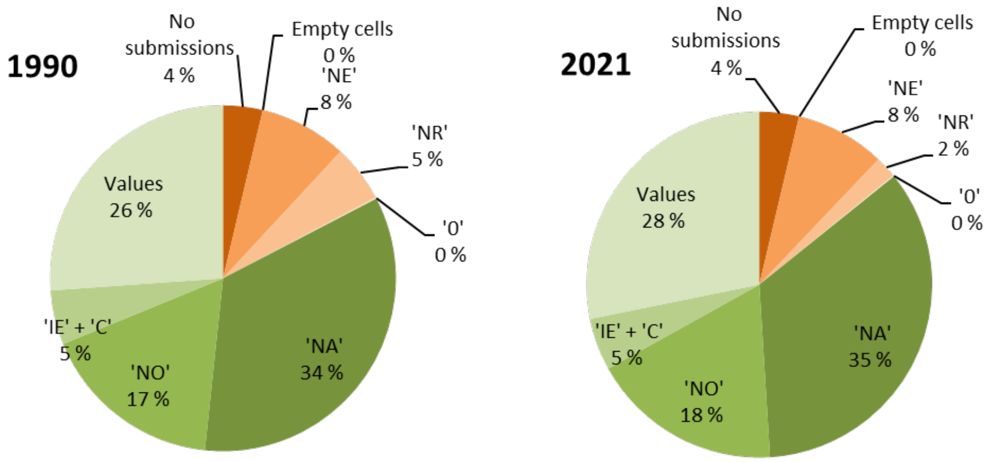
In this context, completeness means that reports include estimates for all pollutants, all relevant source categories, all years and all territorial areas. For substances for which there are existing reporting obligations under the Convention and the protocols as further specified by Executive Body Decision 2013/4 (please see Appendix 3), all Member States except Croatia provided a complete time series. For substances and data for which reporting is encouraged, Austria and Luxembourg submitted no data for additional HMs. Finland did not report national totals for the additional HM Se; however, it provided most of the sectoral data. Poland did not provide data for Se. Austria and Luxembourg did not report data for BC. All EU Member States except Croatia reported activity data([16]), and all countries reported activity data for the complete time series (1990-2021). The stage 1 review provides detailed results for the completeness of Member State submissions (EMEP CEIP, 2023d).

Figure 1.3 shows a simple compilation indicating the completeness of Member State reporting for the inventory years 1990 and 2021. It uses the NFR templates that were submitted originally, i.e. before gap filling. It gives the percentages of each notation key or values that the reports present for source categories. The data are for all EU Member States and all pollutants (excluding national totals). The figures show that more data are available for 2021 than for 1990. The notation key 'NA' (not applicable) appears often because an air pollutant is relevant only to specific emission sources (e.g. NH_3 for agriculture). This makes it necessary to use 'NA' for other sources. The use of the notation key 'NE', the reporting of empty cells, '0', in some circumstances the reporting of the notation key 'NR'([17]), 'No submissions' and 'Empty cells' count as incomplete reporting. EU Member States reported 10% of the 2021 data entries incompletely, while for 1990 they reported 13% of the data incompletely.

The EMEP reporting guidelines (UNECE, 2022c) require Parties to report data at least for the base year of the relevant protocol, and from the year it entered into force and up to the latest year (2 years before the present) (see Appendix 2, Table A2.1). Therefore, ideally, there should be no difference between the availability of data submissions for 1990 and for 2021.

([15]) Croatia has not submitted data by the data cut-off date of this report, and hence the data for this Member State are entirely gap filled.
([16]) Activity data should be reported, together with emissions, from 2009 onwards (UNECE, 2009).
([17]) According to the reporting guidelines (UNECE, 2022c), emission inventory reporting should cover all years from 1990 onwards if data are available. However, 'NR' has been added to ease reporting where the different protocols do not strictly require details of emissions. Only in these circumstances is 'NR' correct and appropriate.

Figure 1.3 **Completeness of reporting of NFR templates submitted by EU Member States (all data entries for all pollutants, excluding national totals)**



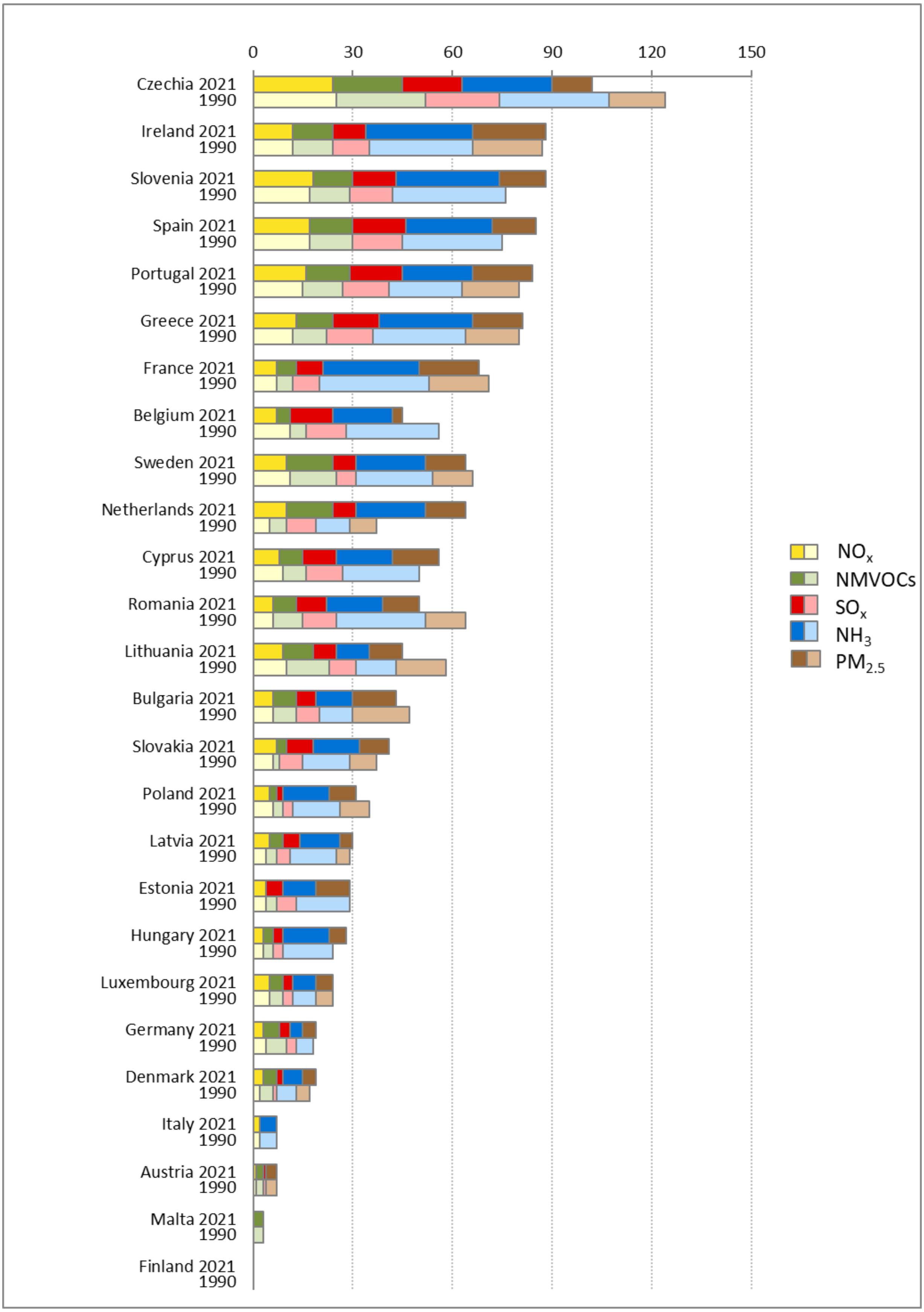
Notes: Appendix 1 provides further explanations of notation keys.
C, confidential; NO, not occurring.

There are many instances in which some countries report emissions for a particular NFR category and pollutant while others use the notation keys ‘NA’ or ‘NO’. Annex H shows, for each Member State for all categories, where data were reported, although 80% or more of the other countries reported ‘NA’ or ‘NO’ (not occurring) for these categories.

The official reporting guidelines of the Air Convention (UNECE, 2022c) allow countries to report emissions as ‘NE’ for some sectors. This is carried out when they know that emissions occur but have not estimated or reported them. Countries should report in their IIR why they have not estimated emissions.

Certain EU Member States use the notation key NE for many source categories (see Figure 1.4). For example, in 1990, Slovenia reported 34 source categories of NH_3 as ‘NE’. Overall, in most cases, the use of ‘NE’ in reporting in 2021 is quite similar to its use in 1990. Most uses (across all pollutants and EU Member States) are in the categories ‘1A3bvii — Road transport: Automobile road abrasion’, ‘5E — Other waste’, ‘2D3g — Chemical products’, ‘1A3ai(i) — International aviation LTO (civil)’, ‘1A3aii(i) — Domestic aviation LTO (civil)’ and ‘5B2 — Biological treatment of waste’. Within these categories, more than 25% of the entries mention ‘NE’.

Figure 1.4 **Number of 'NE' source categories for 2021 and 1990**



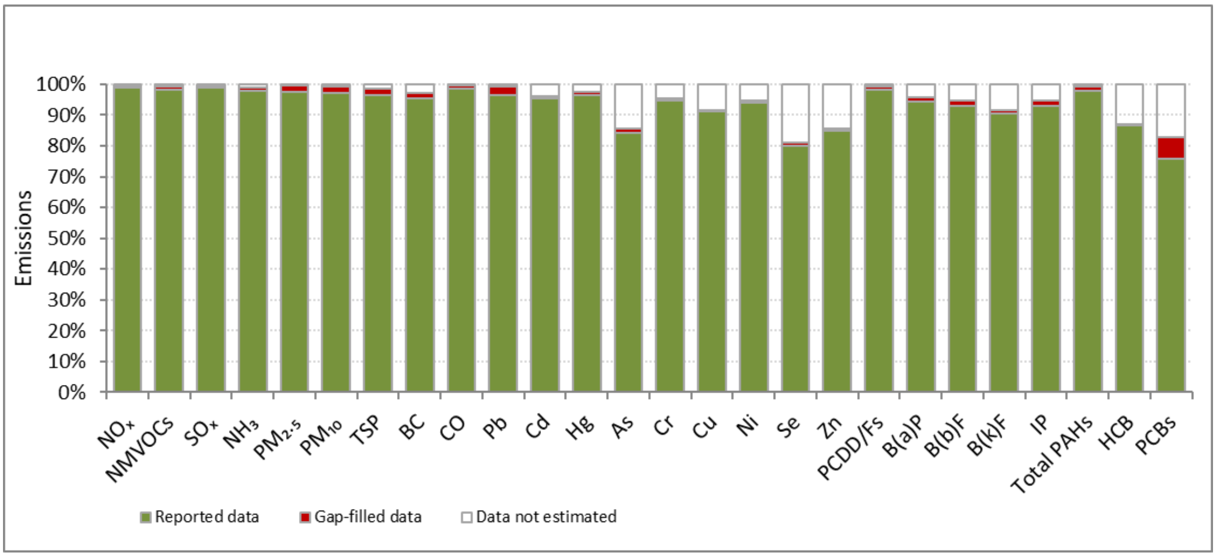
Notes: The Air Convention formally requests Parties to report emissions of PM for 2000 and thereafter.

Therefore, 'NE' reporting for $PM_{2.5}$ in 1990 might be high for several countries.

Figure 1.5 and Figure 1.6 show the proportions of gap-filled data and the estimated underestimation of the EU inventory for 1990 (2000 for PMs and BC) and 2021. The calculated underestimation comprises missing data (e.g. if emission data of a pollutant were not estimated by a Member State and no data were available for gap filling) and the use of the notation keys 'NE' and 'NO' and zero values. To calculate the underestimation, the specific share of total emissions for each Member State was first assessed. The share was calculated as the mean value of the respective EU Member State's share of those pollutants where a national total (gap filled or reported) from all EU Member States was available. In the gap-filled inventory, whenever the notation key 'NE' or 'NR' was used, or zero data were reported within a sector, this EU Member State's share was used to calculate the missing emissions within the respective sector. The sum of the missing emissions from all sectors and EU Member States was then calculated as the percentage value of the total emissions of a pollutant.

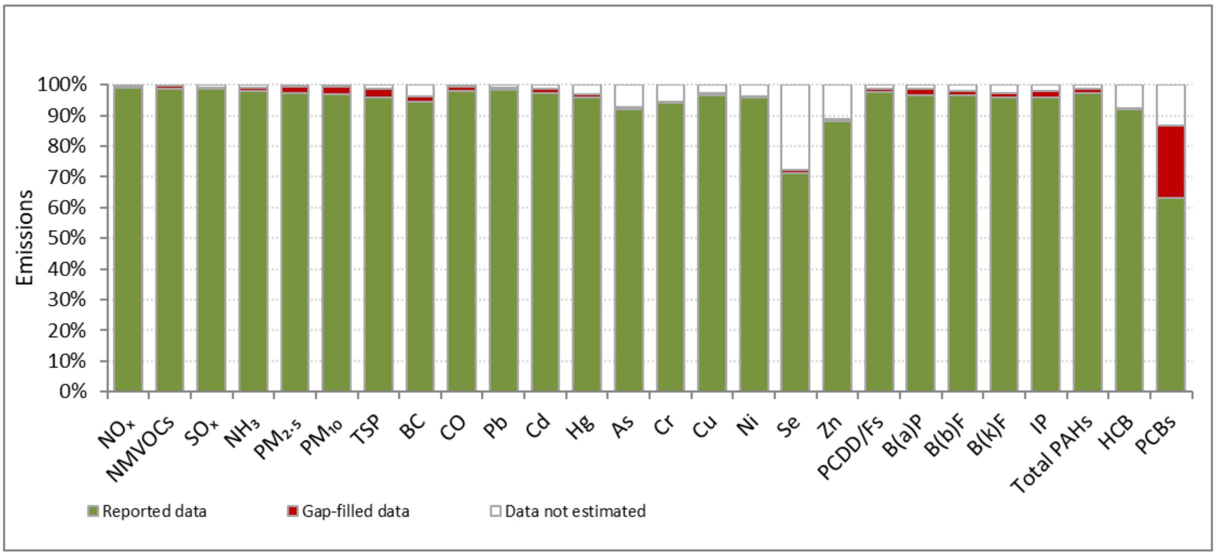
This year gap-filled data had an impact on the EU totals, as one country, namely Croatia, had to be gap filled.

Figure 1.5 Completeness and effect of gap filling on EU emission data for 1990



Note: For $PM_{2.5}$, PM_{10}, TSP and BC, data for the year 2000 are shown.

Figure 1.6 Completeness and effect of gap filling on EU emission data for 2021



2. Adjustments made under the Gothenburg Protocol

In 2012, the Executive Body of the Convention on Long-range Transboundary Air Pollution (Air Convention) decided that adjustments to emission reduction commitments or inventories may be made in some circumstances (UNECE, 2012a). The European Monitoring and Evaluation Programme (EMEP) Centre on Emission Inventories and Projections (CEIP) leads the adjustment procedure, coordinates the review of any supporting documentation and assesses whether or not the adjustment is consistent with the particular circumstances and the guidance for adjustments (UNECE, 2012c). It makes the review available to the Parties, which then have the option of making a submission to the Implementation Committee under Decision 2006/2 (UNECE, 2006).

These circumstances are as follows:

- Emission source categories are identified that were not accounted for at the time the emission reduction commitments were made.
- Emission factors used to determine emission levels for particular source categories have changed since the emission reduction commitments were made.
- The ways of determining emissions from specific source categories have changed significantly between the time when emission reduction commitments were made and the year that they are to be attained.

Table 2.1 lists inventory adjustment applications accepted by the EMEP Steering Body in the years

Table 2.1 Accepted inventory adjustment applications

Year of acceptance	Member State	Pollutant	NFR19 code	Years
2014	Denmark	NH_3	3Da1, 3De	2010-2012
2014	Germany	NO_X	1A3b	2010-2012
2014	Germany	NO_X	3B, 3D	2005-2012
2015	Belgium	NO_X	1A3bi-iv, 3B, 3Da1, 3Da2a	2010-2013
2015	Belgium	NMVOCs	3B, 3De	2010-2013
2015	Denmark	NMVOCs	3B	2010-2013
2015	Finland	NH_3	1A2gviii, 1A4ai, 1A4bi, 1A4ci, 1A3bi-iv	2010-2013
2015	France	NO_X	1A3bi-iv	2010-2013
2015	Germany	NMVOCs	3B, 3De	2010-2013
2015	Luxembourg	NO_X	1A3bi-iv	2010-2013
2015	Spain	NO_X	1A3bi, 1A3biii	2010-2012
2016	Germany	NO_X	3Da2c, 3I	2010-2014
2016	Germany	NH_3	3Da2c, 3I	2010-2014
2016	Luxembourg	NO_X	3B, 3De	2010-2014
2016	Luxembourg	NMVOCs	3B, 3De	2010-2014

Year of acceptance	Member State	Pollutant	NFR19 code	Years
2017	Spain	NO_X	3B	2010-2015
2018	Hungary	NMVOCs	3B, 3De	2010-2016
2019	Netherlands	NMVOCs	3B1a, 3B4h, 3B4d, 3B4e, 3B4giii, 3B4giv, 3B2, 3B4h, 3B4f, 3B1b, 3Da2a, 3Dc, 3B3, 3B4gii, 3B4gi, 3De, 3Da3	2010-2017
2019	Netherlands	NH_3	3Da4, 3De, 3B3	2014-2017
2020	Czechia	NMVOCs	3B	2010-2018
2021	France	NO_X	3B, 3D	2010-2018
2021	France	NMVOCs	3B, 3D	2010-2018
2022	Denmark	NMVOCs	3B1a	2005, 2020
2022	France	NMVOCs	3B, 3D	2005, 2020
2022	Netherlands	NMVOCs	3B1a	2005, 2020

Note: For nomenclature for reporting (NFR) codes, see the list of source sector abbreviations in Appendix 4.
NH_3, ammonia; NMVOCs, non-methane volatile organic compounds; NO_X, nitrogen oxides.

Sources: UNECE (2014b, 2015, 2016, 2017, 2018, 2019a, 2020, 2021, 2022a).

2014-2022.

If a Party is planning to adjust its inventory for the purpose of comparing total national emissions with emission reduction commitments, it indicates in its notification to the Air Convention via the United Nations Economic Commission for Europe (UNECE) Secretariat and the CEIP which categories and pollutants are affected. It uses Annex II to the reporting guidelines as a basis (UNECE, 2022c).

Table 2.2 gives an overview of reported adjustments within the Air Convention submission in 2023. All approved and reported adjustments also appear in the emission trend table in Section 3.3 (non-methane volatile organic compounds, NMVOCs; Table 3.4). Parties must report details of their approved adjusted aggregated emissions using the appropriate row in the main emissions reporting template (Annex I to the reporting guidelines; UNECE, 2022c). They must also provide detailed information by pollutant and sector for each adjustment, using the template provided in Annex VII to the reporting guidelines. Reporting of

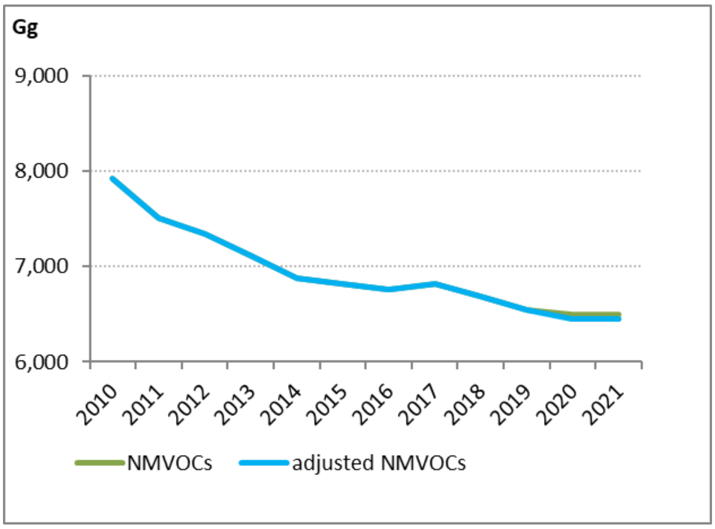
Table 2.2 Reporting of approved adjustments within the Air Convention submission 2023 (Annex I and Annex VII to the reporting guidelines; UNECE, 2022c), as of 14 March 2023

Member State	Pollutant	Years	Annex I ('adjustment row')	Annex VII	Declaration on consistent reporting of approved adjustments
Denmark	NMVOCs	2005, 2020-2021	Yes	Yes	No
France	NMVOCs	2005, 2020-2021	Yes	Yes	Yes
Netherlands	NMVOCs	2005, 2020-2021	Yes	Yes	Yes

information on adjusted emissions in no way suspends the mandatory requirement for Parties to report unadjusted emissions, as laid down in Section V, Sub-sections A-D, of the guidelines.

Figure 2.1 shows the effect in the EU of the adjustments on the emissions (sum of EU Member States' adjustments).

Figure 2.1 Adjusted and unadjusted emissions of NMVOCs for the EU, 2010-2021



3. Trends and key categories of EU pollutant emissions

The present EU inventory lists emissions for all the main air pollutants, particulate matter (PM), heavy metals (HMs) and persistent organic pollutants (POPs). It also reports the individual polycyclic aromatic hydrocarbons (PAHs) for which the Air Convention requires or recommends inventory reporting (UNECE, 1979).

In Chapter 3, the individual sections summarise the contributions each Member State has made to total EU emissions of nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOCs), sulphur oxides (SO_X), ammonia (NH_3), carbon monoxide (CO), PM with a diameter of 2.5µm or less ($PM_{2.5}$), PM with a diameter of 10µm or less (PM_{10}), total suspended particulates (TSPs), black carbon (BC), lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr), copper (Cu), nickel (Ni), selenium (Se), zinc (Zn), polychlorinated dibenzodioxins/dibenzofurans (PCDD/Fs), total PAHs, benzo(a)pyrene (B(a)P), benzo(b) fluoranthene (B(b)F), benzo(k)fluoranthene (B(k)F), indeno(1,2,3-cd)pyrene (IP), hexachlorobenzene (HCB) and polychlorinated biphenyls (PCBs). For BC, TSPs, additional HMs, B(a)P, B(b)F, B(k)F and IP, data for several countries (at least for some years) were missing and could not be gap filled. Therefore, the EU total is not complete (see also Section 1.9). For the main pollutants, PM, HMs and POPs, as well as B(a)P and BC, the EU trends in emissions from the five most important key categories, share by sector group and sectoral emission trends are presented.

In the pollutant-specific sections, Sections 3.2-3.27, the countries listed are always ranked according to certain criteria, e.g. the percentage of their share of the EU total. The criteria for the ranking are specified in brackets.

Table 3.3-Table 3.28 include two EU totals. The first is the sum of national totals that EU Member States officially reported. The second is the sum of the sectors of all EU Member States. A difference between these two EU totals occurs when only national totals but no sectoral data are available. There is a third EU total for NMVOCs (Table 3.4). This total allows for approved adjustments (see also Chapter 2).

3.1 Total EU emission trends, projection reporting and progress towards Gothenburg Protocol reduction commitments

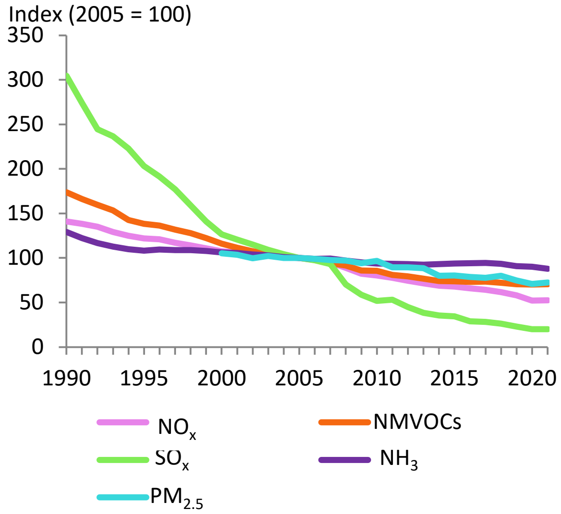
3.1.1 Total trends in EU emissions

In 2021, emissions of all pollutants were lower than in 1990 (or in 2000 for PM) (Table 3.1). Among regulated pollutants with a reduction obligation, the largest reductions across the EU (in percentage terms) since 1990 were for SO_X emissions (which decreased by 93%), followed by NO_X (63%), NMVOCs (59.%) NH_3 (32%) and $PM_{2.5}$ (31%) (Figure 3.1 a). NH_3 emissions decreased between the years 1990 and 1995, but since then emissions have remained stable with minor fluctuations. The biggest contributors to the total EU NH_3 emissions are France, Germany, Italy and Spain, with a share of 56.7% of the EU total. The NH_3 emissions of these countries have not fluctuated much over the years.

All regulated pollutants with a reduction obligation are declining between the years 2005 and 2021 (Figure 3.1 b). Largest decreases were observed in SO_X emissions (80.1%), followed by NO_X emissions (47.4%), NMVOCs (29.4%), $PM_{2.5}$ (27.7%) and NH_3 (12.2%).

Figure 3.1 (a) EU-27 emission trends and (b) indexed emissions for regulated pollutants with a reduction obligation

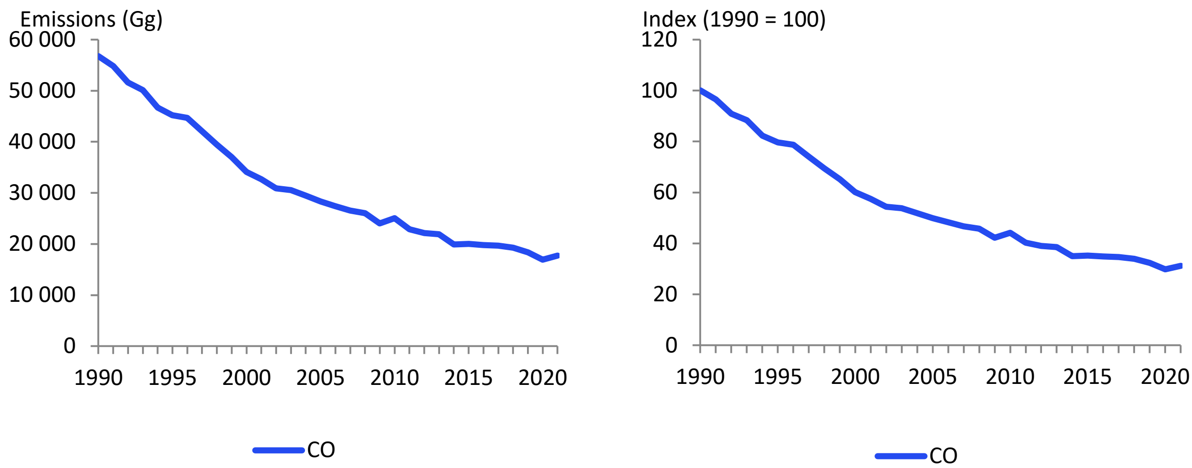
(a) (b)



Note: The right-hand axis gives values for $PM_{2.5}$ emissions.
The indexed emissions are based on emissions in 2005 (=100%).

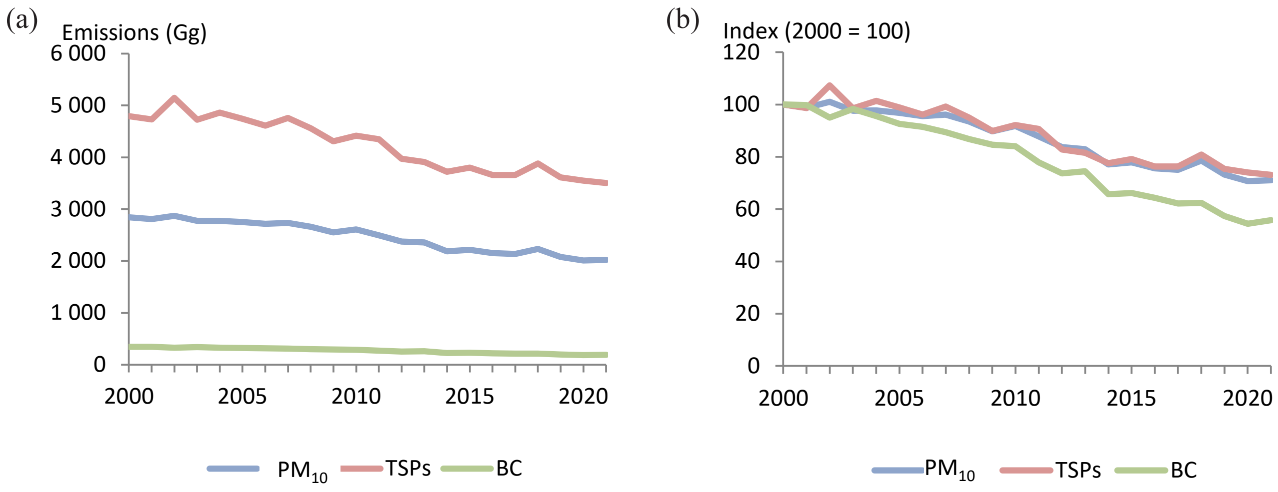
CO emissions decreased by 68.8% (-39,052kt CO) between 1990 and 2021 (Figure 3.2).

Figure 3.2 (a) EU-27 emission trends and (b) indexed emissions for CO emissions



Emissions of TSPs, PM_{10} and BC have also dropped substantially since 2000. Emission data for the period 2000-2021 indicate that TSP and PM_{10} emissions fell by 27% and 29%, respectively. BC emissions also dropped by 44% during the same period (Figure 3.3).

Figure 3.3 (a) EU-27 emission trends and (b) indexed emissions for TSP, PM_{10} and BC



Notes: Not all countries reported data for BC.

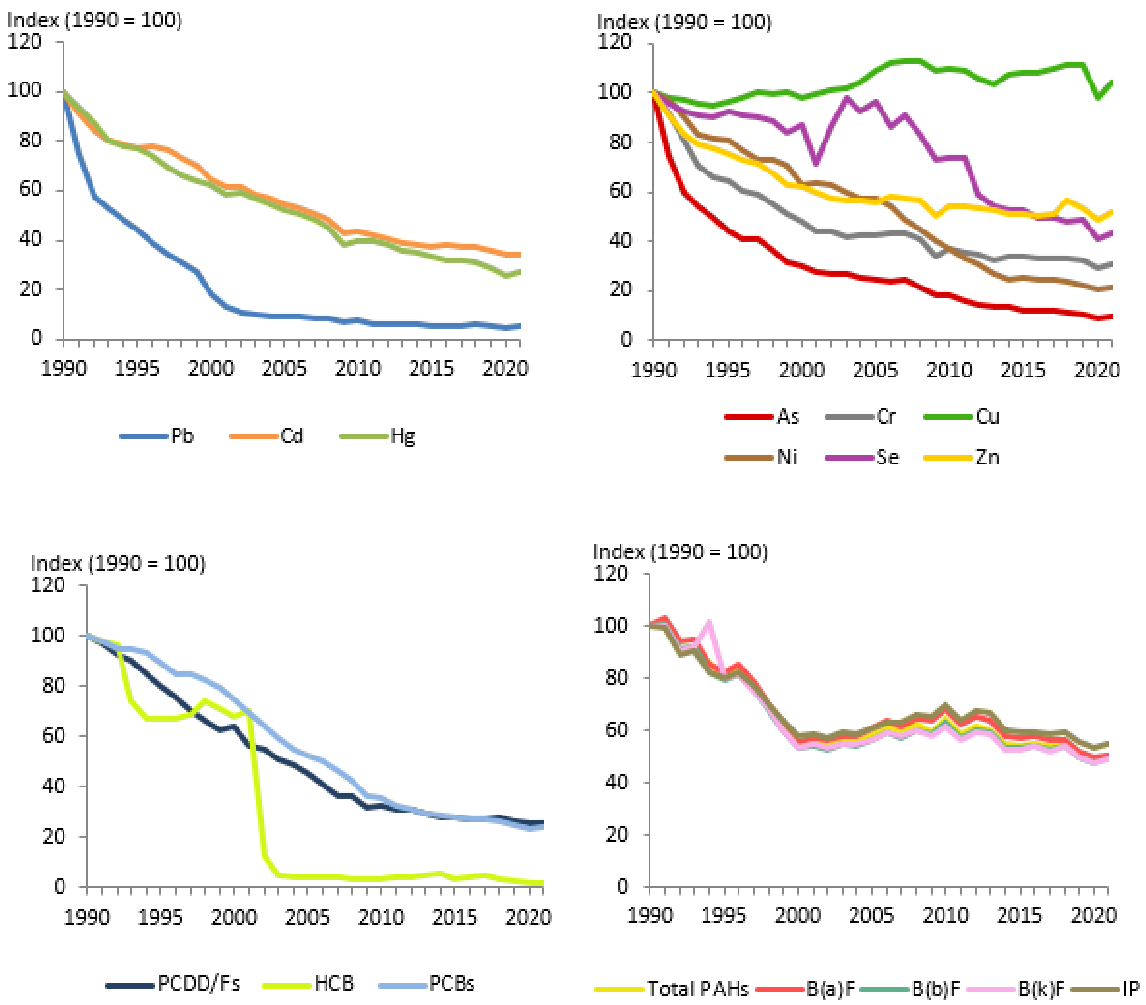
The Air Convention formally requests Parties to report emissions of PM for 2000 and thereafter. Thus, emission trends can be shown for these years only.

The indexed emissions are based on emissions in 2000 (=100%).

In addition, for HMs and POPs, emissions have reduced significantly since 1990 (Figure 3.4). Reductions are especially high for Pb (95%) and HCB (98%).

For various pollutants (e.g. BC and HMs), some EU Member States either did not report data or reported the notation key 'NR' (not relevant) for certain years or the whole time series. In some cases, the data could not be gap filled and so they were not included in the EU total. See also Section 1.9 for details on completeness and underestimations.

Figure 3.4 Indexed EU-27 emission trends for HMs and POPs



Notes: The drop in HCB emissions between 2001 and 2002 is caused by reductions reported by Germany.
The peak in B(k)F emissions in 1994 is caused by a large increase reported by Bulgaria.

Table 3.3-Table 3.28 show each Member State's reported emissions. They indicate instances where emissions of a certain pollutant are unrecorded for all years. Furthermore, information received from the EU Member States or found in their informative inventory reports (IIRs) is included in the trend sections (see Sections 3.2-3.27). If no information is provided on unusual trends, EU Member States are contacted by the EEA, informed about the findings and requested to send an explanation. As information on unusual trends is often not received, Sections 3.2-3.27 are very inconsistent regarding which variations in trends are explained and which are not.

Table 3.1 Total EU emissions of the main air pollutants, HMs, POPs and PM

Pollutant	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	Change 1990—2021	Change 2020—2021
NO_x	Gg	15,127	13,087	11,513	10,721	8,627	7,278	7,050	6,906	6,607	6,223	5,581	5,636	-63 %	1.0 %
NMVOCs	Gg	16,112	12,807	10,747	9,267	7,928	6,823	6,765	6,818	6,687	6,546	6,500	6,540	-59 %	0.6 %
NMVOCs (adjusted data)*	*Gg*					*7,928*	*6,823*	*6,765*	*6,818*	*6,687*	*6,546*				
SO_x	Gg	21,354	14,254	8,879	7,015	3,641	2,424	2,033	1,988	1,849	1,606	1,403	1,399	-93 %	-0.3 %
NH_3	Gg	4,902	4,115	4,040	3,799	3,566	3,565	3,576	3,590	3,548	3,455	3,419	3,336	-32 %	-2.4 %
CO	Gg	56,790	45,199	34,114	28,313	25,058	20,026	19,810	19,656	19,273	18,357	16,948	17,738	-69 %	4.7 %
Pb	Mg	20,461	9,156	3,785	1,844	1,576	1,162	1,116	1,141	1,207	1,098	982	1,065	-95 %	8.5 %
Cd	Mg	160	123	104	87	70	60	61	60	60	58	54	55	-66 %	0.5 %
Hg	Mg	147	113	92	77	58	49	47	47	46	42	38	40	-73 %	7.2 %
As	Mg	570	253	173	138	106	71	67	67	66	59	53	55	-90 %	4.9 %
Cr	Mg	1,018	657	487	433	378	345	340	341	342	330	299	313	-69 %	4.6 %
Cu	Mg	2,239	2,154	2,202	2,440	2,451	2,429	2,424	2,460	2,493	2,489	2,190	2,332	4 %	6.5 %
Ni	Mg	1,926	1,554	1,213	1,105	721	486	481	474	462	433	399	413	-79 %	3.5 %
Se	Mg	184	170	160	178	135	97	91	91	89	89	75	79	-57 %	5.6 %
Zn	Mg	6,868	5,199	4,256	3,821	3,743	3,521	3,452	3,502	3,898	3,677	3,336	3,581	-48 %	7.3 %
PCDD/Fs	g I-Teq	7,908	6,369	5,049	3,602	2,562	2,232	2,169	2,165	2,221	2,088	2,034	2,057	-74 %	1.1 %
B(a)P	Mg	453	374	253	275	310	258	263	257	257	235	227	230	-49 %	1.5 %
B(b)f	Mg	494	394	263	279	312	263	267	261	267	245	236	241	-51 %	2.1 %
B(k)f	Mg	237	190	128	135	147	125	128	124	129	119	113	116	-51 %	2.4 %
IP	Mg	225	181	131	137	158	134	135	132	135	126	121	125	-45 %	3.3 %
Total PAHs	Mg	1,527	1,241	841	895	983	829	843	826	839	771	737	760	-50 %	3.1 %
HCB	kg	5,624	3,784	3,817	235	195	192	248	267	184	169	122	121	-98 %	-1.4 %
PCBs	kg	6,891	6,181	5,172	3,627	2,439	1,912	1,897	1,877	1,805	1,725	1,615	1,692	-75 %	4.8 %
														Change 2000—2021	**Change 2020—2021**
TSPs	Gg			4,796	4,744	4,420	3,799	3,658	3,660	3,881	3,615	3,549	3,507	-27 %	-1.2 %
$PM_{2.5}$	Gg			1,940	1,844	1,786	1,480	1,451	1,433	1,473	1,375	1,306	1,333	-31 %	2.1 %
PM_{10}	Gg			2,841	2,752	2,609	2,213	2,150	2,133	2,232	2,079	2,009	2,020	-29 %	0.5 %
BC	Gg			345	320	291	229	222	215	215	198	188	193	-44 %	2.5 %

Notes: Negative percentage values indicate that emissions have decreased.

Table 3.1 and Table 3.3-Table 3.28 express changes in emissions between 1990 and 2021 as $100\times(E_{2021}-E_{1990})/E_{1990}$ (%), where E_{2021} and E_{1990} are 2021 and 1990 total emissions, respectively. They express changes in emissions from 2020 to 2021 as $100\times(E_{2021}-E_{2020})/E_{2020}$ (%), where E_{2020} and E_{2021} are the 2020 and 2021 total emissions, respectively.

The bases for the EU inventory shown in Table 3.1 and Table 3.3-Table 3.28 provide total national data for the entire territory based on fuel sold for all EU Member States. See Section 1.4.4 for further details.

*Adjusted data: under the Gothenburg Protocol, the EMEP Steering Body accepted inventory adjustment applications([18]) for emissions from several EU Member States. This table takes these adjustments into account, whereas emission data are based on fuel sold. See Chapter 2 for further details.

3.1.2 Progress towards the Gothenburg Protocol reduction commitments

The Gothenburg Protocol to the UNECE Air Convention (UNECE, 1999) and its amendment (UNECE, 2012a) specifies emission reduction commitments for the pollutants NO_X, NMVOCs, SO_X, NH_3 and $PM_{2.5}$. Parties to the protocol must meet them by 2020 and every year thereafter.

The emission reduction commitment for the EU as a whole is the sum of the reduction commitments for the EU Member States([19]). Table 3.2 sets out the emissions reported for 2021 by the EU-27, compared with the reduction commitments specified for the EU (see Table A2.2 in Appendix 2 for an explanation of the country groupings). In this report, the comparison with the EU-27 reduction commitments in the Gothenburg Protocol is based on fuel sold. For all pollutants, emissions in 2021 were below the emission reduction commitments.

([18]) In 2012, the Executive Body for the Air Convention decided that adjustments to emission reduction commitments, or to inventories for the purposes of comparing them with total national emissions, may be made in some circumstances (UNECE, 2012a).

([19]) The reduction commitment levels specified in the amended Gothenburg Protocol annex II for the EU as a whole were based on the EU membership in 2012 (before Croatia's accession and the UK departure); the EU reduction commitment is therefore subject to technical correction when the EU membership changes, cf EB decision 2021/3

Table 3.2 Emissions reported for 2021 by the EU-27 compared with the Gothenburg Protocol EU reduction commitments for 2020 and beyond

Pollutant	EU-15 emissions 2021 (Gg)	EU-27 emission levels 2005 (Gg)	Reduction commitment from 2005 level (%)	Current difference (%)
NO_X	4,993	10,011	-40	-51
NMVOCs	6,078	8,811	-28	-31
SO_x	1,399	7,015	-59	-80
NH_3	3,336	3,799	-6	-12
$PM_{2.5}$	1,333	1,844	-22	-28

Notes: For Spain, data for emission comparisons exclude emissions from the Canary Islands, i.e. data comprise the EMEP domain only.

For Portugal's reduction commitments, emissions from the Azores and Madeira are excluded.

Under the Gothenburg Protocol, the EMEP Steering Body accepted applications from Belgium, Czechia, Denmark, Finland, France, Germany, Hungary, Luxembourg, the Netherlands and Spain for emission inventory adjustments in 2014, 2015, 2016, 2017, 2018, 2019, 2020 and 2021This table takes these adjusted data into account.

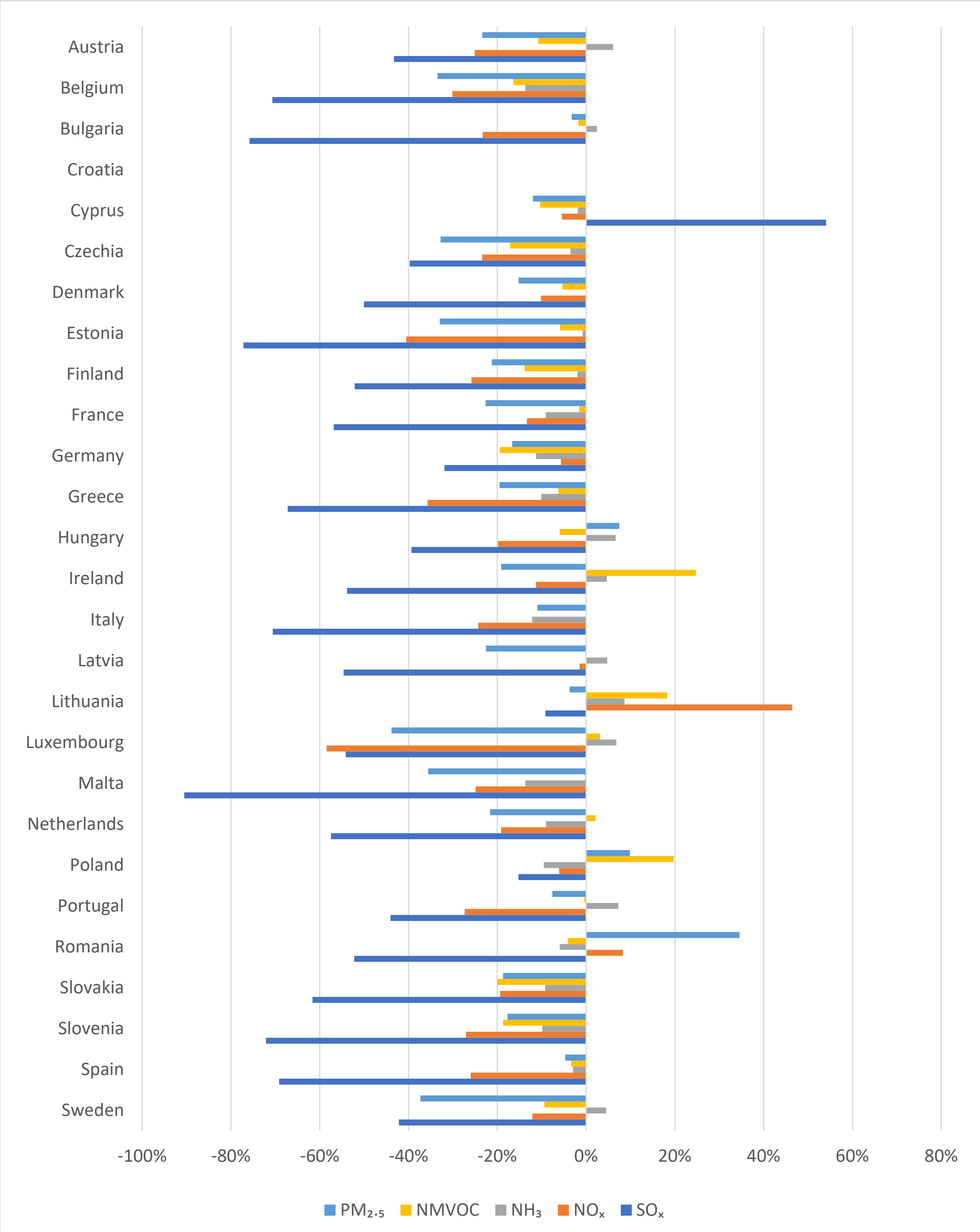
Emission reduction commitments are also specified for individual EU Member States.

Figure 3.5 shows whether or not EU Member States met the Gothenburg Protocol EU reduction commitments in 2021. Cyprus did not meet the reduction commitment for SO_X emissions. Several Member States ([20]) did not meet their reduction commitment for NO_X emissions (Lithuania and Romania), NH_3 emissions (Austria, Bulgaria, Denmark, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Portugal, Sweden), NMVOC emissions (Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Poland) and $PM_{2.5}$ emissions (Hungary, Poland, Romania).

The EEA plans to publish its annual analysis of data reported under the National Emission reduction Commitments Directive ("NEC report") in June 2023. This report analyses the emission data reported under the EU NEC Directive for EU Member States (EEA, forthcoming). The NEC Directive (EU, 2016b) contains national emission reduction commitments for EU Member States for NO_X, NMVOCs, sulphur dioxide (SO_2), NH_3 and $PM_{2.5}$ for the period 2020-2029 and for any year from 2030.

([20]) Austria, Italy and Poland have signed the Gothenburg Protocol but have not ratified it. For this reason, the targets are not binding for these countries.

Figure 3.5 Distance to Gothenburg Protocol reduction commitments for EU Member States in 2021



Note: Croatia is not included due to missing submissions.
Adjustments of NMVOC emissions from Denmark, France and the Netherlands are considered.
NO_x emissions from soils are not included in the estimates from the member states.

3.2 *Nitrogen oxide emission trends and key categories*

Between 1990 and 2021, NO_X emissions dropped by 63% in the EU, and between 2020 and 2021 they increased by 1%. This recent increase was mainly caused by Spain, France, Italy and Romania (countries ranked according to the size of their contributions to the absolute change) (Table 3.3).

Table 3.3 Member State contributions to EU emissions of NO_X

Member State	NO_x (Gg)												Change		Share in EU-27	
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	1990—2021	2020—2021	1990	2021
Austria	219	199	213	248	206	184	177	167	155	146	124	123	-44 %	-1.5 %	1.4 %	2.2 %
Belgium	422	410	359	329	250	201	189	177	170	159	139	142	-66 %	2.1 %	2.8 %	2.5 %
Bulgaria	306	211	164	187	138	117	111	98	95	92	87	94	-69 %	8.9 %	2.0 %	1.7 %
Croatia	106	79	88	86	69	54	54	55	50	49	46	44	-59 %	-4.7 %	0.7 %	0.8 %
Cyprus	18	21	22	22	19	14	14	13	13	14	12	12	-32 %	5.6 %	0.1 %	0.2 %
Czechia	760	391	311	302	255	206	197	194	187	174	156	159	-79 %	1.9 %	5.0 %	2.8 %
Denmark	294	282	218	199	145	109	109	107	101	97	89	89	-70 %	-0.1 %	1.9 %	1.6 %
Estonia	75	48	44	42	42	31	31	32	31	25	23	23	-70 %	-3.0 %	0.5 %	0.4 %
Finland	307	273	241	208	187	139	135	131	127	120	106	105	-66 %	-0.5 %	2.0 %	1.9 %
France	2,182	1,982	1,816	1,587	1,236	1,035	986	956	902	849	737	756	-65 %	2.6 %	14.4 %	13.4 %
Germany	2,843	2,169	1,866	1,616	1,459	1,368	1,334	1,279	1,191	1,107	976	969	-66 %	-0.7 %	18.8 %	17.2 %
Greece	409	402	431	483	364	263	262	268	259	250	222	222	-46 %	0.2 %	2.7 %	3.9 %
Hungary	247	191	189	179	148	128	121	122	121	115	108	110	-55 %	2.0 %	1.6 %	1.9 %
Ireland	169	171	181	175	120	113	114	111	112	104	96	100	-41 %	3.8 %	1.1 %	1.8 %
Italy	2,124	1,988	1,506	1,290	942	728	716	674	678	662	596	611	-71 %	2.4 %	14.0 %	10.8 %
Latvia	99	53	43	46	42	38	36	36	37	35	33	34	-66 %	2.8 %	0.7 %	0.6 %
Lithuania	151	74	63	64	57	57	57	56	56	55	53	52	-66 %	-1.5 %	1.0 %	0.9 %
Luxembourg	41	35	41	57	39	29	26	23	21	19	15	14	-65 %	-5.6 %	0.3 %	0.3 %
Malta	7	8	8	10	9	6	5	5	4	5	4	4	-41 %	3.0 %	0.0 %	0.1 %
Netherlands	680	581	496	440	360	282	267	258	253	238	216	211	-69 %	-2.3 %	4.5 %	3.7 %
Poland	1,121	1,080	869	858	845	721	730	768	689	641	605	591	-47 %	-2.3 %	7.4 %	10.5 %
Portugal	260	297	301	283	204	170	162	165	160	155	135	137	-47 %	1.1 %	1.7 %	2.4 %
Romania	474	376	316	333	248	221	211	220	222	218	205	214	-55 %	4.5 %	3.1 %	3.8 %
Slovakia	136	112	110	106	88	68	64	63	62	59	56	58	-57 %	4.4 %	0.9 %	1.0 %
Slovenia	75	75	59	55	48	35	35	34	33	30	26	26	-66 %	1.0 %	0.5 %	0.5 %
Spain	1,311	1,320	1,335	1,322	936	812	762	754	742	679	599	620	-53 %	3.5 %	8.7 %	11.0 %
Sweden	289	258	222	193	170	147	144	139	134	125	117	115	-60 %	-1.3 %	1.9 %	2.0 %
EU-27 (a)	**15,127**	**13,087**	**11,513**	**10,721**	**8,627**	**7,278**	**7,050**	**6,906**	**6,607**	**6,223**	**5,581**	**5,636**	**-63%**	**1.0%**	**100%**	**100%**
EU-27 (b)	15,127	13,087	11,513	10,721	8,627	7,278	7,050	6,906	6,607	6,223	5,581	5,636				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

The NO_X emission trends of the EU were largely determined by emissions from Germany, France, Spain, Italy and Poland (see Figure 3.6). NO_X emissions from road transport and fuel combustion activities in the energy and industry sector are the main emission sources. In general, these are the sources showing the highest emission reductions since 1990, mainly due to the introduction of Euro standards in the road transport sector and abatement technologies and fuel shifts.

The trend in **Germany** is dominated by emissions from road transport and public electricity and heat production. These categories also saw the highest emission decreases (56% and 79%, respectively) between 1990 and 2021. This is due to constantly improving fuels and stricter regulations that result in technical improvements (see Germany's IIR, listed in Appendix 5).

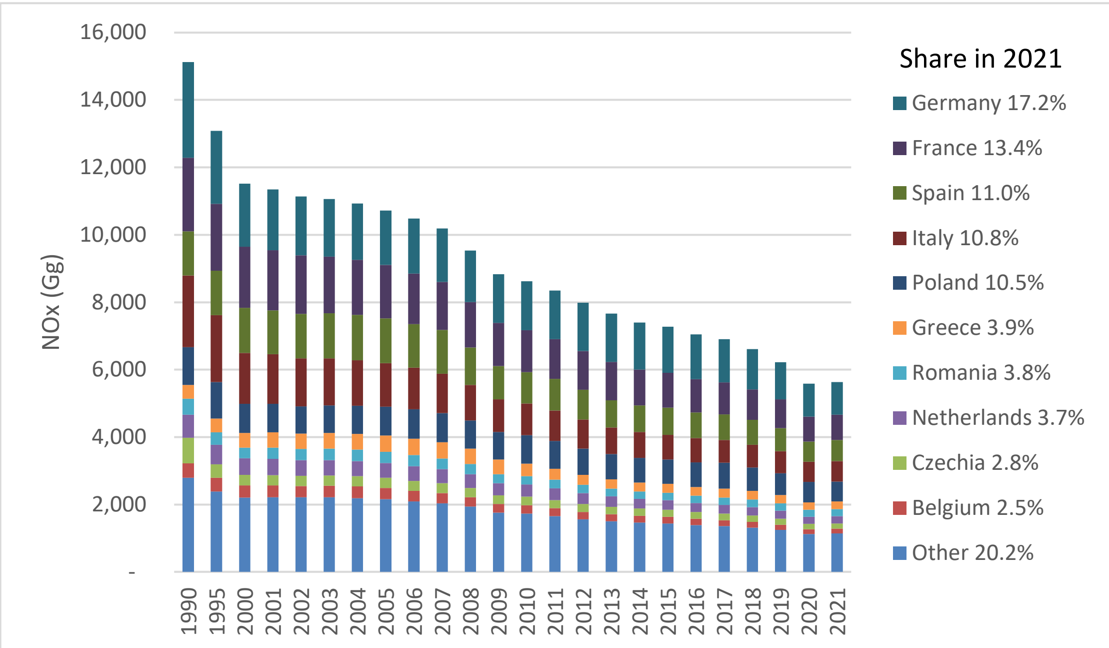
In **France**, NO_X emissions arise during the combustion of fossil fuels or biofuels in road transport (1A3), and from combustion plants for electricity generation and district heating (1A1a), industry (1A2) and residential/tertiary (1A4). The energy sector was thus responsible for the majority (79%) of emissions in 2021. NO_X emissions also arise in agriculture from biological processes of nitrification and denitrification in the soil following the addition of mineral or organic nitrogen fertilisers; and in livestock areas at the level of building/storage stations from the nitrogen contained in animal waste. The decrease in NO_X emissions between 1990 and 2021 is caused by (1) the implementation of primary and secondary treatment systems to eliminate NO_X in industry and in combustion facilities, (2) the gradual introduction of catalytic purification devices on road vehicles, (3) structural changes in the energy mix (nuclear power programme and development of renewable energies) and (4) better energy performance of industrial facilities (see France's IIR, listed in Appendix 5).

In **Spain**, NO_X emissions are mostly attributed to fuel combustion in road transport (1A3b), in energy industries (1A1a) and in manufacturing industries (1A2). The highest relative reductions are those achieved in public power plants, which have decreased by 85% since 1990. The reduction is driven by the progressive introduction of renewable energies, the introduction of abatement techniques in thermal power plants and the shift to combined-cycle gas plants. For example, a drastic drop occurred in 2008, due to the closure of the main brown coal mine in Spain in 2007 and the necessary retrofitting in 2008 of the adjacent thermal plant. The reduction in NO_X emissions for road transport (53% since 1990) is caused by the introduction of Euro standards in petrol passenger cars (1A3bi) in 1993 (Euro 1-91/441/EEC) and in heavy-duty vehicles and buses (1A3biii) since 2000 (Euro III). The reduction in NO_X emissions in the industry sector (1A2) is mainly the result of the progressive introduction of abatement techniques in industrial plants and the shift from liquid fuels to natural gas, especially in the non-metallic minerals industry (1A2f) (see Spain's IIR, listed in Appendix 5).

In **Poland**, NO_X emissions mainly result from road transport (1A3) and energy industries (1A1), and also from stationary combustion in buildings (1A4). The reductions seen since 1990 are caused by the decline in heavy industry and the lower share of coal in combusted fuels in the late 1980s and early 1990s. Since the late 1990s, the largest source of NO_X emissions has been the combustion of fuels in road transport, from which emissions steadily increased until 2017. This is mainly due to the increase in the number of vehicles since 1990. The decrease in NO_X emissions from 2017 is caused by the increasing share of vehicles with the latest Euro quality standards (see Poland's IIR, listed in Appendix 5).

In **Italy**, in 2021, 42% of NO_X emission are caused by road transport. Between 1990 and 2021, a decrease of 74% was reported. The decrease is the result of two opposing trends: (1) an increase in emissions in the early years of the historical series, with a peak in 1992, due to the increase in the fleet and in the total mileage travelled by passengers and goods transported by road; and (2) a decrease due to the introduction of technologies to reduce vehicle emissions, as the catalytic converter, required by European directives, in particular Directives 91/441/EC (EC, 1991), 94/12/EC (EC, 1994) and 98/69/EC (EC, 1998) on light vehicles (see Italy's IIR, listed in Appendix 5).

Figure 3.6 NO_X emission trends in the EU and shares of Member States



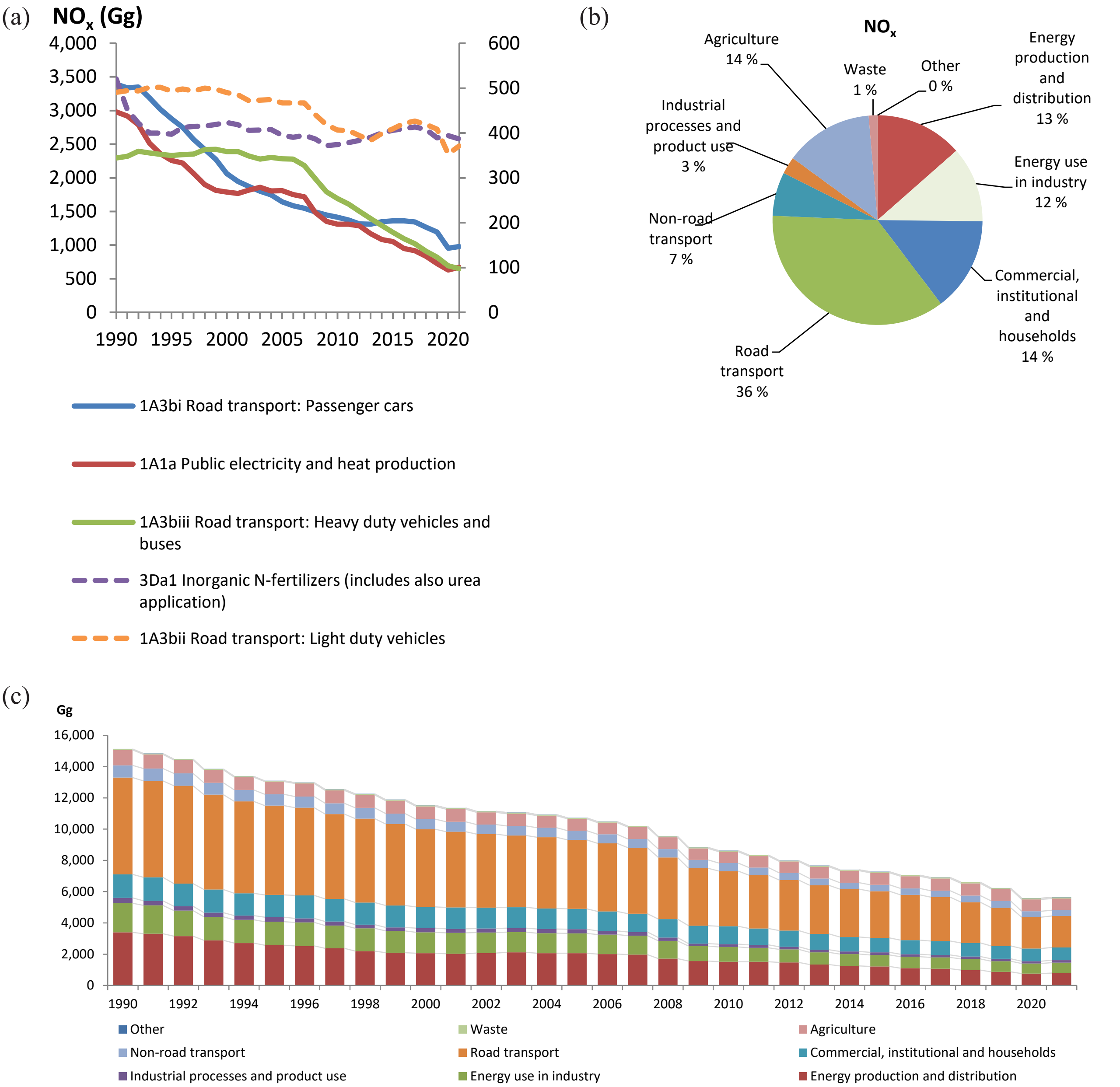
Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

The main key categories for NO_X emissions were road transport (1A3bi — Passenger cars, 1A3biii — Heavy duty vehicles and buses) and 'Public electricity and heat production' (1A1a). Together, they made up 41% of total emissions (see Figure 3.7). The highest relative reduction in NO_X emissions between 1990 and 2021 occurred in 'Public electricity and heat production' (77.5%) (see Figure 3.7(a)). Significant reductions were also reported for

NO_X emissions from passenger cars (71.1%) and from heavy duty vehicles and buses (71.7%). Emissions from light duty vehicles decreased by only 24.3% between 1990 and 2021, whereby the recent increase between 2020 and 2021 is mainly caused by Spain, France and Italy.

Figure 3.7(b) shows the contribution made by each aggregated sector group to total EU emissions. For NO_X, common key emission sources are the energy and transport sectors. Emission reductions from the road transport sector are primarily a result of fitting catalytic converters to vehicles (EEA, 2022c). Legislative standards, known as Euro standards, have driven this move. Nevertheless, the road transport sector represents the largest source of NO_X emissions, accounting for 36% of total EU emissions in 2021. The electricity/energy production sectors have also reduced their emissions, thanks to measures such as introducing combustion modification technologies (e.g. low-NO_X burners), implementing flue gas abatement techniques (e.g. NO_X scrubbers and selective catalytic reduction and selective non-catalytic reduction techniques) and switching from coal to gas (EEA, 2022c).

Figure 3.7 NO_X emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Note: In (a), the right-hand axis shows values for '1A3bii — Road transport: Light duty vehicles' and '3Da1 — Inorganic N fertilisers (also includes urea application)'.

3.3 *Non-methane volatile organic compound emission trends and key categories*

Between 1990 and 2021, NMVOC emissions dropped by 59% in the EU, and between 2020 and 2021 they dropped by 0.6% (Table 3.4). This recent decrease was due to lower emissions in Poland, Spain, Czechia and Finland (countries ranked according to the size of their contributions to the absolute change).

Table 3.4 Member State contributions to EU emissions of NMVOCs

Member State	NMVOCs (Gg)												Change		Share in EU-27	
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	1990—2021	2020-2021	1990	2021
Austria	334	249	181	157	138	113	112	113	109	108	111	111	-67 %	0.3 %	2.1 %	1.7 %
Belgium	353	312	235	184	145	119	119	118	117	117	118	122	-66 %	3.2 %	2.2 %	1.9 %
Bulgaria	476	159	135	112	101	96	94	93	89	87	89	87	-82 %	-1.9 %	3.0 %	1.3 %
Croatia	172	120	104	114	91	70	72	69	69	74	70	70	-59 %	-0.5 %	1.1 %	1.1 %
Cyprus	13	14	13	16	13	7	8	9	8	8	7	8	-42 %	3.1 %	0.1 %	0.1 %
Czechia	555	386	318	275	255	215	212	210	210	202	194	187	-66 %	-3.7 %	3.4 %	2.9 %
Denmark	212	210	181	154	131	115	111	109	108	103	106	107	-50 %	0.1 %	1.3 %	1.6 %
*Adjusted data**				*134*							*83*	*82*				
Estonia	64	40	35	31	22	22	22	23	22	23	24	27	-59 %	11.0 %	0.4 %	0.4 %
Finland	235	204	179	148	114	91	91	89	87	85	85	83	-65 %	-2.4 %	1.5 %	1.3 %
France	2,928	2,518	2,149	1,783	1,465	1,211	1,204	1,203	*1,165*	*1,129*	1,125	1,164	-60 %	3.5 %	18.2 %	17.8 %
*Adjusted data**				*1,372*							*708*	*770*				
Germany	3,949	2,363	1,814	1,490	1,363	1,147	1,139	1,143	1,096	1,066	1,028	1,044	-74 %	1.5 %	24.5 %	16.0 %
Greece	321	307	313	338	219	169	160	155	149	149	141	146	-55 %	3.6 %	2.0 %	2.2 %
Hungary	311	213	191	174	130	126	124	124	117	118	112	114	-63 %	1.8 %	1.9 %	1.7 %
Ireland	154	142	124	123	114	112	114	117	117	117	113	115	-26 %	1.8 %	1.0 %	1.8 %
Italy	1,982	2,051	1,625	1,335	1,113	899	887	931	908	904	843	868	-56 %	2.9 %	12.3 %	13.3 %
Latvia	86	63	53	50	40	36	34	35	40	36	36	37	-58 %	2.6 %	0.5 %	0.6 %
Lithuania	128	88	62	59	53	50	49	52	50	49	46	48	-63 %	3.9 %	0.8 %	0.7 %
Luxembourg	28	21	16	15	12	11	11	11	*11*	*11*	11	11	-60 %	5.8 %	0.2 %	0.2 %
Malta	5	6	5	4	4	3	3	3	3	3	3	3	-32 %	5.9 %	0.0 %	0.0 %
Netherlands	607	436	338	273	279	253	248	249	242	238	270	277	-54 %	2.7 %	3.8 %	4.2 %
*Adjusted data**				*249*							*226*	*234*				
Poland	841	951	826	797	776	734	744	746	755	731	753	715	-15 %	-5.0 %	5.2 %	10.9 %
Portugal	249	236	233	187	152	142	139	140	143	142	152	152	-39 %	0.5 %	1.5 %	2.3 %
Romania	395	290	306	326	263	239	232	235	231	233	232	234	-41 %	1.1 %	2.5 %	3.6 %
Slovakia	255	171	144	141	117	105	105	103	95	92	88	92	-64 %	4.7 %	1.6 %	1.4 %
Slovenia	65	63	55	48	40	33	33	32	32	31	31	30	-54 %	-2.0 %	0.4 %	0.5 %
Spain	1,026	919	887	729	601	550	549	565	*575*	*551*	575	549	-46 %	-4.4 %	6.4 %	8.4 %
Sweden	367	277	222	204	177	157	150	143	*139*	*139*	138	138	-62 %	0.4 %	2.3 %	2.1 %
EU-27 (a)	**16 112**	**12 807**	**10 747**	**9 267**	**7 928**	**6 823**	**6 765**	**6 818**	**6687**	**6546**	**6500**	**6540**	**-59%**	**0.6%**	**100%**	**100%**
EU-27 (b)	16 112	12 807	10 747	9 267	7 928	6 823	6 765	6 818	6 687	6 546	6 500	6 540				
EU-27 (c)	16 112	12 807	10 747	9 242	7 928	6 823	6 765	6 818	6 687	6 546	6 456	6 497				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

([c]) Sum of national totals, as reported by EU Member States, allowing for approved adjustments.

*Adjusted data: under the Gothenburg Protocol, the EMEP Steering Body accepted inventory adjustment applications for emissions from Denmark, France and the Netherlands.

The NMVOC emission trends of the EU were largely determined by emissions from France, Germany, Italy, Poland and Spain (see Figure 3.8). In general, NMVOC emissions in 1990 were caused by emission sources different from those in recent years. In 1990, NMVOC emissions from road transport were most important; however, on account of the introduction of catalytic converters and renewal of the fleets, these emissions decreased significantly. Nowadays, the emission trend is dominated by NMVOC emissions from residential heating, solvent use and manure management.

In **Germany**, in 1990, NMVOC emissions were mainly caused by passenger cars (1A3bi) and coating application (2D3d), the latter of which includes the use of paints within the industrial and domestic sector. Until 2021, NMVOC emissions in Germany decreased significantly (by 74%), with coating applications and manure management still being the most important emission sources. The strong decline in emissions from passenger cars (1A3bi) is due to increasingly stricter regulations, especially incentives for car users to retrofit or buy cars with catalytic converters, and the implementation of the Technical Instructions on Air Quality Control (TA-Luft 2002). Furthermore, decreases in the subcategory '1B2av — Emissions from petrol storage and from fuelling of motor vehicles' can be explained by the implementation of the 20th and 21st Ordinances on the Execution of the Federal Immission Control Act (BImSchV). A decline in petrol consumption has played a major role with regard to the reduction in NMVOC emissions (see Germany's IIR, listed in Appendix 5).

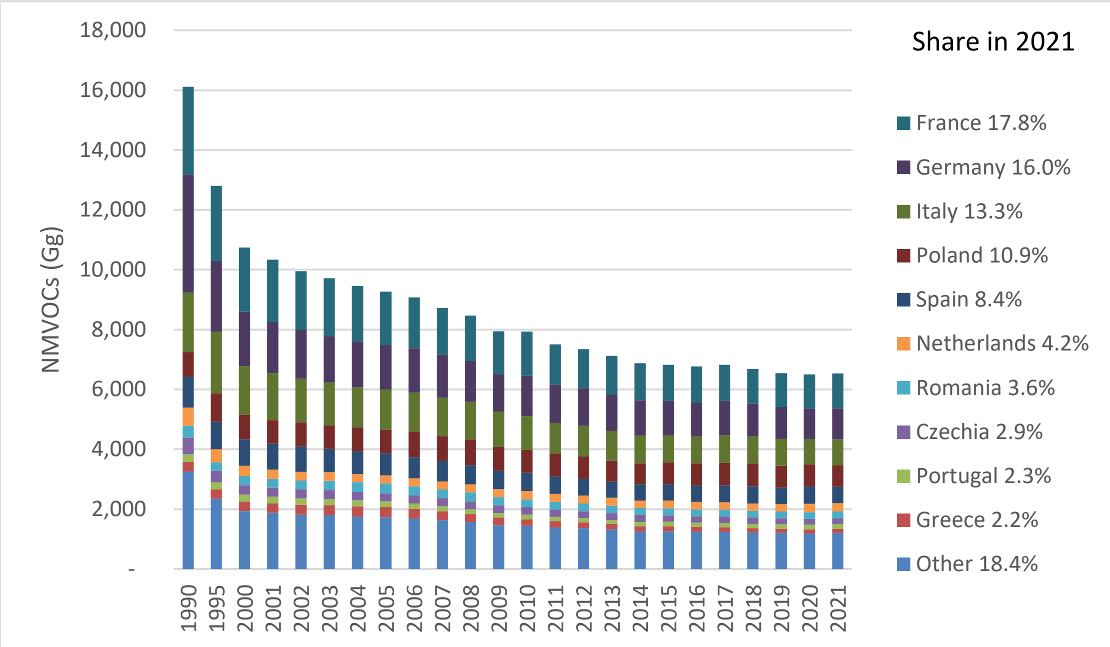
In **France**, the major contributing sectors in 2021 were residential stationary combustion (1A4bi) and the biological functioning of crops (emissions attracting pollinating insects, for example) (3De). In 1990, the main emission sources were road transport (1A3b), residential heating (1A4b) and coating applications (2D3d). The decrease in NMVOC emissions of 96% between 1990 and 2021 in road transport can be explained by the fitting of petrol vehicles with catalytic converters since 1993, in addition to the management of evaporation from these vehicles equipped with activated carbon filters in the tanks, as well as the dieselisation of the vehicle fleet, diesel vehicles emitting less volatile organic compounds (VOCs). NMVOC emissions from biomass combustion in households (1A4b) decreased by 65% as a result of the renewal of installations with more efficient and less emitting appliances. The substitution of products containing solvents with products with a lower content or without solvent (2D) led to a reduction of 56% in the respective category (see France's IIR, listed in Appendix 5).

In **Italy**, solvent and other product use is the main source of emissions, comprising 38% of total emissions, a decrease from 46% in 1990.Significant reductions occurred in the 1990s as a result of the introduction of paints with low solvent contents to the market, and the reduction of the total amount of organic solvent used for metal degreasing and in glues and adhesives. Furthermore, in many cases, local authorities imposed abatement equipment in the industrial painting sector and forced the replacement of open-loop machines with closed-loop machines, even before EU Directive 99/13/EC (EU, 1999) came into force. In 2020, due to the pandemic, the use of household products containing solvents increased considerably. The main reductions relate to the road transport sector (85%), mainly attributed to renewal of the fleet and the use of catalytic devices to reduce exhaust and evaporative emissions from cars. NMVOC emissions gradually reduced.

NMVOC emissions from **Poland** decreased by 15% between 1990 and 2021. The largest reduction occurred in road transport (1A3b) and NMVOC emissions resulting from coal mining and handling (1B1a). The largest increase (76%) occurred in sector 2D — Other solvent and product use. This is mainly due to a significant increase in the consumption of solvent-based paints. NMVOC emissions from residential heating increased by 16% between 1990 and 2021.

In **Spain**, NMVOC emissions in 2021 declined by 46% compared with 1990. These reductions were achieved mainly in road transport (93%) due to the introduction of the Euro standards for road vehicles since 1996, and to the shift towards a diesel-dominated car fleet. The drop in NMVOC emissions from solvent use is a result of the entry into force of different legislation on paint and painting installations. This led to a fall in emissions from coating applications (2D3d) of 64% between 2003 and 2021. Furthermore, the economic downturn also caused a noticeable contraction in activity and therefore consumption of paints. The decreasing trend had stopped by 2012, and from then a steady trend in emissions is observed, with minor fluctuations (see Spain's IIR, listed in Appendix 5).

Figure 3.8 NMVOC emission trends in the EU and shares of Member States

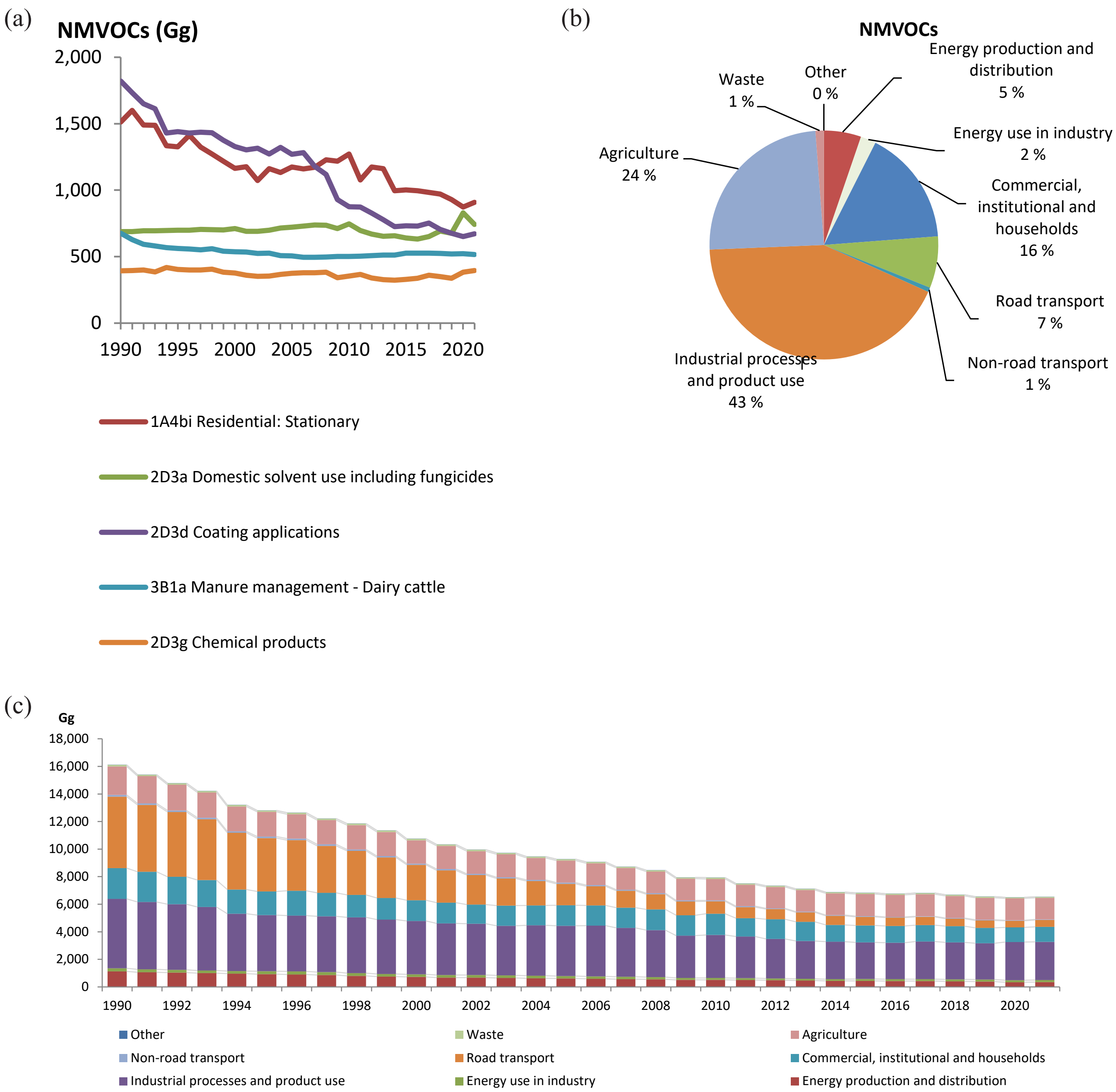


Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

The most important key categories for NMVOC emissions were residential heating (1A4bi), domestic solvent use including fungicides (2D3a) and coating applications (2D3d). Together, they made up 36% of total emissions (Figure 3.9 (a)). Among the top five key categories, the highest relative reduction in emissions between 1990 and 2021 is reported for coating applications (2D3d) (63%).

Figure 3.9(b) shows the contribution made by each aggregated sector group to total EU emissions. The main emission source of NMVOCs is industrial processes and product use (43%), followed by agriculture (24%), commercial, institutional and households (16%), road transport (7%) and energy production and distribution (5%).

Figure 3.9 NMVOC emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

3.4 *Sulphur oxide emission trends and key categories*

Between 1990 and 2021, SO_X emissions dropped by 93% in the EU, and by 0.3% between 2020 and 2021 (see Table 3.5). This recent decrease is due to reduced emissions in Bulgaria, Italy, Spain and Hungary (countries ranked according to the size of their contributions to the absolute change).

Table 3.5 Member State contributions to EU emissions of SO_X

Member State	SO_x (Gg)												Change		Share in EU-27	
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	1990—2021	2020—2021	1990	2021
Austria	74	47	32	26	16	14	13	13	12	11	10	11	-85 %	4.4 %	0.3 %	0.8 %
Belgium	365	258	171	140	61	41	34	32	32	30	24	23	-94 %	-2.4 %	1.7 %	1.7 %
Bulgaria	1,465	1,698	1,102	955	329	135	94	93	79	72	69	51	-97 %	-26.4 %	6.9 %	3.6 %
Croatia	171	77	60	59	35	16	15	12	10	8	6	5	-97 %	-22.5 %	0.8 %	0.3 %
Cyprus	32	40	48	38	22	13	16	16	17	16	12	10	-69 %	-14.3 %	0.1 %	0.7 %
Czechia	1,754	1,059	234	208	164	129	115	110	97	80	67	69	-96 %	2.8 %	8.2 %	4.9 %
Denmark	178	145	33	26	16	10	10	10	11	9	9	9	-95 %	-7.7 %	0.8 %	0.6 %
Estonia	278	117	97	77	83	36	35	39	31	19	11	12	-96 %	7.1 %	1.3 %	0.8 %
Finland	249	105	82	70	66	41	40	35	33	30	23	23	-91 %	0.3 %	1.2 %	1.7 %
France	1,287	938	616	458	269	150	131	127	121	98	89	89	-93 %	0.02 %	6.0 %	6.4 %
Germany	5,464	1,743	643	473	403	334	310	302	290	261	241	254	-95 %	5.5 %	25.6 %	18.2 %
Greece	512	492	532	549	233	102	81	90	86	80	49	47	-91 %	-4.6 %	2.4 %	3.3 %
Hungary	829	613	427	43	30	24	23	28	23	17	16	14	-98 %	-14.7 %	3.9 %	1.0 %
Ireland	183	163	144	73	27	16	15	15	14	11	11	12	-94 %	9.7 %	0.9 %	0.8 %
Italy	1,783	1,322	756	411	224	128	123	119	113	112	85	79	-96 %	-7.5 %	8.4 %	5.6 %
Latvia	100	49	18	9	4	4	3	4	4	4	4	4	-96 %	3.8 %	0.5 %	0.3 %
Lithuania	218	86	40	28	18	15	15	13	13	12	11	11	-95 %	0.6 %	1.0 %	0.8 %
Luxembourg	16	9	4	3	2	1	1	1	1	1	1	1	-95 %	-1.3 %	0.1 %	0.1 %
Malta	13	11	9	12	8	2	2	1	0	0	0	0	-98 %	8.9 %	0.1 %	0.0 %
Netherlands	198	137	79	68	36	31	29	27	25	23	20	21	-89 %	6.0 %	0.9 %	1.5 %
Poland	2,553	2,044	1,325	1,129	825	639	518	506	480	396	385	392	-85 %	1.8 %	12.0 %	28.1 %
Portugal	318	322	295	189	62	45	45	46	45	44	38	39	-88 %	3.2 %	1.5 %	2.8 %
Romania	819	696	492	603	355	149	98	78	71	86	61	66	-92 %	8.9 %	3.8 %	4.7 %
Slovakia	140	121	117	86	68	67	26	28	20	16	13	14	-90 %	7.0 %	0.7 %	1.0 %
Slovenia	203	125	93	40	10	6	5	5	5	4	4	4	-98 %	1.8 %	1.0 %	0.3 %
Spain	2,050	1,767	1,388	1,207	245	260	217	220	199	151	128	123	-94 %	-3.7 %	9.6 %	8.8 %
Sweden	102	71	44	34	28	17	17	17	17	16	15	15	-85 %	6.2 %	0.5 %	1.1 %
EU-27 (a)	**21,354**	**14,254**	**8,879**	**7,015**	**3,641**	**2,424**	**2,033**	**1,988**	**1,849**	**1,606**	**1,403**	**1,399**	**-93%**	**-0.3%**	**100%**	**100%**
EU-27 (b)	21,354	14,254	8,879	7,015	3,641	2,424	2,033	1,988	1,849	1,606	1,403	1,399				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

The SO_X emission trend in the EU was largely determined by emissions from Poland (28.1% in 2021), Germany (18.2% in 2021), Spain (8.8% in 2020) and France (6.4% in 2021) (see Figure 3.10). SO_X emissions are largely determined by fuel combustion in thermal power plants and industrial installations. The main reductions are due to a shift to fuels with lower sulphur content and retrofitting with desulphurisation installations. After 2010, reductions are also a result of technical improvements to meet the more stringent standards of the Industrial Emissions Directive. In recent years, the shift from the use of fossil fuels to renewable energy sources has also contributed to lower SO_X emissions.

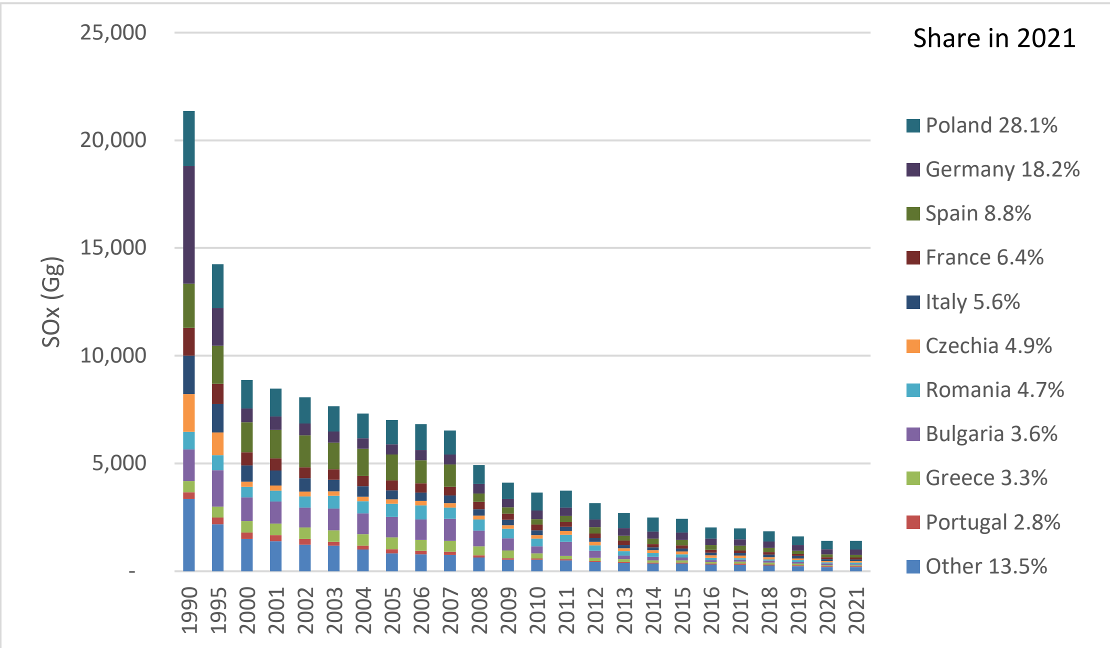
In **Poland**, the main emissions source is public electricity and heat production (1A1a); emissions in this category have decreased by 92% since 1990. Most of the reductions were caused by the decline in heavy industry in the late 1980s and early 1990s. In the late 1990s, the emissions decreased as a result of the diminished share of coal (both hard and brown) among fuels used for power and heat generation. Furthermore, the number of power plants equipped with desulphurisation installations contributed to further SO_X emission decreases. In 2021, SO_X emissions from the residential sector (1A4b) were the second most important emission source (see Poland's IIR, listed in Appendix 5).

In **Germany**, SO_X emissions have decreased by 95% since 1990. The main emission sources are stationary combustion for public electricity and heat production (1A1a), petroleum refining (1A1b), iron and steel production (2C1), manufacturing industries and construction (1A2) and commercial and residential heating (1A4a and 1A4b). All these sectors saw substantial reductions.

Spain reported a SO_X emissions reduction of 94% between 1990 and 2021, which can be mainly attributed to the reductions achieved in public electricity and heat production (1A1a). The reduction is a result of the progressive introduction of desulphurisation abatement techniques in thermal power plants and the shift from coal power plants to combined-cycle gas plants. The sharp drop observed in 2008 was due to the closure of the main brown coal mine in Spain in 2007 and the necessary retrofitting in 2008 of the adjacent thermal plant. Desulphurisation abatement technologies have also been applied to industrial installations with fuel combustion (e.g. chemical industry, non-metallic industry), leading to substantially lower SO_X emissions. The decrease in fugitive SO_X emissions from oil refining and storage (1B2aiv) is linked to the reduction observed in the petroleum refining sector (1A1b) (see Spain's IIR, listed in Appendix 5).

In **France**, SO_X emissions saw a decrease of 93% between 1990 and 2021. The largest reductions occurred in public electricity and heat production (1A1a) and fuel combustion for industrial activities, reflecting the reduction in sulphur content of fossil fuels and abatement technologies. In recent years, the increased importance of renewable energy has also become visible. Fluctuations in SO_X emissions are also a result of climatic conditions (e.g. warm winters) and changes in energy transformations (nuclear power, fossil fuels, renewables) (see France's IIR, listed in Appendix 5).

Figure 3.10 SO_X emission trends in the EU and shares of Member States



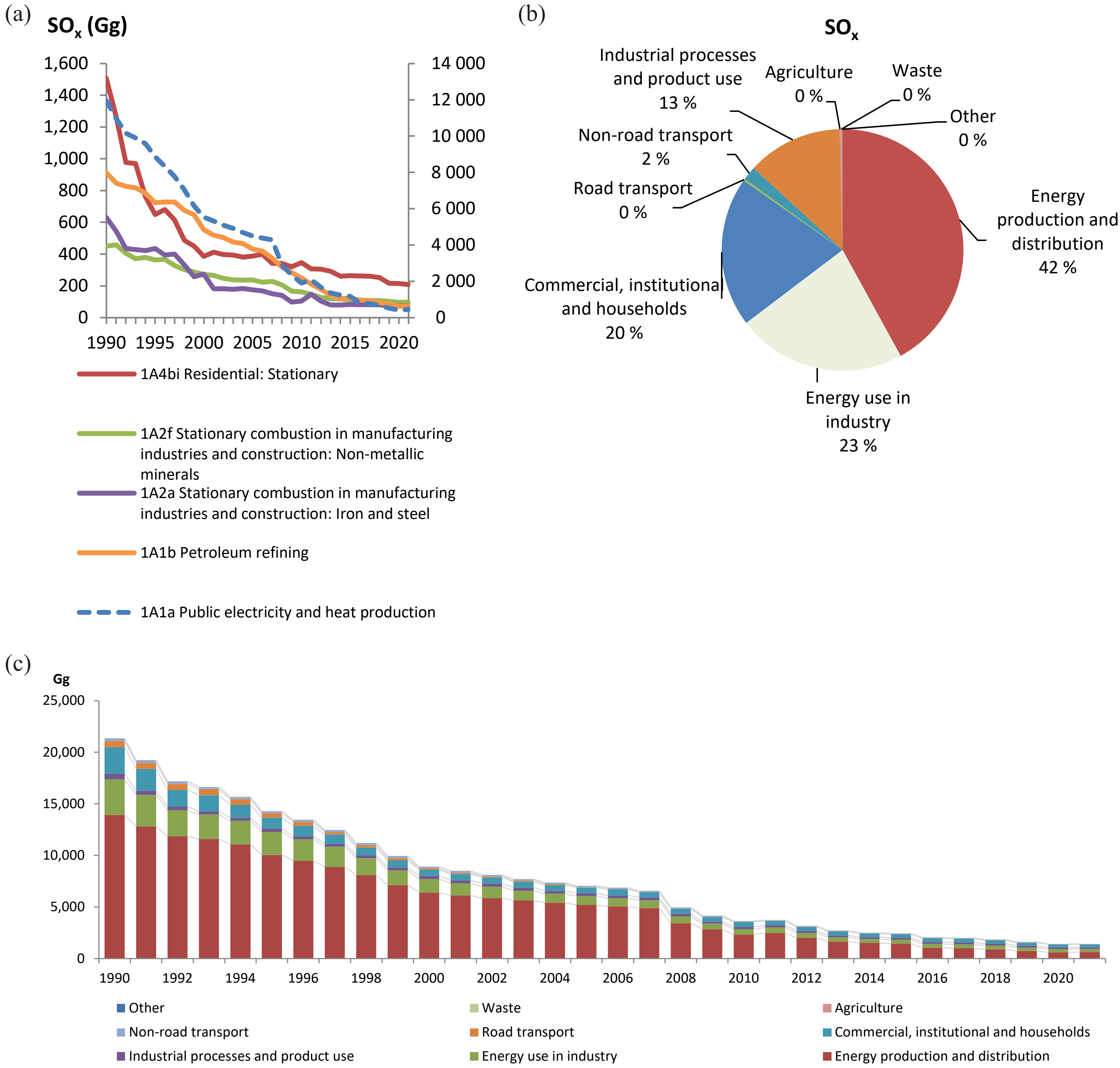
Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

Category '1A1a — Public electricity and heat production' is the most significant key category for SO_X emissions, making up 32% of total SO_X emissions (Figure 3.11(a)). Among the top five key categories, the highest relative reductions in emissions between 1990 and 2021 were achieved in '1A1a — Public electricity and heat production' (96.2%) and '1A1b — Petroleum refining' (92.2%). The other three categories of the top five key categories also saw significant reductions.

Since 1990, several measures have been combined to reduce emissions from these main emitting sources, including switching fuel in energy-related sectors away from high-sulphur solid and liquid fuels to low-sulphur fuels such as natural gas; fitting flue gas desulphurisation (FGD) abatement technology in industrial facilities; and the impact of implementing EU directives relating to the sulphur content of certain liquid fuels (EEA, 2022a).

Figure 3.11(b) shows the contribution made by each aggregated sector group to total EU emissions. For SO_X, the common main emission sources are the energy sectors.

Figure 3.11 SO_X emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Note: In (a), the right-hand axis shows values for '1A1a — Public electricity and heat production'.

3.5 *Ammonia emission trends and key categories*

Between 1990 and 2021, NH_3 emissions dropped by 32% in the EU and, between 2020 and 2021, emissions decreased by 2.4% (see Table 3.6).

This recent decrease (2020-2021) is mainly due to decreases in Poland, Germany, France and Spain (countries ranked according to the size of their contributions to the absolute change), but it should be noted that four countries reported emission increases, with the highest noted for Romania. Between 1990 and 2021, NH_3 emissions decreased in all countries, except Ireland (14%), Luxembourg (0.5%) and Cyprus (0.3%). Ireland reported higher emissions in 2021 than in 1990, mostly in the categories '3Da2a — Animal manure applied to soils' and '3B1b — Manure management — Non-dairy cattle'.

Table 3.6 Member State contributions to EU emissions of NH_3

Member State	NH₃ (Gg)												Change		Share in EU-27	
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	1990—2021	2020—2021	1990	2021
Austria	69	68	64	63	65	66	67	68	67	66	66	66	-5 %	0.5 %	1.4 %	2.0 %
Belgium	132	136	95	80	75	72	72	70	70	68	68	68	-49 %	-0.8 %	2.7 %	2.0 %
Bulgaria	113	52	45	43	37	41	43	43	*43*	*44*	42	43	-62 %	1.4 %	2.3 %	1.3 %
Croatia	50	38	39	41	36	31	29	32	33	31	32	31	-37 %	-0.6 %	1.0 %	0.9 %
Cyprus	6	7	7	7	6	5	5	5	5	5	6	6	4 %	2.5 %	0.1 %	0.2 %
Czechia	136	87	80	74	66	79	79	77	74	70	67	67	-51 %	-0.5 %	2.8 %	2.0 %
Denmark	141	117	104	93	85	79	80	81	80	76	79	71	-50 %	-10.3 %	2.9 %	2.1 %
Estonia	21	10	8	10	11	11	10	10	10	10	10	10	-53 %	0.6 %	0.4 %	0.3 %
Finland	36	35	36	40	38	36	35	34	34	33	32	31	-13 %	-1.5 %	0.7 %	0.9 %
France	675	656	669	627	606	603	603	602	*599*	*580*	560	547	-19 %	-2.3 %	13.8 %	16.4 %
Germany	726	620	633	612	625	644	637	619	591	570	530	516	-29 %	-2.6 %	14.8 %	15.5 %
Greece	91	80	77	75	71	64	64	64	63	63	64	63	-31 %	-1.4 %	1.9 %	1.9 %
Hungary	138	81	87	80	70	76	77	78	77	76	77	77	-44 %	0.0 %	2.8 %	2.3 %
Ireland	111	117	121	120	115	120	125	130	136	126	124	125	13 %	0.7 %	2.3 %	3.7 %
Italy	469	454	457	421	379	357	370	363	351	349	362	351	-25 %	-2.8 %	9.6 %	10.5 %
Latvia	33	16	14	15	15	16	16	16	16	16	16	16	-53 %	-2.1 %	0.7 %	0.5 %
Lithuania	85	41	34	39	38	40	39	39	38	39	40	38	-55 %	-3.8 %	1.7 %	1.1 %
Luxembourg	6	6	7	6	6	6	6	6	6	6	7	7	8 %	-0.1 %	0.1 %	0.2 %
Malta	2	2	2	2	2	1	1	1	*1*	*1*	1	1	-35 %	-0.4 %	0.0 %	0.0 %
Netherlands	344	218	173	154	134	129	130	132	130	125	123	122	-65 %	-1.1 %	7.0 %	3.7 %
Poland	495	375	350	323	300	289	291	304	315	302	310	289	-42 %	-6.8 %	10.1 %	8.7 %
Portugal	73	70	73	62	57	58	58	59	59	60	61	61	-16 %	0.1 %	1.5 %	1.8 %
Romania	320	216	176	194	169	170	166	164	162	159	156	159	-50 %	1.6 %	6.5 %	4.8 %
Slovakia	58	38	33	32	28	28	29	31	31	30	27	25	-56 %	-6.3 %	1.2 %	0.8 %
Slovenia	24	22	22	21	20	19	19	19	19	19	18	18	-22 %	-0.1 %	0.5 %	0.6 %
Spain	489	492	573	509	456	471	471	488	484	478	491	479	-2 %	-2.4 %	10.0 %	14.3 %
Sweden	60	61	60	57	54	54	52	53	53	52	52	51	-15 %	-1.9 %	1.2 %	1.5 %
EU-27 (a)	**4,902**	**4,115**	**4,040**	**3,799**	**3,566**	**3,565**	**3,576**	**3,590**	**3,548**	**3,455**	**3,419**	**3,336**	**-32%**	**-2.4%**	**100%**	**100%**
EU-27 (b)	4,902	4,115	4,040	3,799	3,566	3,565	3,576	3,590	3,548	3,455	3,419	3,336				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to NH_3 emissions were France, Germany, Spain and Italy (countries ranked according to their shares of the EU total) (see Figure 3.12). NH_3 emissions are mainly the result of agricultural activities resulting from manure management (3B) and application of fertiliser to soils (3D). For the EU-27, both categories show a decrease between 1990 and 2021. Factors driving the emission trend are mainly the number of livestock and changes in manure management practices, feeding practices and abatement technologies in fertiliser application.

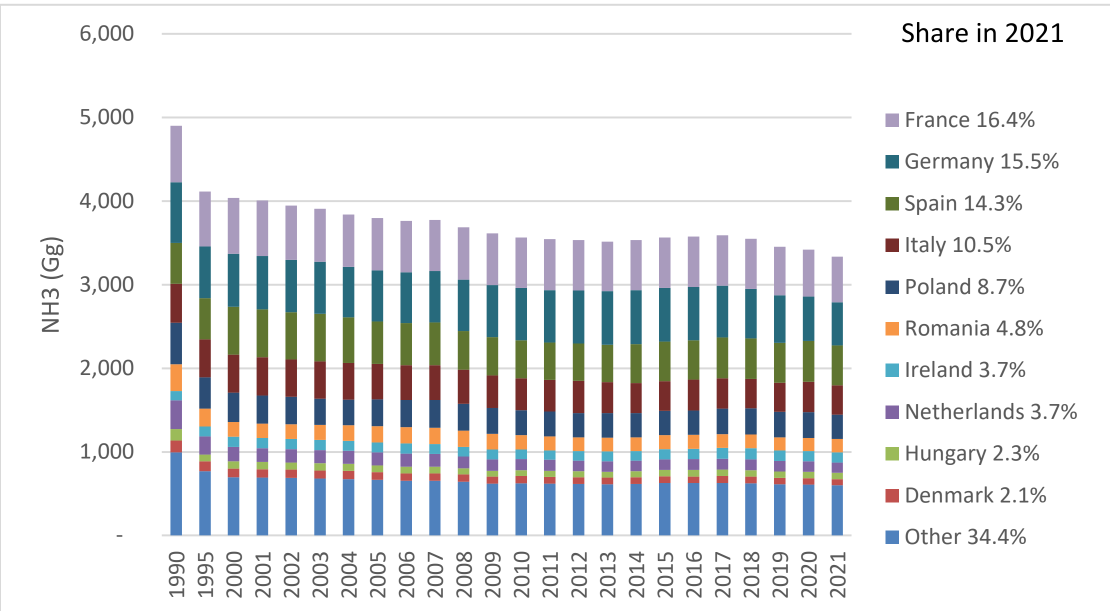
The decrease in NH_3 emissions in **France** (19% between 1990 and 2021) is mainly driven by changes in agricultural activities, primarily to the use of mineral fertilisers and a drop in the total amount of mineral nitrogen applied. The second item contributing to this drop is a reduction in the area of pasture, mainly in connection with the decline in livestock. Lastly, emissions related to the spreading of manure are also low, combining both a drop in the amount of manure spread and a drop in livestock numbers, but also an increase in spreading practices with lower emissions. Emissions related to the spreading of manure produced by animals reared in France are decreasing more rapidly than the associated quantity of nitrogen spread. Manure management (3B) has also seen its emissions drop by 22% between 1990 and 2021. This change is observed mainly in dairy cows, in connection with the decline in numbers. Notable reductions are also found in pigs because of the increase in biphasic feeding and the nitrification and denitrification of effluents, and in poultry, with the gradual disappearance until 2006 of deep pit systems for laying hens (which have very high emissions), the change in feed composition resulting in a drop in the nitrogen excreted for certain categories of poultry, and a very sharp drop in the size of the turkey herd over the period (see France's IIR, listed in Appendix 5).

Germany reported a decrease in NH_3 emissions since 1990 of 29%. The biggest emission sources in 1990 and 2021 were manure management (3B) and application of fertiliser to soils, which includes animal manure (3Da2a) and inorganic nitrogen fertiliser (3Da1) (see Germany's IIR, listed in Appendix 5).

In **Spain**, NH_3 emissions decreased by 2% between 1990 and 2021 and by 2.4% between 2020 and 2021. In the period 1990-1996, a decline was observed, related to a significant economic recession in Spain together with a period of drought (the fact that fertilisation intensifies drought stress implies a decrease in the size of the fertiliser market during poor rainfall periods). From 1996 onwards, the trend continued steadily, reaching maximum levels in the period 2000-2004. During these years, the number of non-dairy cattle had increased significantly relative to 1990, as had the white swine population. This led to higher NH_3 emissions not only from livestock but also from application of animal manure to soils. Decreases in the following years are a combination of factors: a second period of drought (2005-2008), an economic downturn (as of 2007), a change in fertiliser application practices, a reduction in the number of non-dairy cattle (3B1b), the progressive introduction of abatement techniques in white swine manure management (3B3), improvements in animal feed formulations and the enforcement of animal welfare legislation affecting laying hens since 2010. The recent upwards trend in NH_3 emissions is driven by increases in fertiliser application and changes in livestock practices (see Spain's IIR, listed in Appendix 5).

In **Italy**, in 2021, agriculture was the main source of emissions, contributing 95% of the total NH_3 emissions. During the period 1990-2021, emissions from this sector show a decrease of 26%. Emissions from road transport show a strong increase, but the share of the total is 1.5%. Emissions from waste treatment and disposal, accounting for only 2.6% of the total, show an increase of about 77% because of the increase in NH_3 emissions from anaerobic digestion at biogas facilities. Specifically, emissions from agriculture have decreased because of the reduction in the number of animals and the trend in agricultural production, and the introduction of abatement technologies due to the implementation of the EU Integrated Pollution Prevention and Control Directive (EU, 1996). In recent years, a further reduction in emissions has been the result of the implementation of EU rural development programmes, which provide incentives to introduce good practices and technologies for protecting the environment and mitigating greenhouse gas and NH_3 emissions. The decrease in emissions of 2.8% between 2020 and 2021 is mainly due to lower NH_3 emissions reported for the use of inorganic fertiliser (3Da1) (see Italy's IIR, listed in Appendix 5).

Figure 3.12 NH_3 emission trends in the EU and shares of Member States

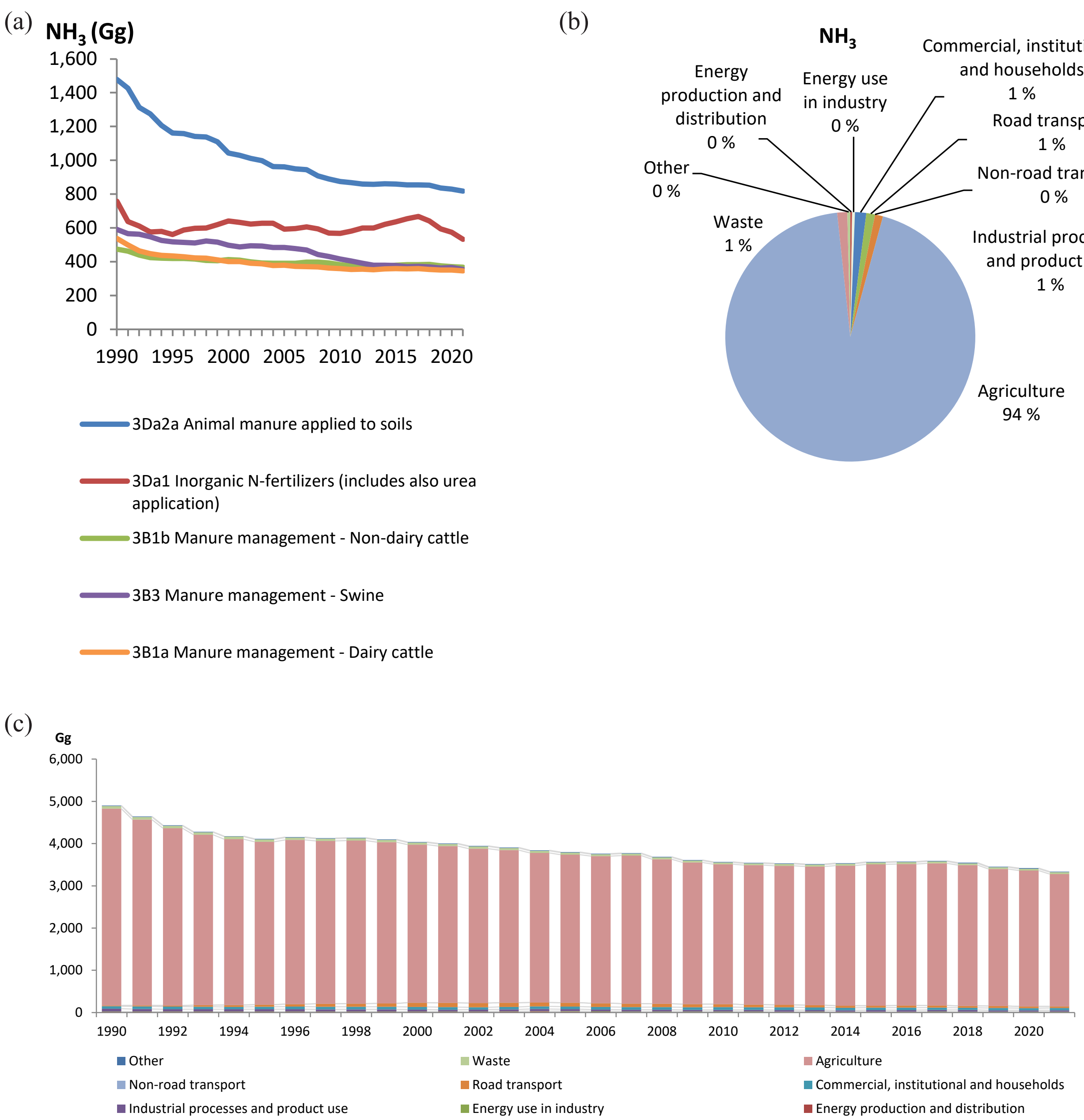


Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

The principal key categories for NH_3 emissions are '3Da2a — Animal manure applied to soils', '3Da1 — Inorganic N fertilisers' and '3B1b — Manure management — Non-dairy cattle'. They jointly make up 52% of total NH_3 emissions (see Figure 3.13 (a)). Among the top five key categories, the highest relative reduction in emissions between 1990 and 2021 occurred in '3Da2a — Animal manure applied to soils' (44.7%). There were also large reductions in emissions in the fourth most important category '3B3 — Manure management — Swine' (40%).

Figure 3.13(b) shows the contribution made by each aggregated sector group to total EU emissions. A single sector group — agriculture — is responsible for most (94%) of the NH_3 emissions in the EU.

Figure 3.13 **NH_3 emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions**



Note: In (a), the right-hand axis shows values for '1A1a — Public electricity and heat production'.

3.6 *Fine particulate matter emission trends and key categories*

Between 2000 and 2021, $PM_{2.5}$ emissions dropped by 31% in the EU, and between 2020 and 2021, emissions increased by 2% (see Table 3.7), mainly because emissions increased in France, Romania, Italy and Germany (countries ranked according to the size of their contributions to the absolute change). Decreases have been reported by Poland, Croatia([21]), the Netherlands and Sweden in in 2021.

Table 3.7 Member State contributions to EU emissions of $PM_{2.5}$

Member State	$PM_{2.5}$ (Gg)														Change		Share in EU-27	
	2000	2001	2002	2003	2004	2005	2010	2015	2016	2017	2018	2019	2020	2021	2000—2021	2020—2021	2000	2021
Austria	24	25	24	24	23	23	20	16	16	15	14	14	13	14	-43%	4%	1.3 %	1.0 %
Belgium	40	39	36	37	37	34	30	22	22	20	19	18	17	18	-54%	10%	2.1 %	1.4 %
Bulgaria	35	32	37	40	40	39	35	34	31	31	30	30	31	31	-13%	-3%	1.8 %	2.3 %
Croatia	36	39	38	44	42	44	38	32	31	29	29	27	28	27	-25%	-5%	1.8 %	2.0 %
Cyprus	2	2	2	2	2	2	2	1	1	1	1	1	1	1	-60%	9%	0.1 %	0.1 %
Czechia	50	51	48	48	47	44	45	31	30	30	29	27	25	24	-51%	-2%	2.6 %	1.8 %
Denmark	20	20	20	21	21	21	21	17	17	16	14	13	12	12	-41%	0%	1.1 %	0.9 %
Estonia	11	11	11	10	9	8	11	7	6	6	6	5	5	5	-55%	-6%	0.6 %	0.4 %
Finland	26	27	27	27	27	26	23	17	18	17	17	16	14	14	-45%	1%	1.3 %	1.1 %
France	376	373	352	362	353	335	294	220	223	212	200	195	172	189	-50%	10%	19.4 %	14.2 %
Germany	165	159	153	146	141	135	119	103	97	96	95	90	81	83	-50%	2%	8.5 %	6.3 %
Greece	66	70	69	68	69	68	47	42	39	39	37	36	34	36	-46%	4%	3.4 %	2.7 %
Hungary	48	52	38	46	43	40	50	51	49	47	41	38	37	38	-22%	2%	2.5 %	2.8 %
Ireland	19	19	18	18	18	19	16	14	14	13	14	13	13	13	-34%	0%	1.0 %	1.0 %
Italy	205	197	181	185	165	186	213	169	162	170	156	151	144	149	-27%	4%	10.6 %	11.2 %
Latvia	27	28	28	29	30	27	21	16	17	18	19	18	17	18	-34%	5%	1.4 %	1.3 %
Lithuania	7	7	8	8	8	9	9	9	9	9	9	8	7	7	2%	-1%	0.4 %	0.5 %
Luxembourg	2	3	2	3	3	3	2	1	1	1	1	1	1	1	-51%	8%	0.1 %	0.1 %
Malta	1	1	1	1	1	1	1	0	0	1	0	0	0	0	-48%	1%	0.0 %	0.0 %
Netherlands	35	33	32	31	30	29	23	18	18	17	17	16	15	14	-59%	-5%	1.8 %	1.1 %
Poland	293	305	311	304	311	322	360	297	307	300	373	324	307	297	1%	-3%	15.1 %	22.3 %
Portugal	66	63	63	60	60	58	50	47	46	47	47	46	44	45	-31%	3%	3.4 %	3.4 %
Romania	106	87	90	106	119	120	129	109	109	110	109	111	110	116	9%	6%	5.5 %	8.7 %
Slovakia	44	43	32	32	30	36	26	21	21	21	17	18	17	19	-57%	7%	2.2 %	1.4 %
Slovenia	14	16	14	15	14	16	15	13	13	12	11	11	10	10	-29%	0%	0.7 %	0.8 %
Spain	185	178	172	188	173	167	161	153	134	134	149	130	133	135	-27%	1%	9.6 %	10.1 %
Sweden	34	33	32	32	31	31	26	19	19	19	18	18	17	16	-53%	-6%	1.7 %	1.2 %
EU-27 (a)	**1,940**	**1,912**	**1,839**	**1,885**	**1,846**	**1,844**	**1,786**	**1,480**	**1,451**	**1,433**	**1,473**	**1,375**	**1,306**	**1,333**	**-31%**	**2%**	**100 %**	**100 %**
EU-27 (b)	1,940	1,912	1,839	1,885	1,846	1,844	1,786	1,480	1,451	1,433	1,473	1,375	1,306	1,333				

Notes: The Air Convention formally requests Parties to report emissions of PM for 2000 and thereafter.
([a]) Sum of national totals, as reported by EU Member States.
([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to $PM_{2.5}$ emissions were Poland, France, Italy and Spain (countries ranked according to their shares of the EU total) (see Figure 3.13). The emission decrease of 31% between 2000 and 2021 can be attributed to reductions achieved in stationary fuel combustion in public electricity and heat production (1A1a) and road transport (1A3) as a result of EU directives introduced for installations as well as the transport sector. The reduction in emissions from the heating of buildings (1A4a and 1A4b) is mainly caused by a shift in fuel type and improved heating facilities.

In **Poland**, $PM_{2.5}$ emissions increased by 1% between 2000 and 2021. The main source of emissions is the burning of coal and wood by households (1A4), representing 74% of total $PM_{2.5}$ emissions in 2021.

Italy reported $PM_{2.5}$ emission decreases of 27% between 2000 and 2021, but an increase of 4% during the last year. In 2000, $PM_{2.5}$ emissions were mainly the result of residential heating of buildings (1A4b). $PM_{2.5}$ emissions resulting from road transport (1A3), stationary combustion (1A1a and 1A2) and agriculture activities (1A4c) have been substantially reduced since 2000. This is due to the introduction of EU directives controlling and limiting PM emissions from car exhaust pipes and the introduction of two regulatory instruments (introduction of plant emission limits) (see Italy's IIR, listed in Appendix 5).

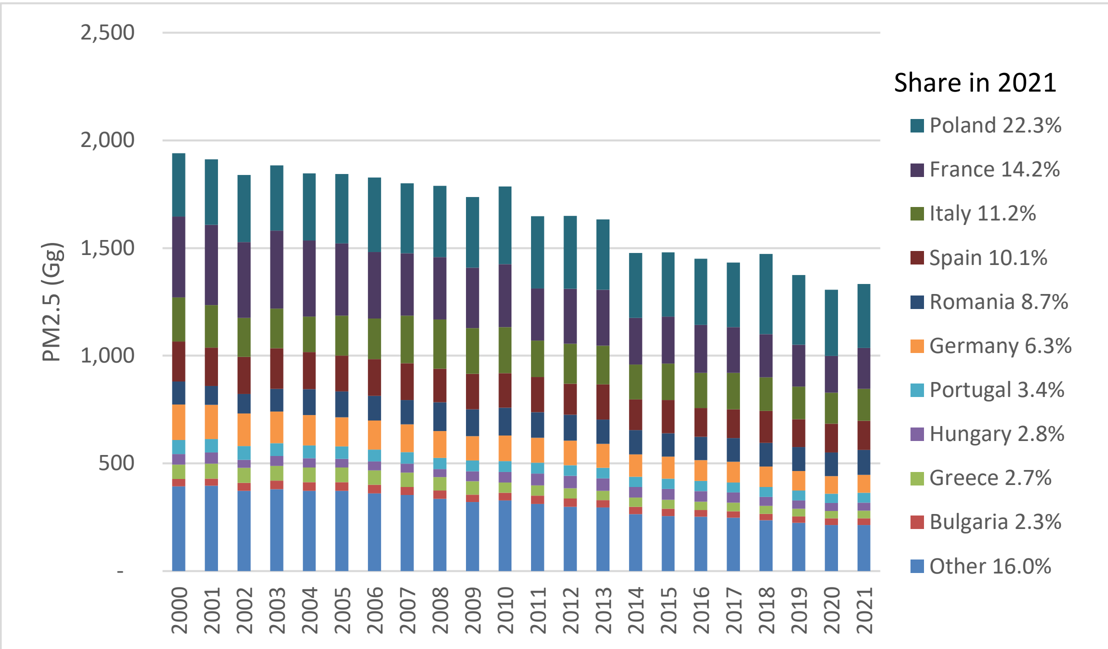
Spain reported a decrease of 27% in $PM_{2.5}$ emissions since 2000. While in 2000, commercial and residential heating (1A4a and 1A4b) was the highest contributing sector, this changed in 2021, when $PM_{2.5}$ emissions from burning of waste (5C) were the most relevant. The most relevant reduction in emissions affected passenger cars and heavy duty vehicles as a result of the introduction of Euro standards. $PM_{2.5}$ emissions

([21]) Croatia had not submitted data on time, and hence the data for this Member State have entirely been gap filled.

related to industrial activities are linked to the economic downturn (from 2008), the shift from fossil liquid fuels to a more predominant gas consumption and the installation of abatement techniques. In addition, the restriction of field burning (3F) due to the introduction of legislation to prevent forest fires had an effect.

France showed the most $PM_{2.5}$ reductions in absolute terms between 2000 and 2021, namely -187Gg (50%). $PM_{2.5}$ emissions from the heating of buildings (1A4b) was the most relevant source category, showing a reduction of 41% between 2000 and 2021. This decrease is linked to the improved performance of individual wood-burning equipment in the residential sector. The transport sector also contributed to the decline observed due to the decrease in the number of vehicles, the growing share of diesel vehicles equipped with particulate filters in recent years, the implementation of the Euro standards and the strengthening of these standards in recent years. In the industrial sector, the reductions are mainly found in the mineral production sector and are explained by the installation of dust collectors on several sites.

Figure 3.14 $PM_{2.5}$ emission trends in the EU and shares of Member States



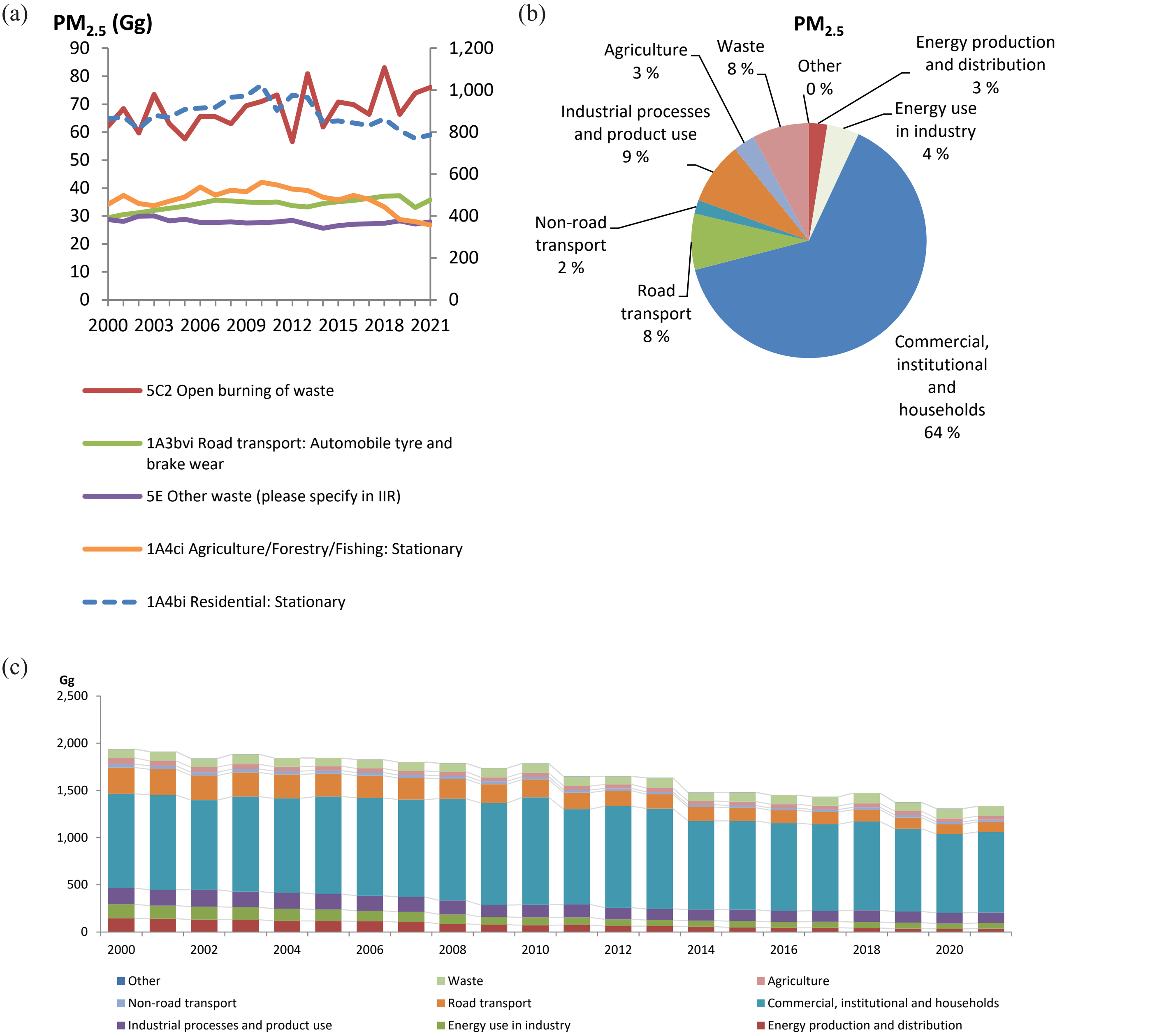
Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

Domestic fuel use in '1A4bi — Residential: Stationary' is the principal key category for $PM_{2.5}$ emissions, making up 59% of the total (Figure 3.15 (a)). Among the top five key categories, the highest relative reduction in emissions between 2000 and 2021 was in '1A4ci — Agriculture/forestry/fishing: Stationary' (21.7%), but reductions also occurred in '1A4bi — Residential: Stationary' and '5E — Other waste' (8.7% and 2.9%, respectively).

In contrast, emissions from '1A3bvi — Road transport: Automobile tyre and brake wear' (21.5%) and '5C2 — Open burning of waste' (22.6%) have increased significantly since 1990.

Figure 3.15(b) shows the contribution to total EU emissions made by each aggregated sector group. The commercial, institutional and households sector group is a major source of $PM_{2.5}$, as well as PM_{10}, CO and PCDD/Fs.

Figure 3.15 $PM_{2.5}$ emissions in the EU: (a) trends in emissions from the five most important key categories, 2000-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Notes: In (a), the right-hand axis shows values for '1A4bi — Residential: Stationary'.

The Air Convention formally requests Parties to report emissions of PM for 2000 and thereafter.

3.7 Particulate matter emission trends and key categories

Between 2000 and 2021, PM_{10} emissions decreased by 29% in the EU. Between 2020 and 2021, the increase was 1% (see Table 3.8), mainly because emissions increased in France, Romania, Spain and Latvia (countries ranked according to the size of their contributions to the absolute change).

Table 3.8 Member State contributions to EU emissions of PM_{10}

Member State	PM_{10} (Gg)										Change		Share in EU-27	
	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2000—2021	2020—2021	2000	2021
Austria	40	38	34	29	29	29	28	28	27	28	-30%	4%	1.4 %	1.4 %
Belgium	55	46	40	31	31	29	28	27	26	27	-50%	8%	1.9 %	1.4 %
Bulgaria	63	69	49	51	44	43	43	44	45	43	-31%	-3%	2.2 %	2.1 %
Croatia	48	57	53	40	44	38	42	35	51	50	5%	-3%	1.7 %	2.5 %
Cyprus	5	4	3	2	2	2	2	2	2	2	-59%	6%	0.2 %	0.1 %
Czechia	70	61	60	44	43	43	42	41	37	37	-48%	-2%	2.5 %	1.8 %
Denmark	33	33	33	27	27	26	26	23	22	22	-31%	0%	1.1 %	1.1 %
Estonia	27	18	22	15	13	14	14	12	13	12	-56%	-4%	1.0 %	0.6 %
Finland	43	42	38	31	32	31	31	30	27	28	-35%	5%	1.5 %	1.4 %
France	481	431	379	301	305	296	282	278	248	270	-44%	9%	16.9 %	13.4 %
Germany	303	249	228	216	201	204	209	196	182	184	-39%	1%	10.7 %	9.1 %
Greece	127	123	89	68	67	65	59	58	56	57	-55%	1%	4.5 %	2.8 %
Hungary	72	71	71	72	69	65	60	58	54	53	-26%	-1%	2.5 %	2.6 %
Ireland	39	43	36	31	31	31	31	30	30	31	-22%	1%	1.4 %	1.5 %
Italy	293	290	341	248	227	237	262	215	220	200	-32%	-9%	10.3 %	9.9 %
Latvia	32	36	29	27	26	27	28	28	26	29	-8%	11%	1.1 %	1.4 %
Lithuania	9	27	21	30	24	23	30	27	28	25	184%	-10%	0.3 %	1.2 %
Luxembourg	3	3	3	2	2	2	2	2	2	2	-41%	6%	0.1 %	0.1 %
Malta	1	2	1	1	1	1	1	1	2	1	24%	-14%	0.0 %	0.1 %
Netherlands	50	43	36	32	31	31	31	30	28	26	-48%	-5%	1.8 %	1.3 %
Poland	406	435	473	395	406	402	474	421	396	388	-5%	-2%	14.3 %	19.2 %
Portugal	84	74	67	58	58	57	58	58	57	58	-30%	3%	2.9 %	2.9 %
Romania	139	158	165	145	143	143	146	151	149	157	13%	5%	4.9 %	7.8 %
Slovakia	54	45	33	29	27	28	23	24	24	25	-54%	3%	1.9 %	1.2 %
Slovenia	18	21	18	15	15	15	14	13	13	14	-21%	9%	0.6 %	0.7 %
Spain	295	285	244	238	215	212	230	211	212	215	-27%	2%	10.4 %	10.7 %
Sweden	53	51	44	37	38	39	38	37	35	35	-34%	-2%	1.9 %	1.7 %
EU-27 (a)	**2,841**	**2,752**	**2,609**	**2,213**	**2,150**	**2,133**	**2,232**	**2,079**	**2,009**	**2,020**	**-29%**	**1%**	**100 %**	**100 %**
EU-27 (b)	2,841	2,752	2,609	2,213	2,150	2,133	2,232	2,079	2,009	2,020				

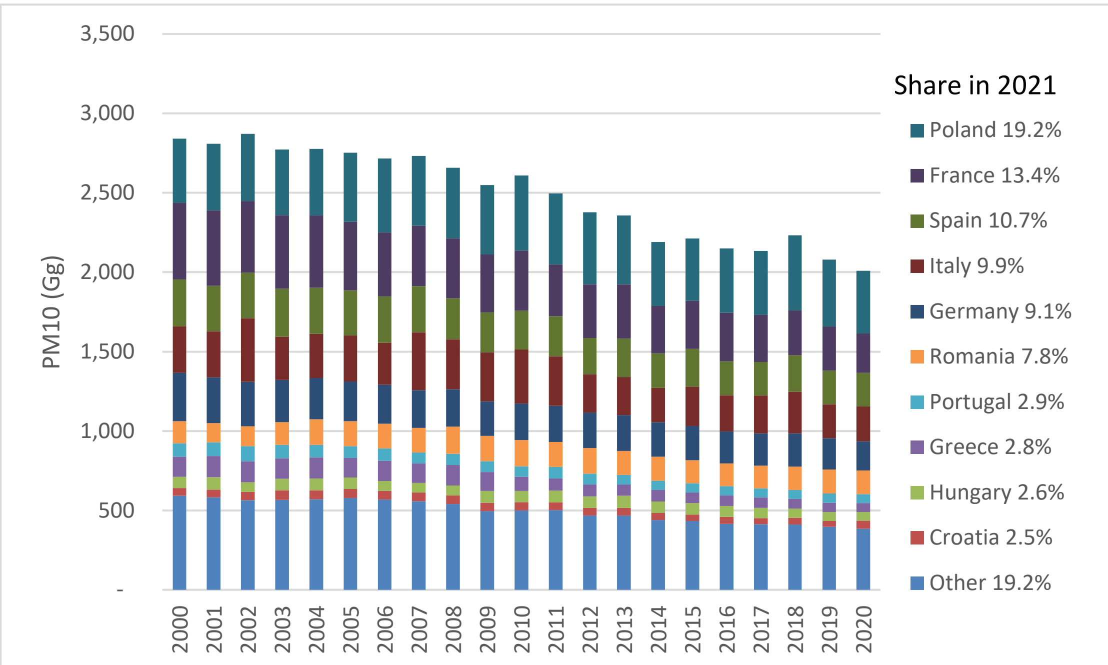
Notes: The Air Convention formally requests Parties to report emissions of PM for 2000 and thereafter.

([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to PM_{10} emissions were Poland, France, Spain and Italy (countries ranked according to their shares of the EU total) (see Figure 3.15).

Figure 3.16 PM_{10} emission trends in the EU and shares of Member States

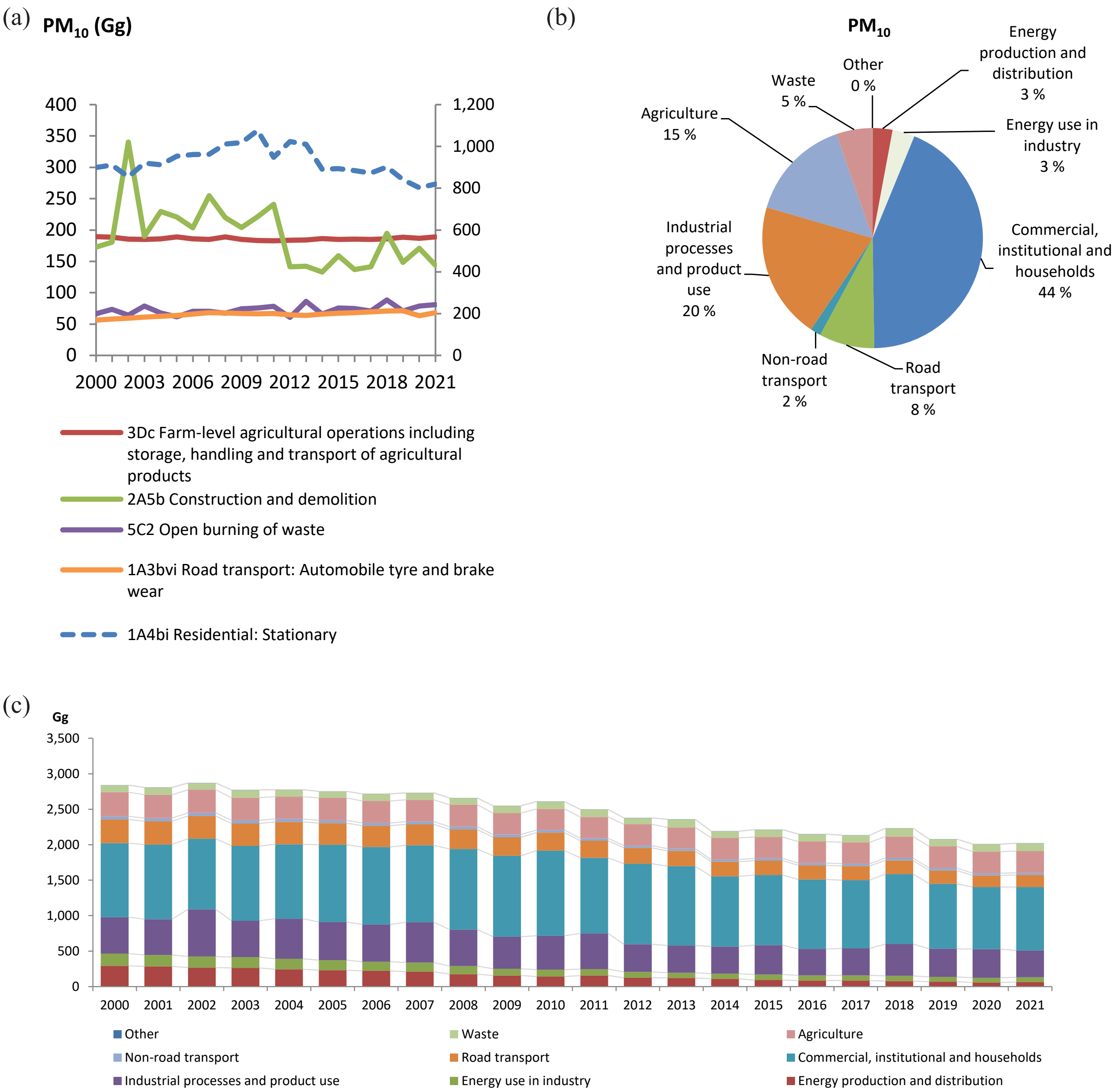


Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

As for $PM_{2.5}$, '1A4bi — Residential: Stationary' is the most significant key category for PM_{10} emissions, accounting for 41% of total PM_{10} emissions (see Figure 3.17 (a)). Among the top five key categories, the highest relative reduction in emissions between 1990 and 2021 was in the third most important '2A5b — Construction and demolition' (16.7%). Reductions in emissions were also observed in the categories '3Dc — Farm-level agricultural operations including storage, handling and transport of agricultural products' (0.5%) and '1A4bi — Residential: Stationary' (8.9%). The emissions of the categories '5C2 — Open burning of waste' (21.6%) and '1A3bvi — Road transport: Automobile tyre and brake wear' (21.5%) have increased since 1990.

Figure 3.17(b) shows the contribution of each aggregated sector group to total EU emissions. The commercial, institutional and households sector group is a major source of $PM_{2.5}$ and of PM_{10}, CO, PAHs and PCDD/Fs.

Figure 3.17 PM_{10} emissions in the EU: (a) trends in emissions from the five most important key categories, 2000-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Notes: In (b), the right-hand axis shows values for '1A4bi — Residential: Stationary'.

The Air Convention formally requests Parties to report emissions of PM for 2000 and thereafter.

3.8 *Total suspended particulate emission trends*

Between 2000 and 2021, TSP emissions dropped by 27% in the EU. Between 2020 and 2021, emissions decreased by 1.2% (Table 3.9), mainly because of decreases in Italy, Hungary, Romania, and Bulgaria (countries ranked according to the size of their contributions to the absolute change).

Table 3.9 Member State contributions to EU emissions of TSPs

	TSPs (Gg)														Change		Share in EU—27	
Member State	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2000—2021**	**2020—2021**	**2000**	**2021**
Austria	60	57	50	49	48	47	47	46	46	47	45	46	44	46	-23 %	5.0 %	1.2 %	1.3%
Belgium	81	70	57	50	50	52	46	47	48	46	46	45	43	46	-43 %	6.4 %	1.7 %	1.3%
Bulgaria	120	137	72	86	77	69	84	95	64	66	71	76	70	66	-45 %	-5.3 %	2.5 %	1.9%
Croatia	72	84	81	72	75	78	75	54	67	51	69	45	101	99	38 %	-1.8 %	1.5 %	2.8%
Cyprus	10	7	6	5	4	3	3	3	3	3	3	4	3	3	-64 %	4.8 %	0.2 %	0.1%
Czechia	96	78	74	73	72	72	69	56	54	55	54	52	48	47	-51 %	-1.2 %	2.0 %	1.3%
Denmark	102	95	97	93	91	90	92	87	86	92	91	88	84	84	-17 %	-0.1 %	2.1 %	2.4%
Estonia	64	32	33	48	31	33	28	25	22	24	26	23	27	26	-60 %	-2.6 %	1.3 %	0.7%
Finland	56	57	54	51	48	49	48	45	47	45	45	45	39	43	-23 %	9.6 %	1.2 %	1.2%
France	1,103	1,031	946	901	913	909	851	865	878	872	851	846	788	827	-25 %	5.0 %	23.0 %	23.6%
Germany	528	430	390	396	390	400	390	385	358	369	383	358	336	337	-36 %	0.2 %	11.0 %	9.6%
Greece	245	230	169	124	113	114	127	118	126	120	104	108	107	105	-57 %	-1.6 %	5.1 %	3.0%
Hungary	104	131	106	101	90	103	106	104	99	90	88	87	78	72	-31 %	-7.8 %	2.2 %	2.0%
Ireland	86	101	81	59	61	61	60	62	63	67	65	66	65	67	-23 %	3.0 %	1.8 %	1.9%
Italy	432	480	623	630	341	356	306	406	348	370	494	336	373	286	-34 %	-23.3 %	9.0 %	8.2%
Latvia	40	56	46	56	55	49	49	53	47	45	46	47	46	55	38 %	20.5 %	0.8 %	1.6%
Lithuania	13	20	19	19	18	19	19	19	19	19	19	17	17	17	36 %	2.0 %	0.3 %	0.5%
Luxembourg	4	4	3	3	3	3	3	3	3	3	3	3	2	2	-38 %	6.3 %	0.1 %	0.1%
Malta	2	4	3	3	3	3	3	3	4	4	4	5	6	5	157 %	-17.4 %	0.0 %	0.1%
Netherlands	57	51	44	42	40	39	38	37	36	36	35	34	32	30	-46 %	-5.5 %	1.2 %	0.9%
Poland	572	589	614	594	608	567	530	515	527	533	604	552	510	510	-11 %	0.0 %	11.9 %	14.5%
Portugal	139	128	116	137	128	105	93	92	96	93	94	95	94	95	-31 %	1.8 %	2.9 %	2.7%
Romania	234	298	288	286	284	257	260	237	219	207	225	235	241	232	-1 %	-3.6 %	4.9 %	6.6%
Slovakia	75	61	43	40	41	40	31	41	35	37	31	31	32	32	-57 %	0.8 %	1.6 %	0.9%
Slovenia	25	30	26	24	22	21	16	17	20	20	19	19	19	20	-20 %	5.3 %	0.5 %	0.6%
Spain	406	414	320	340	308	311	289	326	283	287	308	296	289	297	-27 %	2.7 %	8.5 %	8.5%
Sweden	71	69	62	65	59	63	57	56	58	59	59	57	55	55	-23 %	-0.2 %	1.5 %	1.6%
EU-27 (a)	**4,796**	**4,744**	**4,420**	**4,346**	**3,974**	**3,911**	**3,719**	**3,799**	**3,658**	**3,660**	**3,881**	**3,615**	**3,549**	**3,507**	**-27%**	**-1.2%**	**100 %**	**100 %**
EU-27 (b)	4,796	4,744	4,420	4,346	3,974	3,911	3,719	3,799	3,658	3,660	3,881	3,615	3,549	3,507				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to TSP emissions were France and Poland (countries ranked according to their shares of the EU total).

Poland described that the main source of TSP emissions are stationary combustion processes, which account for the majority of national emissions. Since 1990, TSP emissions have decreased by 11%. In 2021, emissions decreased by only 0.01% relative to 2020. The largest increase in TSP emissions in relation to 2020 occurred in the '2A — Mineral industry' category and was related to the increase in the number of newly built roads in 2021 (see Poland's IIR, listed in Appendix 5).

Germany explained that, between 2000 and 2021, TSP emissions dropped by 36% because of the application of the former West Germany's stricter regulations in the new German *Länder*, following Germany's reunification, the transition from solid to gaseous and liquid fuels, and improved filter technologies for combustion plants and industrial processes (see Germany's IIR, listed in Appendix 5).

France explained that the reported drop in TSP emissions between 1990 and 2021 was mainly linked to improvements in wood-burning equipment in the residential sector. Improvements in the transport sector (increase in the number of diesel vehicles with particulate filters) in recent years also contributed to this decrease in TSP emissions.

3.9 Black carbon emission trends

Between 2000 and 2021, BC emissions dropped by 44% in the EU (see Table 3.10). Between 2020 and 2021, emissions increased by 2.5%, mainly because of slightly higher emissions from France, Italy, Romania and Spain (countries ranked according to the size of their contributions to the absolute change).

Table 3.10 Member State contributions to EU emissions of BC

	Black Carbon (Gg)										Change		Share in EU-27	
Member State	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2000—2021**	**2020—2021**	**2000**	**2021**
Austria														
Belgium	8.7	7.8	6.8	4.1	3.9	3.4	3.1	2.8	2.4	2.6	-70 %	8.1 %	2.8 %	1.3 %
Bulgaria	3.0	3.9	3.8	3.8	3.9	3.8	3.6	3.5	3.8	3.8	26 %	-0.2 %	0.9 %	2.0 %
Croatia	5.4	6.4	5.4	4.4	4.3	4.2	3.9	3.8	3.7	3.5	-36 %	-6.5 %	1.4 %	1.8 %
Cyprus	0.6	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-64 %	10.8 %	0.2 %	0.1 %
Czechia	6.5	6.3	5.9	4.0	3.9	3.9	3.8	3.6	3.4	3.4	-48 %	-0.7 %	4.7 %	1.8 %
Denmark	4.0	3.8	3.3	2.5	2.4	2.3	2.1	1.9	1.8	1.8	-56 %	-1.2 %	1.3 %	0.9 %
Estonia	2.1	1.8	1.8	1.3	1.4	1.3	1.3	1.2	1.3	1.2	-42 %	-3.7 %	0.7 %	0.6 %
Finland	6.5	5.9	5.5	4.1	4.3	4.1	3.9	3.8	3.2	3.4	-48 %	6.5 %	2.6 %	1.8 %
France	77.7	67.5	58.3	42.8	41.5	38.2	35.5	34.0	29.2	32.0	-59 %	9.7 %	20.7 %	16.6 %
Germany	38.1	30.9	22.5	15.8	14.7	13.7	12.3	11.5	10.1	9.9	-74 %	-2.1 %	13.6 %	5.1 %
Greece	11.0	12.0	10.4	9.2	8.9	8.9	8.7	8.6	8.1	8.4	-24 %	3.6 %	2.8 %	4.4 %
Hungary	8.2	7.5	8.5	8.0	7.7	7.4	6.5	6.0	5.7	5.8	-28 %	2.7 %	2.1 %	3.0 %
Ireland	3.9	3.6	2.7	2.3	2.2	1.9	1.9	1.7	1.6	1.6	-59 %	-1.5 %	1.1 %	0.8 %
Italy	43.8	39.8	33.5	23.8	22.7	22.1	20.1	20.0	18.0	18.7	-57 %	4.2 %	12.3 %	9.7 %
Latvia	3.4	3.4	2.7	2.0	2.0	2.2	2.3	2.2	2.0	2.0	-40 %	2.4 %	1.0 %	1.0 %
Lithuania	2.4	2.5	2.5	2.6	2.5	2.5	2.4	2.0	1.9	1.9	-21 %	-0.1 %	0.8 %	1.0 %
Luxembourg														
Malta	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-52 %	-1.4 %	0.0 %	0.0 %
Netherlands	10.6	8.5	5.6	3.5	3.3	3.1	2.9	2.6	2.4	2.3	-79 %	-6.2 %	3.5 %	1.2 %
Poland	20.5	21.8	24.1	19.6	20.6	21.0	22.7	20.7	19.4	18.3	-11 %	-5.5 %	5.9 %	9.5 %
Portugal	11.4	9.6	8.5	7.0	6.9	6.9	6.7	6.6	5.6	5.9	-48 %	4.5 %	2.3 %	3.0 %
Romania	12.5	14.1	15.0	12.9	13.0	13.3	13.2	13.1	12.9	13.7	10 %	6.5 %	1.5 %	7.1 %
Slovakia	3.9	4.2	3.9	2.8	2.7	2.8	2.3	2.4	2.2	2.4	-38 %	7.7 %	2.1 %	1.3 %
Slovenia	2.6	3.0	2.8	2.4	2.3	2.2	2.0	1.8	1.7	1.7	-35 %	-0.5 %	0.6 %	0.9 %
Spain	53.0	49.9	52.3	46.6	44.1	42.7	51.7	41.9	45.3	46.2	-13 %	2.0 %	13.4 %	24.0 %
Sweden	5.5	4.8	4.0	2.7	2.6	2.5	2.2	2.1	2.0	1.9	-66 %	-4.7 %	1.8 %	1.0 %
EU-27 (a)	**345**	**320**	**291**	**229**	**222**	**215**	**215**	**198**	**188**	**193**	**-44 %**	**2.5 %**	**100 %**	**100 %**
EU-27 (b)	345	320	291	229	222	215	215	198	188	193				

Notes: Dark blue-shaded cells indicate that no emission values are available. See Appendix 1 for an explanation of the notation keys reported by EU Member States.

([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to BC emissions were Spain and France (countries ranked according to their shares of the EU total). As Austria and Luxembourg did not provide data for BC, these gaps could not be filled with data. Thus, the EU total is an underestimate.

3.10 Carbon monoxide emission trends and key categories

Between 1990 and 2021, CO emissions fell by 69% in the EU. Between 2020 and 2021, they increased by 4.7% (Table 3.11), mainly because emissions rose in France, Italy, Germany and Spain (countries ranked according to the size of their contributions to the absolute change).

Table 3.11 Member State contributions to EU emissions of CO

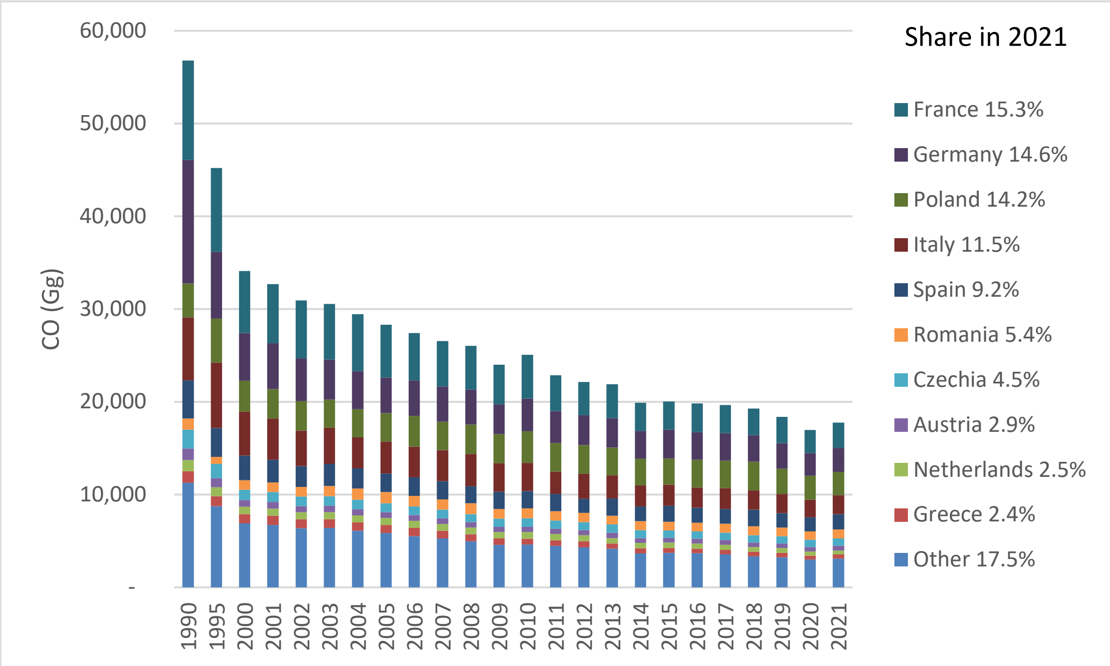
	CO (Gg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	1,249	974	729	627	582	544	539	529	487	499	474	523	-58 %	10.4 %	2.2 %	2.9 %
Belgium	1,506	1,278	996	801	497	370	354	288	334	368	274	290	-81 %	5.7 %	2.7 %	1.6 %
Bulgaria	936	642	413	372	334	291	301	301	281	268	260	267	-71 %	2.7 %	1.6 %	1.5 %
Croatia	564	452	474	428	336	270	260	254	232	219	217	206	-63 %	-5.0 %	1.0 %	1.2 %
Cyprus	45	39	30	24	14	11	12	12	11	11	10	10	-77 %	6.6 %	0.1 %	0.1 %
Czechia	2,040	1,546	1,104	945	927	792	794	791	793	780	789	790	-61 %	0.2 %	3.6 %	4.5 %
Denmark	717	643	472	423	348	257	248	237	221	205	191	192	-73 %	0.8 %	1.3 %	1.1 %
Estonia	246	215	181	142	147	116	124	126	123	122	120	109	-56 %	-9.2 %	0.4 %	0.6 %
Finland	764	662	594	519	446	359	366	357	349	343	317	338	-56 %	6.5 %	1.3 %	1.9 %
France	10,711	9,027	6,710	5,687	4,707	3,035	3,104	3,025	2,879	2,819	2,463	2,707	-75 %	9.9 %	18.9 %	15.3 %
Germany	13,319	7,217	5,130	3,853	3,529	3,094	2,969	2,976	2,859	2,754	2,451	2,586	-81 %	5.5 %	23.5 %	14.6 %
Greece	1,239	1,061	1,006	864	612	533	477	490	467	460	422	424	-66 %	0.5 %	2.2 %	2.4 %
Hungary	1,451	982	857	697	552	464	450	440	378	359	341	345	-76 %	1.3 %	2.6 %	1.9 %
Ireland	560	418	324	283	216	178	175	149	145	126	121	123	-78 %	1.9 %	1.0 %	0.7 %
Italy	6,794	7,067	4,728	3,437	3,054	2,259	2,191	2,262	2,062	2,080	1,898	2,044	-70 %	7.7 %	12.0 %	11.5 %
Latvia	405	292	240	212	154	107	105	112	116	112	99	102	-75 %	3.3 %	0.7 %	0.6 %
Lithuania	385	219	183	175	159	125	124	122	124	117	111	112	-71 %	1.1 %	0.7 %	0.6 %
Luxembourg	469	213	47	40	30	22	23	23	21	22	16	20	-96 %	20.6 %	0.8 %	0.1 %
Malta	20	27	20	15	12	9	9	9	7	7	5	6	-72 %	3.9 %	0.0 %	0.0 %
Netherlands	1,189	953	772	747	709	572	555	548	535	517	449	438	-63 %	-2.6 %	2.1 %	2.5 %
Poland	3,659	4,719	3,359	3,069	3,407	2,844	2,975	2,955	3,098	2,717	2,582	2,521	-31 %	-2.4 %	6.4 %	14.2 %
Portugal	792	815	670	510	381	309	296	295	277	286	254	285	-64 %	11.9 %	1.4 %	1.6 %
Romania	1,208	751	1,059	1,225	1,051	914	935	942	943	950	910	964	-20 %	6.0 %	2.1 %	5.4 %
Slovakia	1,033	655	542	548	447	358	368	373	313	283	277	334	-68 %	20.8 %	1.8 %	1.9 %
Slovenia	290	280	203	182	142	121	121	115	105	97	87	87	-70 %	-0.3 %	0.5 %	0.5 %
Spain	4,104	3,116	2,628	1,995	1,861	1,736	1,599	1,595	1,806	1,534	1,524	1,637	-60 %	7.4 %	7.2 %	9.2 %
Sweden	1,094	936	643	493	406	333	336	328	308	301	284	277	-75 %	-2.6 %	1.9 %	1.6 %
EU-27 (a)	**56,790**	**45,199**	**34,114**	**28,313**	**25,058**	**20,026**	**19,810**	**19,656**	**19,273**	**18,357**	**16,948**	**17,738**	**-69%**	**4.7%**	**100%**	**100%**
EU-27 (b)	56,790	45,199	34,114	28,313	25,058	20,026	19,810	19,656	19,273	18,357	16,948	17,738				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to CO emissions were France, Germany, Poland and Italy (countries ranked according to their shares of the EU total) (see Figure 3.17).

Figure 3.18 CO emission trends in the EU and shares of Member States



Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

France explained that the decreasing trend in CO emissions between 1990 and 2021 was driven by improvements in the transport sector (installation of catalytic converters to vehicles) and sector 'small combustion' (progress in biomass combustion, renewal of residential stock, more efficient and less emitting appliances). The increase in CO emissions between 2020 and 2021 was mainly caused by increases in CO emissions from small residential combustion installations (1A4bi).

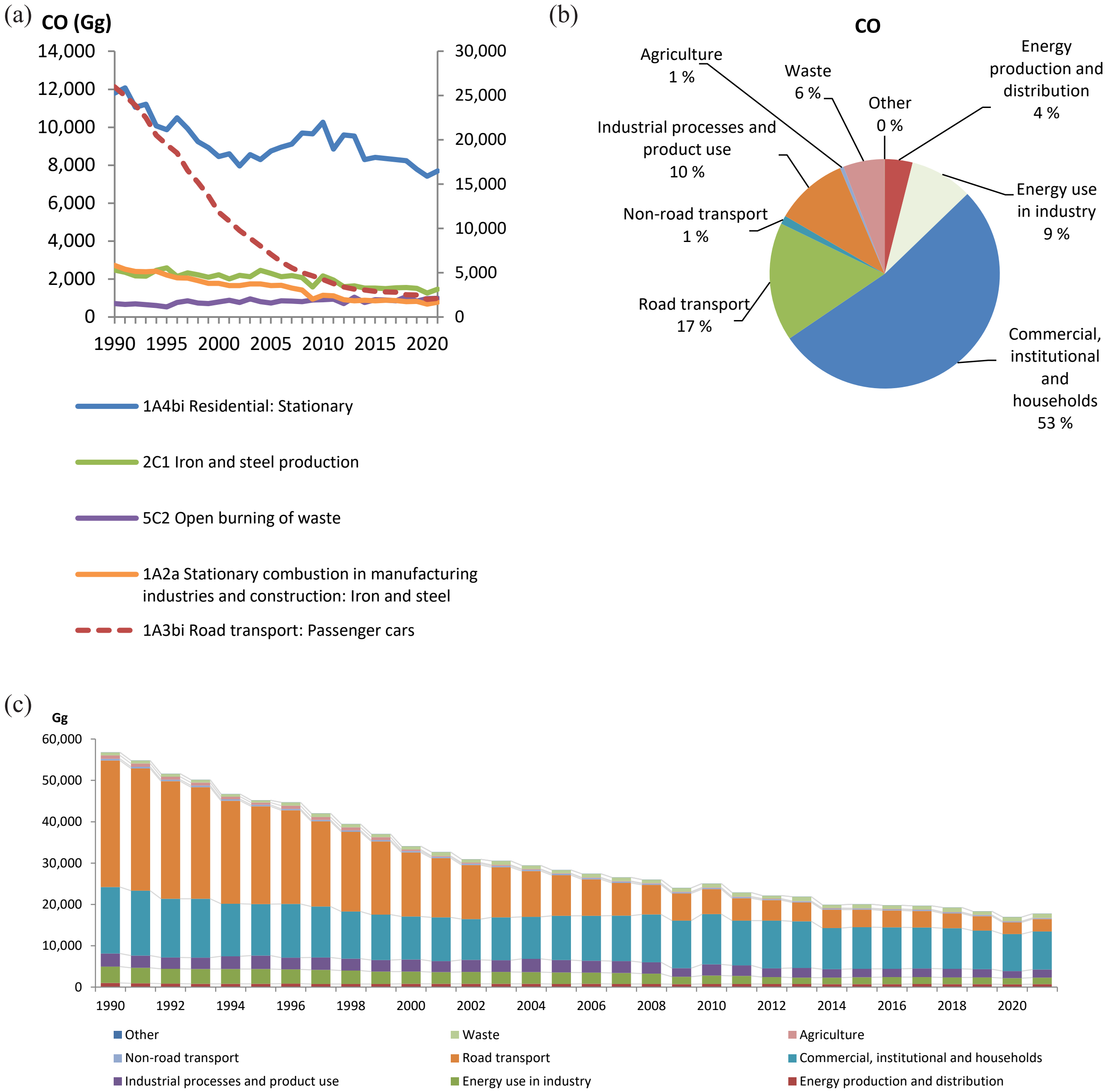
The decline in CO emissions in **Italy** between 1990 and 2021 was mostly caused by reductions in the transport sector (including road, railway, air and maritime transport).

Reductions in CO emissions between 1990 and 2021 in **Spain** were also driven by reductions in the transport sector (introduction of the Euro standards) and the agriculture sector (abandonment of the practice of field burning of agricultural waste).

Categories '1A4bi — Residential: Stationary' and '1A3bi — Road transport: Passenger cars' were the most important for CO emissions, jointly accounting for 55% of the total. Among the top five key categories, the highest relative reduction in emissions between 1990 and 2021 was in the second most important '1A3bi — Road transport: Passenger cars' (91.9%) (see Figure 3.19(a)). Reductions in emissions were observed in the categories '1A4bi — Residential: Stationary' (34.8%), '2C1 — Iron and steel production' (40.5%) and '1A2a — Stationary combustion in manufacturing industries and construction: Iron and steel' (71.5%). CO emissions from the fifth most important key category '5C2 — Open burning of waste' have increased by 39.2% since 1990.

Figure 3.19(b) shows the contribution to total EU emissions made by each aggregated sector group. For CO, the common major emission sources are commercial, institutional and households, and road transport.

Figure 3.19 CO emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Note: In (a) the right-hand axis gives values for '1A3bi — Road transport: Passenger cars'.

3.11 Lead emission trends and key categories

Between 1990 and 2021, Pb emissions dropped by 95% in the EU. Between 2020 and 2021, emissions increased by 8.5% (see Table 3.12), mainly in Italy, Spain, Germany and Poland (countries ranked according to the size of their contributions to the absolute change).

Table 3.12 Member State contributions to EU emissions of Pb

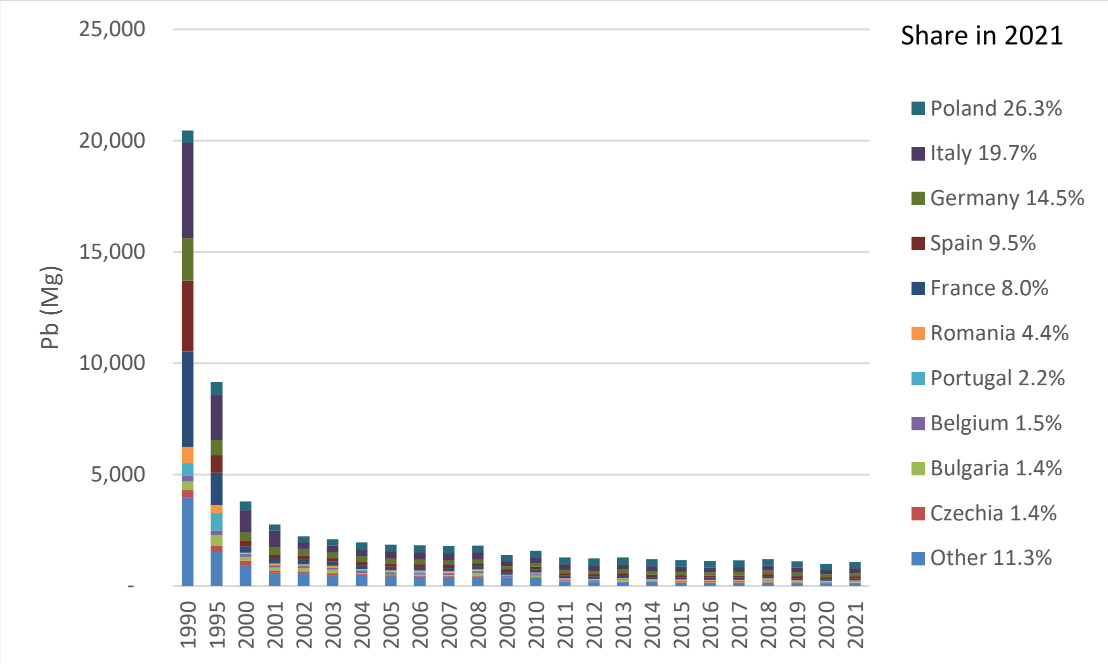
	Pb (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	233	26	23	26	14	14	14	14	14	13	12	13	-95 %	5.3 %	1.1 %	1.2 %
Belgium	258	202	105	81	47	36	33	31	19	21	17	16	-94 %	-8.7 %	1.3 %	1.5 %
Bulgaria	385	479	176	43	91	12	12	13	91	15	14	15	-96 %	5.3 %	1.9 %	1.4 %
Croatia	523	264	145	14	8	8	8	8	8	5	5	5	-99 %	-0.8 %	2.6 %	0.5 %
Cyprus	25	27	21	1	1	1	1	1	1	1	1	1	-96 %	6.2 %	0.1 %	0.1 %
Czechia	317	256	222	39	25	22	18	18	19	19	16	15	-95 %	-8.4 %	1.5 %	1.4 %
Denmark	132	29	22	20	16	15	15	15	16	15	14	15	-89 %	1.2 %	0.6 %	1.4 %
Estonia	202	83	30	9	9	6	6	6	6	6	5	5	-98 %	0.5 %	1.0 %	0.5 %
Finland	321	73	31	21	20	15	16	16	15	13	12	13	-96 %	11.7 %	1.6 %	1.2 %
France	4,288	1,455	266	162	121	92	91	92	91	91	78	85	-98 %	9.1 %	21.0 %	8.0 %
Germany	1,899	679	355	230	168	163	160	165	160	158	143	154	-92 %	8.3 %	9.3 %	14.5 %
Greece	505	405	340	73	37	15	14	16	15	13	10	11	-98 %	17.2 %	2.5 %	1.1 %
Hungary	818	145	21	14	12	13	13	13	13	13	13	15	-98 %	16.1 %	4.0 %	1.4 %
Ireland	161	101	17	11	9	9	9	9	8	8	7	8	-95 %	4.5 %	0.8 %	0.7 %
Italy	4,304	2,023	993	329	249	231	204	210	211	206	179	210	-95 %	17.1 %	21.0 %	19.7 %
Latvia	233	128	153	170	165	4	4	4	4	4	4	4	-98 %	1.9 %	1.1 %	0.4 %
Lithuania	10	4	3	3	3	4	4	4	4	4	3	4	-61 %	9.2 %	0.0 %	0.3 %
Luxembourg	19	9	1	2	1	2	1	2	1	1	1	1	-93 %	0.0 %	0.1 %	0.1 %
Malta	0	1	1	1	1	1	1	1	1	1	0	0	15 %	5.8 %	0.0 %	0.0 %
Netherlands	339	155	28	30	38	9	9	9	6	5	6	5	-99 %	-15.9 %	1.7 %	0.5 %
Poland	544	579	397	281	306	302	296	310	311	290	270	280	-49 %	3.5 %	2.7 %	26.3 %
Portugal	570	790	35	31	28	26	25	25	26	25	23	24	-96 %	3.0 %	2.8 %	2.2 %
Romania	729	356	50	72	49	46	45	45	47	47	42	46	-94 %	11.6 %	3.6 %	4.4 %
Slovakia	54	46	45	17	8	8	9	9	8	7	6	8	-85 %	41.4 %	0.3 %	0.8 %
Slovenia	43	24	8	7	7	6	6	6	6	6	5	6	-87 %	13.2 %	0.2 %	0.5 %
Spain	3,179	790	279	144	132	98	93	90	95	103	87	101	-97 %	15.2 %	15.5 %	9.5 %
Sweden	369	30	19	12	10	8	9	9	8	8	8	7	-98 %	-13.0 %	1.8 %	0.6 %
EU-27 (a)	**20,461**	**9,156**	**3,785**	**1,844**	**1,576**	**1,162**	**1,116**	**1,141**	**1,207**	**1,098**	**982**	**1,065**	**-95%**	**8.5%**	**100%**	**100%**
EU-27 (b)	20,461	9,156	3,785	1,844	1,576	1,162	1,116	1,141	1,207	1,098	982	1,065				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to Pb emissions were Poland, Italy and Germany (countries ranked according to their shares of the EU total) (see Figure 3.19).

Figure 3.20 Pb emission trends in the EU and shares of Member States



Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

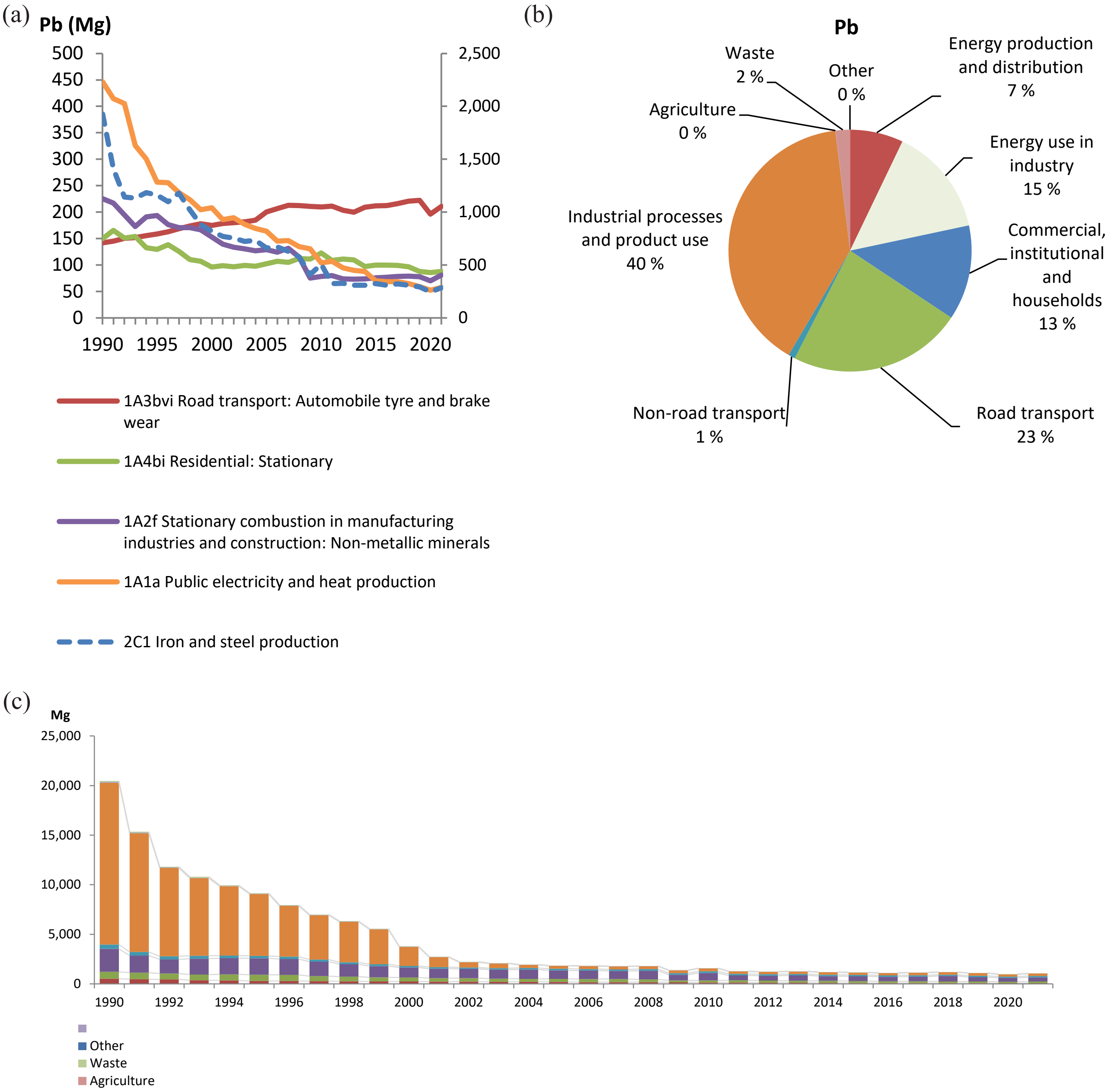
EU total emissions of Pb have declined to less than a 10th of the emissions in 1990, primarily because of reduced emissions from the road transport sector. Thanks to a combination of fiscal and regulatory measures, the promotion of unleaded petrol within the EU has proved a notable success. EU Member States have now phased out the use of leaded petrol. In the EU, the Directive on the Quality of Petrol and Diesel Fuels (98/70/EC) regulated that goal (EEA, 2022b).

Categories '2C1 — Iron and steel production', '1A3bvi — Road transport: Automobile tyre and brake wear' and '1A4bi — Residential: Stationary' were the leading key categories for Pb emissions in 2021, together making up 55% of total Pb emissions (see Figure 3.21 (a)).

The largest relative reductions in emissions between 1990 and 2021 were from the fifth important key category '1A1a — Public electricity and heat production' (87.1%) and the most important category '2C1 — Iron and steel production' (85.1%). Emissions in the second most important key category '1A3bvi — Road transport: Automobile tyre and brake wear' have increased by 48.2% since 1990.

Figure 3.21(b) shows the contribution that each aggregated sector group made to total EU emissions. The sector groups industrial processes and product use, road transport, energy use in industry and commercial, institutional and households are significant sources of Pb emissions.

Figure 3.21 Pb emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Note: In (a), the right-hand axis gives values for '2C1 — Iron and steel production'.

3.12 Cadmium emission trends and key categories

Between 1990 and 2021, Cd emissions fell by 66% in the EU. Between 2020 and 2021, they increased by 0.5% (Table 3.13), mainly because of a slight increase in Italy, Spain , Germany and Romania (countries ranked according to the size of their contributions to the absolute change).

Table 3.13 Member State contributions to EU emissions of Cd

	Cd (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	1.8	1.1	1.0	1.1	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	-48 %	7.1 %	1.1 %	1.7 %
Belgium	6.0	4.9	2.6	2.4	2.0	1.6	2.6	1.3	1.2	1.2	1.1	1.1	-81 %	7.0 %	3.8 %	2.1 %
Bulgaria	7.5	5.6	3.0	5.8	2.0	1.2	1.2	1.3	1.4	1.5	1.5	1.4	-81 %	-4.2 %	4.7 %	2.6 %
Croatia	1.2	0.9	0.9	1.2	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.7	-38 %	-2.8 %	0.7 %	1.4 %
Cyprus	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-60 %	-3.0 %	0.1 %	0.1 %
Czechia	5.3	2.3	1.8	1.7	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	-76 %	1.1 %	3.3 %	2.3 %
Denmark	1.2	0.7	0.6	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.6	0.7	-45 %	4.3 %	0.8 %	1.2 %
Estonia	4.5	2.2	0.8	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	-90 %	-10.1 %	2.8 %	0.8 %
Finland	6.7	2.1	1.4	1.5	1.3	0.9	0.9	1.0	0.9	0.8	0.7	0.8	-87 %	21.4 %	4.2 %	1.6 %
France	20.4	17.8	14.2	6.0	3.5	2.9	3.4	3.0	2.6	2.7	2.7	2.6	-87 %	-3.7 %	12.7 %	4.7 %
Germany	29.1	18.8	17.8	12.2	12.5	12.1	12.0	12.2	11.8	10.6	10.6	10.9	-63 %	2.3 %	18.1 %	19.9 %
Greece	7.5	7.8	8.4	8.9	4.6	2.1	2.0	2.1	1.9	1.7	1.4	1.5	-80 %	4.7 %	4.7 %	2.8 %
Hungary	1.9	1.7	1.8	1.4	1.5	1.7	1.6	1.6	1.5	1.4	1.4	1.4	-28 %	-2.0 %	1.2 %	2.5 %
Ireland	0.6	0.6	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	-52 %	8.8 %	0.4 %	0.5 %
Italy	11.1	10.6	10.2	8.6	5.3	4.4	4.4	4.4	4.4	4.3	3.9	4.4	-60 %	12.1 %	6.9 %	8.0 %
Latvia	0.9	0.8	0.9	1.1	1.0	0.5	0.5	0.5	0.6	0.6	0.5	0.6	-41 %	2.7 %	0.6 %	1.0 %
Lithuania	0.4	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	-33 %	7.7 %	0.2 %	0.5 %
Luxembourg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-40 %	0.0 %	0.1 %	0.1 %
Malta	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-91 %	-86.8 %	0.0 %	0.0 %
Netherlands	4.1	3.1	2.9	3.8	4.7	2.9	3.0	2.7	2.6	2.7	2.0	0.9	-79 %	-56.7 %	2.5 %	1.6 %
Poland	12.1	12.3	9.9	9.7	10.3	10.7	10.4	10.6	12.2	11.8	11.2	11.0	-9 %	-1.8 %	7.5 %	20.0 %
Portugal	2.4	2.5	2.7	2.4	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	-26 %	-2.0 %	1.5 %	3.2 %
Romania	5.0	3.9	3.4	3.7	3.6	3.1	3.2	3.2	3.2	3.2	2.9	3.1	-38 %	8.1 %	3.1 %	5.7 %
Slovakia	1.5	1.2	1.2	0.9	0.8	0.6	0.6	0.7	0.6	0.6	0.6	0.6	-58 %	12.2 %	0.9 %	1.1 %
Slovenia	0.6	0.5	0.6	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.6	-6 %	9.2 %	0.4 %	1.1 %
Spain	26.3	20.9	16.3	11.5	7.8	7.5	7.0	7.1	7.3	6.8	6.4	6.8	-74 %	7.2 %	16.4 %	12.5 %
Sweden	2.3	0.7	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-79 %	-3.8 %	1.4 %	0.9 %
EU-27 (a)	**160**	**123**	**104**	**87**	**70**	**60**	**61**	**60**	**60**	**58**	**54**	**55**	**-66%**	**0.5%**	**100%**	**100%**
EU-27 (b)	160	123	104	87	70	60	61	60	60	58	54	55				

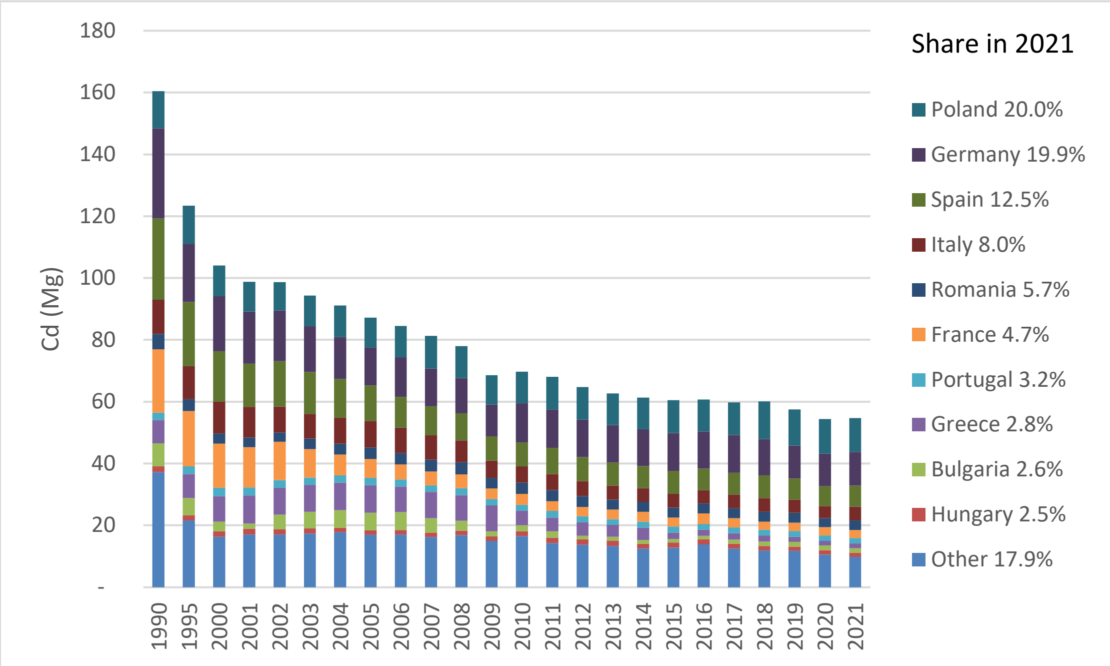
Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to Cd emissions were Poland, Germany and Spain (countries ranked according to their shares of the EU total) (see Figure 3.21).

As with Pb, industrial sources of Cd emissions have fallen since the early 1990s in all EU Member States. This is largely because the abatement technologies for waste water treatment and incinerators have improved, as have those for metal refining and smelting facilities (EEA, 2022b).

Figure 3.22 Cd emission trends in the EU and share of Member States



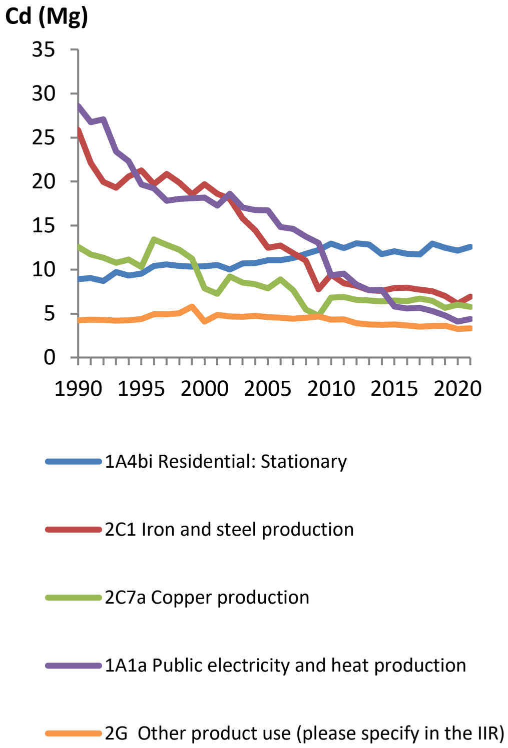
Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

Categories '1A4bi — Residential: Stationary', '2C1 — Iron and steel production' and '2C7a — Copper production' were the principal key categories for Cd emissions, making up 46% of total Cd emissions (see Figure 3.23(a)). Among the top five key categories, the highest relative reductions in emissions between 1990 and 2021 were in the fourth most important '1A1a — Public electricity and heat production' (84.6%), the third most important '2C7a — Copper production' (54.3%) and the second most important '2C1 — Iron and steel production' (73.2%). In the most important key category '1A4bi — Residential: Stationary', the values of reported emissions have increased since 1990 (41%).

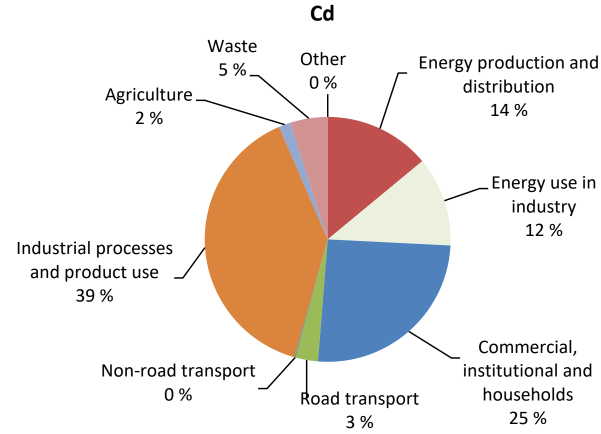
Figure 3.23(b) shows the contribution made by each aggregated sector group to total EU emissions. The common leading sources of Cd emissions are the industrial processes and product use sector and the commercial, institutional and households and energy sector.

Figure 3.23 Cd emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions

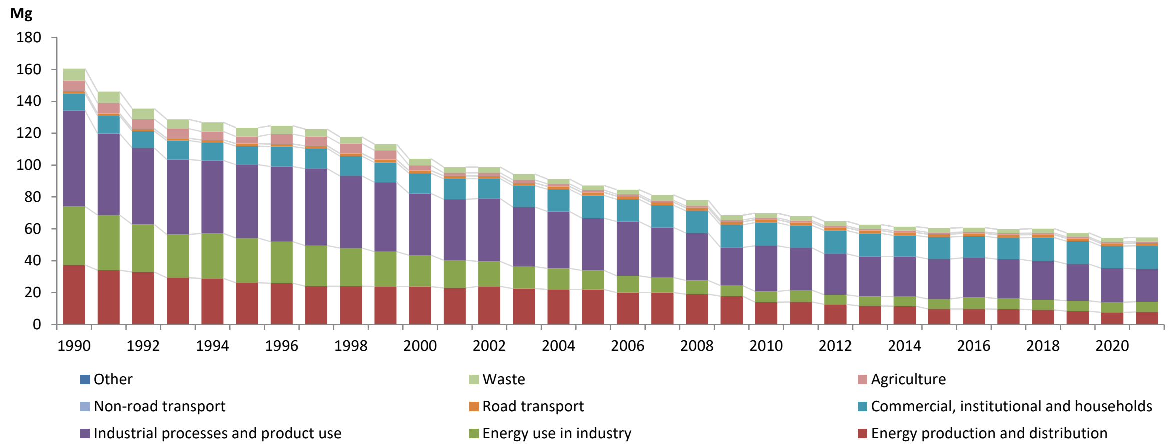
(a)



(b)



(c)



3.13 Mercury emission trends and key categories

Between 1990 and 2021, Hg emissions dropped by 73% in the EU. Between 2020 and 2021, they increased by 7.2% (see Table 3.14), mainly because of slight increases in Poland, Germany, Italy and Bulgaria (countries ranked according to the size of their contributions to the absolute change).

Table 3.14 Member State contributions to EU emissions of Hg

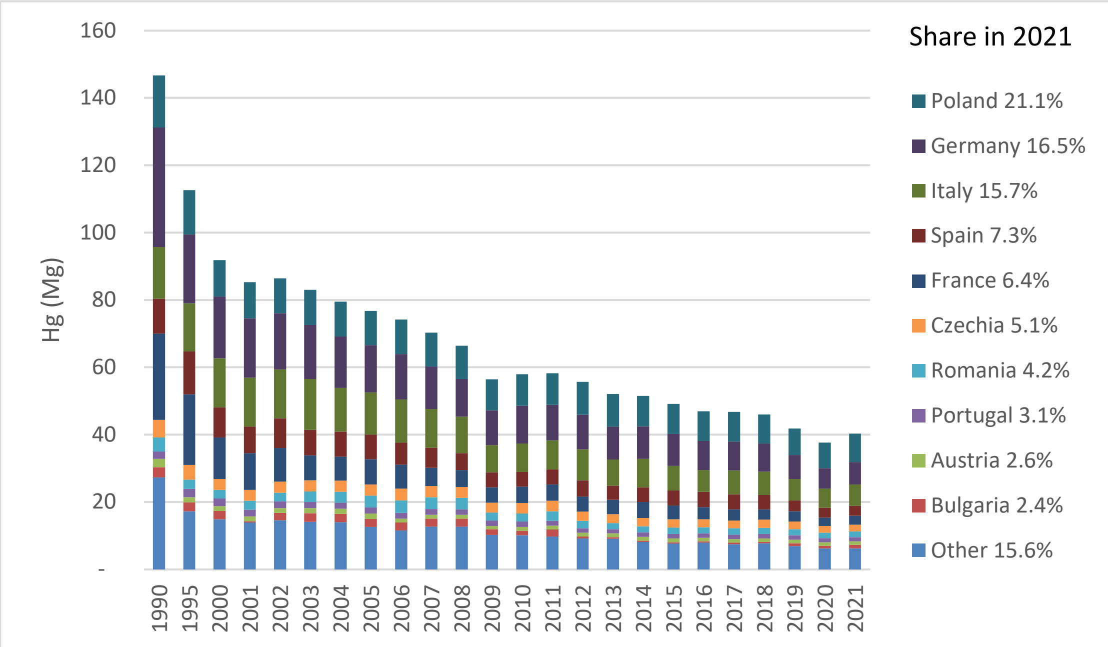
	Hg (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	2.5	1.6	1.4	1.6	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	-59 %	-2.7 %	1.7 %	2.6 %
Belgium	6.1	3.3	3.2	2.2	1.7	1.1	1.4	1.1	1.4	1.0	1.0	0.9	-85 %	-7.9 %	4.1 %	2.3 %
Bulgaria	3.0	2.6	2.5	2.4	1.4	0.4	0.4	0.4	0.4	0.8	0.7	1.0	-68 %	30.7 %	2.1 %	2.4 %
Croatia	1.1	0.3	0.5	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	-68 %	-2.0 %	0.8 %	0.9 %
Cyprus	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-71 %	-1.8 %	0.1 %	0.1 %
Czechia	5.2	4.4	3.3	3.3	3.1	2.5	2.4	2.3	2.4	2.3	2.0	2.1	-60 %	4.0 %	3.5 %	5.1 %
Denmark	3.2	2.3	1.0	0.7	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	-93 %	1.3 %	2.2 %	0.6 %
Estonia	1.2	0.6	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-82 %	4.4 %	0.8 %	0.5 %
Finland	1.1	0.8	0.6	0.9	0.9	0.6	0.6	0.6	0.7	0.6	0.5	0.5	-52 %	-2.6 %	0.7 %	1.3 %
France	25.6	21.0	12.3	7.4	4.9	4.1	3.6	3.3	3.1	3.1	2.5	2.6	-90 %	4.5 %	17.4 %	6.4 %
Germany	35.5	20.4	18.3	14.0	11.2	9.5	8.7	8.6	8.3	7.1	6.0	6.7	-81 %	11.0 %	24.2 %	16.5 %
Greece	2.3	2.3	2.6	2.7	2.5	1.4	1.2	1.3	1.4	1.2	0.8	0.8	-63 %	4.7 %	1.6 %	2.1 %
Hungary	2.8	2.0	1.7	1.4	0.9	0.9	0.9	1.0	0.9	0.9	0.8	0.8	-71 %	-2.7 %	1.9 %	2.0 %
Ireland	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	-54 %	13.0 %	0.5 %	0.9 %
Italy	15.3	14.4	14.6	12.5	8.5	7.2	6.4	7.1	6.9	6.4	5.8	6.3	-59 %	9.7 %	10.4 %	15.7 %
Latvia	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-67 %	15.5 %	0.2 %	0.2 %
Lithuania	0.4	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-54 %	7.4 %	0.3 %	0.5 %
Luxembourg	0.4	0.2	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-82 %	0.0 %	0.3 %	0.2 %
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-87 %	-65.1 %	0.0 %	0.0 %
Netherlands	3.7	1.6	1.2	1.0	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.5	-87 %	-2.6 %	2.5 %	1.2 %
Poland	15.5	13.1	10.9	10.2	9.5	8.9	8.8	8.9	8.7	7.9	7.6	8.5	-45 %	11.9 %	10.5 %	21.1 %
Portugal	2.2	2.4	2.3	1.8	1.6	1.3	1.3	1.4	1.3	1.3	1.2	1.2	-43 %	0.8 %	1.5 %	3.1 %
Romania	4.2	2.7	2.6	3.5	2.4	1.9	1.8	1.8	1.8	1.8	1.6	1.7	-59 %	7.8 %	2.9 %	4.2 %
Slovakia	1.9	1.4	1.6	0.9	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-72 %	6.8 %	1.3 %	1.3 %
Slovenia	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-48 %	1.9 %	0.2 %	0.5 %
Spain	10.4	12.7	8.9	7.4	4.3	4.5	4.5	4.5	4.3	3.2	2.9	2.9	-72 %	1.1 %	7.1 %	7.3 %
Sweden	1.6	1.0	0.8	0.7	0.5	0.4	0.5	0.4	0.4	0.4	0.4	0.4	-74 %	4.2 %	1.1 %	1.0 %
EU-27 (a)	**147**	**113**	**92**	**77**	**58**	**49**	**47**	**47**	**46**	**42**	**38**	**40**	**-73%**	**7.2%**	**100%**	**100%**
EU-27 (b)	147	113	92	77	58	49	47	47	46	42	38	40				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to Hg emissions were Poland, Germany and Italy (countries ranked according to their shares of the EU total) (see Figure 3.23).

Figure 3.24 Hg emission trends in the EU and shares of Member States



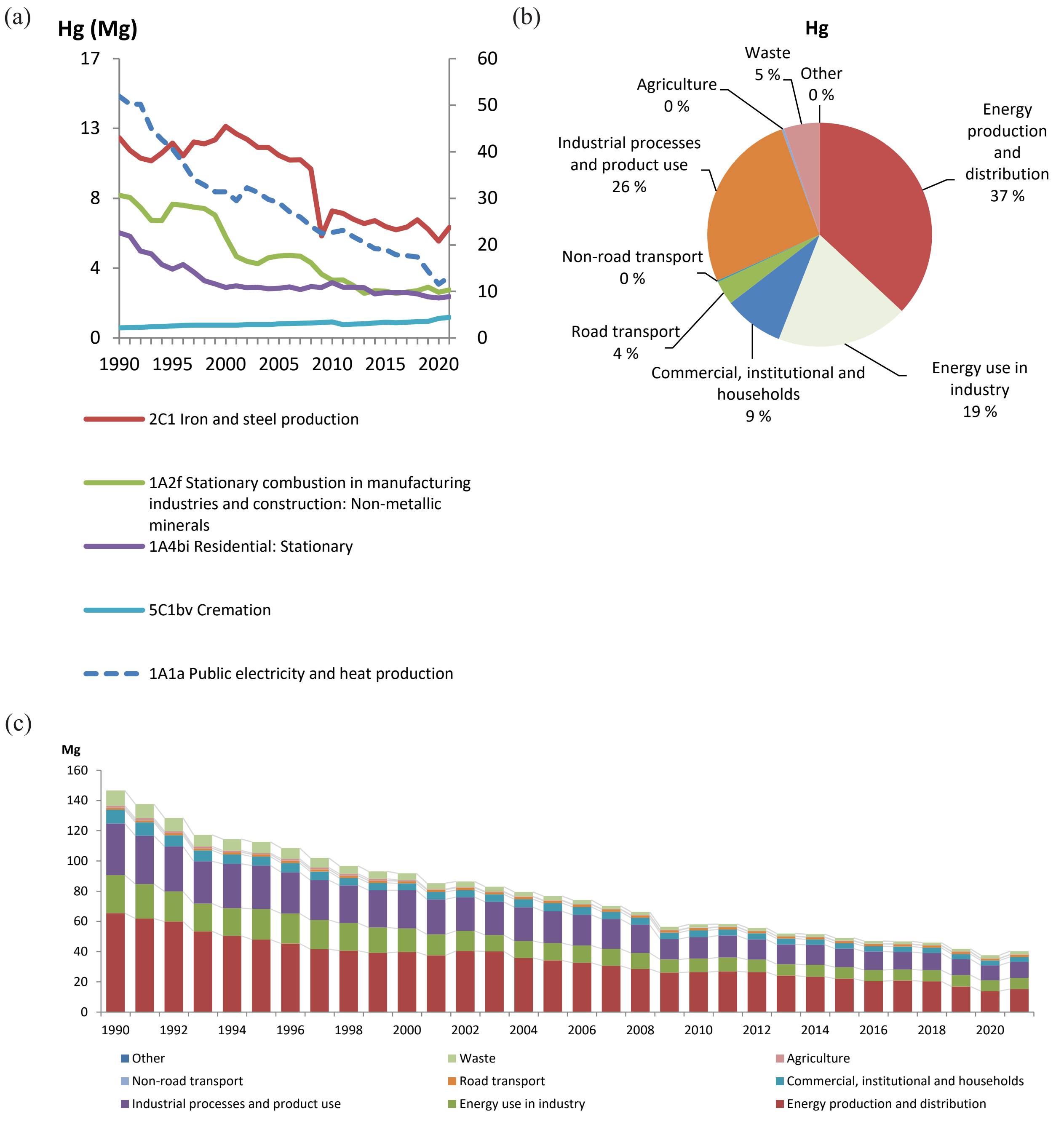
Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed up 'Other'.

Categories '1A1a — Public electricity and heat production', '2C1 — Iron and steel production' and '1A2f — Stationary combustion in manufacturing industries and construction: Non-metallic minerals' were the main key categories for Hg emissions, making up 57% of the total (see Figure 3.25(a)). Among the top five key categories, the highest relative reduction in emissions between 1990 and 2021 was in the most important '1A1a — Public electricity and heat production' (74.7%). The third most important key category '1A2f — Stationary combustion in manufacturing industries and construction: Non-metallic minerals' (66.2%) and the fourth most important category '1A4bi — Residential: Stationary' (60.7%) also show large reductions. In the fifth most important key category '5C1bv — Cremation', the values of reported emissions have increased by 103% since 1990.

The strong decrease in 2009 in the sector '2C1 — Iron and steel production' mainly reflects lower emissions reported by Belgium (see Figure 3.25). Since 1990, the fall in Hg emissions in the industrial sector is mainly due to better emission controls on Hg cells and replacing them with diaphragm or membrane cells and switching from coal to gas and other energy sources in many countries' power- and heat-generating sectors (EEA, 2022c).

Figure 3.25(b) shows the contribution made by each aggregated sector group to total EU emissions. For Hg, the principal emission sources are the energy sectors and the industrial processes and product use sector.

Figure 3.25 Hg emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Note: In (a), the right-hand axis shows values for '1A1a — Public electricity and heat production'.

3.14 *Arsenic emission trends*

Between 1990 and 2021, As emissions dropped by 90% in the EU. Between 2020 and 2021, emissions increased by 4.9% (Table 3.15), mainly because emissions grew in, France, Bulgaria, Italy, Poland and Romania (countries ranked according to the size of their contributions to the absolute change). The EU Member States that contributed most (i.e. more than 10%) to As emissions in 2021 were Poland, Italy and France (countries ranked according to their shares of the EU total). As Austria and Luxembourg did not provide emission data for As, the EU total is an underestimate.

Table 3.15 Member State contributions to EU emissions of As

	As (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria																
Belgium	6.7	6.4	3.9	3.1	1.9	1.2	1.0	0.9	0.9	0.9	0.9	0.8	-88 %	-7.9 %	1.2 %	1.5 %
Bulgaria	19.9	14.6	10.8	11.5	6.5	1.8	2.4	2.4	2.8	3.2	2.7	3.1	-85 %	12.5 %	3.5 %	5.6 %
Croatia	8.6	1.2	1.1	1.1	0.8	0.5	0.4	0.5	0.6	0.6	0.3	0.3	-97 %	2.0 %	1.5 %	0.5 %
Cyprus	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-30 %	-4.7 %	0.0 %	0.2 %
Czechia	69.5	17.0	3.9	2.1	1.7	1.5	1.4	1.6	1.4	1.4	1.2	1.3	-98 %	2.9 %	12.2 %	2.3 %
Denmark	1.4	0.8	0.9	0.6	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	-78 %	12.9 %	0.2 %	0.5 %
Estonia	19.8	9.7	6.7	1.7	2.0	0.9	1.1	1.1	1.0	0.6	0.5	0.6	-97 %	6.6 %	3.5 %	1.0 %
Finland	34.8	5.2	4.4	3.0	3.4	2.5	2.6	2.4	2.4	2.1	2.0	2.1	-94 %	3.6 %	6.1 %	3.7 %
France	17.4	17.3	15.8	12.6	8.7	6.2	6.2	6.0	6.0	5.8	5.0	5.6	-68 %	11.7 %	3.0 %	10.1 %
Germany	85.9	9.1	8.0	7.5	7.2	6.7	6.6	6.4	6.0	5.3	5.0	5.3	-94 %	7.1 %	15.1 %	9.7 %
Greece	2.4	2.6	3.0	3.2	2.4	3.2	2.6	2.8	2.5	1.9	1.2	1.2	-50 %	1.2 %	0.4 %	2.1 %
Hungary	4.1	3.3	3.2	2.6	2.3	2.2	2.0	2.2	2.2	2.0	1.8	1.6	-61 %	-12.2 %	0.7 %	2.9 %
Ireland	1.8	1.9	1.9	1.8	1.4	1.6	1.6	1.5	1.4	1.2	1.1	1.2	-31 %	10.7 %	0.3 %	2.2 %
Italy	37.3	27.7	39.3	28.1	17.3	9.5	8.0	7.5	7.4	6.3	5.4	5.8	-84 %	8.8 %	6.5 %	10.5 %
Latvia	16.7	8.5	15.0	16.6	16.1	0.2	0.2	0.2	0.3	0.3	0.2	0.3	-98 %	13.5 %	2.9 %	0.5 %
Lithuania	0.8	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	-83 %	6.2 %	0.1 %	0.2 %
Luxembourg	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
Malta	0.1	0.1	0.1	0.1	0.1	0.03	0.02	0.01	0.01	0.01	0.01	0.01	-93 %	0.7 %	0.0 %	0.0 %
Netherlands	1.5	1.1	1.1	1.5	0.8	0.8	0.9	0.7	0.5	0.3	0.3	0.3	-82 %	-5.6 %	0.3 %	0.5 %
Poland	144	71	30	17	17	17	16	16	16	15	15	15	-90 %	2.8 %	25.3 %	27.1 %
Portugal	3.3	3.7	3.9	3.9	2.1	2.2	2.0	2.1	2.0	1.6	1.4	1.3	-62 %	-8.9 %	0.6 %	2.3 %
Romania	72.8	36.9	5.8	6.6	5.2	4.7	4.3	4.3	4.3	4.2	3.3	3.7	-95 %	10.8 %	12.8 %	6.6 %
Slovakia	3.5	2.1	2.0	1.6	1.3	1.0	0.8	0.8	0.8	0.7	0.6	0.8	-78 %	31.9 %	0.6 %	1.4 %
Slovenia	0.9	0.8	0.8	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.6	-33 %	-5.6 %	0.2 %	1.1 %
Spain	10.3	9.6	10.1	9.4	5.6	5.6	5.1	5.6	5.4	3.9	3.4	3.5	-66 %	2.6 %	1.8 %	6.3 %
Sweden	5.7	1.6	0.9	1.0	1.0	0.7	0.7	0.8	0.8	0.7	0.7	0.6	-89 %	-11.6 %	1.0 %	1.1 %
EU-27 (a)	**570**	**253**	**173**	**138**	**106**	**71**	**67**	**67**	**66**	**59**	**53**	**55**	**-90%**	**4.9%**	**100%**	**100%**
EU-27 (b)	570	253	173	138	106	71	67	67	66	59	53	55				

Notes: Dark blue-shaded cells indicate that no emission values are available. See Appendix 1 for an explanation of the notation keys reported by EU Member States.

([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.15 Chromium emission trends

Between 1990 and 2021, Cr emissions dropped by 69% in the EU. Between 2020 and 2021, emissions increased by 4.6% (see Table 3.16), mainly because of increases in Italy, Poland, Romania and Sweden (countries ranked according to the size of their contributions to the absolute change). In 2021, the EU Member States contributing most (i.e. more than 10%) to Cr emissions were Germany, Poland and Italy (countries ranked according to their shares of the EU total). As Austria and Luxembourg did not provide emission data for Cr, the EU total is an underestimate.

Table 3.16 Member State contributions to EU emissions of Cr

	Cr (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria																
Belgium	38	34	23	20	16	9	9	7	7	7	7	7	-83 %	-1.2 %	3.7 %	2.1 %
Bulgaria	19	14	9	14	6	4	4	4	4	5	5	5	-72 %	2.1 %	1.9 %	1.7 %
Croatia	5	4	3	4	3	2	2	2	2	2	2	2	-66 %	-5.0 %	0.5 %	0.6 %
Cyprus	0.3	0.4	0.5	0.6	0.5	0.4	0.4	0.5	0.5	0.4	0.4	0.4	29 %	5.4 %	0.0 %	0.1 %
Czechia	26	17	13	12	11	10	10	9	10	9	8	8	-68 %	2.2 %	2.6 %	2.7 %
Denmark	6	3	2	2	2	2	2	2	2	2	2	2	-73 %	6.7 %	0.6 %	0.5 %
Estonia	17	9	7	4	4	3	3	3	3	2	2	2	-90 %	14.2 %	1.7 %	0.6 %
Finland	48	36	29	20	26	17	18	17	15	14	14	14	-70 %	3.2 %	4.7 %	4.6 %
France	399	197	113	59	43	34	34	33	33	33	30	30	-92 %	1.1 %	39.2 %	9.7 %
Germany	166	94	83	76	74	76	77	77	76	72	67	68	-59 %	1.7 %	16.3 %	21.8 %
Greece	6	7	7	10	10	17	13	12	13	12	6	6	1 %	5.7 %	0.6 %	1.9 %
Hungary	18	12	13	13	12	13	11	14	14	13	11	10	-46 %	-13.7 %	1.8 %	3.2 %
Ireland	5	5	6	5	4	4	4	4	4	4	3	3	-31 %	5.9 %	0.5 %	1.1 %
Italy	96	80	56	62	53	48	46	46	46	44	38	45	-53 %	16.6 %	9.4 %	14.3 %
Latvia	3	2	2	3	3	1	1	2	2	2	2	2	-41 %	4.1 %	0.3 %	0.5 %
Lithuania	3	2	1	1	1	2	2	2	2	2	2	2	-45 %	9.1 %	0.3 %	0.5 %
Luxembourg	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
Malta	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	4 %	6.4 %	0.0 %	0.1 %
Netherlands	12	9	5	4	4	4	4	4	4	3	3	4	-70 %	10.1 %	1.2 %	1.1 %
Poland	56	54	42	43	46	44	44	46	48	47	47	48	-15 %	3.4 %	5.5 %	15.4 %
Portugal	12	13	13	12	9	8	7	7	7	7	7	7	-45 %	0.9 %	1.2 %	2.1 %
Romania	25	19	15	20	14	14	14	14	14	15	14	15	-41 %	9.2 %	2.5 %	4.7 %
Slovakia	6	4	3	3	4	4	4	4	3	4	3	4	-37 %	11.3 %	0.6 %	1.2 %
Slovenia	2	2	2	2	2	2	2	2	2	2	2	2	3 %	7.8 %	0.2 %	0.6 %
Spain	27	29	33	32	25	25	24	24	25	23	20	21	-20 %	4.8 %	2.6 %	6.9 %
Sweden	23	12	7	10	5	5	6	7	6	6	5	6	-72 %	21.6 %	2.2 %	2.0 %
EU-27 (a)	**1,018**	**657**	**487**	**433**	**378**	**345**	**340**	**341**	**342**	**330**	**299**	**313**	**-69%**	**4.6%**	**100%**	**100%**
EU-27 (b)	1,018	657	487	433	378	345	340	341	342	330	299	313				

Notes: Dark blue-shaded cells indicate that no emission values are available. See Appendix 1 for an explanation of the notation keys reported by EU Member States.

([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.16 Copper emission trends

Between 1990 and 2021, Cu emissions in the EU increased by 4%. Between 2020 and 2021, they grew by 6.5% (see Table 3.17), mainly because of increases in Italy, Poland, France and Greece (countries ranked according to the size of their contributions to the absolute change). In 2021, the EU Member States contributing most (i.e. more than 10%) to Cu emissions were Germany, Italy, Poland and France (together they account for 66.4% of the EU-27 total) (countries ranked according to their shares of the EU total). As Austria and Luxembourg did not provide emission data for Cu, the EU total is an underestimate.

Table 3.17 Member State contributions to EU emissions of Cu

	Cu (Mg)												Change		Share in EU-27	
Member State	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	1990—2021	2020—2021	1990	2021
Austria																
Belgium	94	99	101	102	102	98	99	96	94	94	80	81	-13 %	1.2 %	4.2 %	3.5 %
Bulgaria	48	32	35	46	37	42	43	44	45	45	43	45	-6 %	4.8 %	2.1 %	1.9 %
Croatia	7	6	7	10	8	8	9	10	9	10	10	10	32 %	0.5 %	0.3 %	0.4 %
Cyprus	5	6	8	9	9	8	8	8	8	8	8	8	67 %	7.8 %	0.2 %	0.3 %
Czechia	32	26	22	26	23	25	25	25	26	26	23	24	-26 %	2.1 %	1.4 %	1.0 %
Denmark	49	57	61	65	67	67	66	67	69	67	62	64	30 %	3.5 %	2.2 %	2.8 %
Estonia	15	8	8	10	11	11	11	12	12	11	10	11	-27 %	7.5 %	0.7 %	0.5 %
Finland	157	116	65	58	42	41	42	41	40	40	38	39	-75 %	4.0 %	7.0 %	1.7 %
France	256	257	265	279	280	282	279	280	278	279	231	247	-3 %	7.2 %	11.4 %	10.6 %
Germany	620	522	543	540	546	580	587	589	596	596	530	527	-15 %	-0.6 %	27.7 %	22.6 %
Greece	22	26	29	89	87	69	68	70	71	72	53	66	194 %	25.3 %	1.0 %	2.8 %
Hungary	32	26	32	44	45	46	47	50	52	54	48	53	65 %	10.4 %	1.4 %	2.3 %
Ireland	21	25	43	51	46	48	49	49	49	49	42	44	108 %	6.0 %	1.0 %	1.9 %
Italy	404	457	484	512	476	468	418	394	400	399	325	393	-3 %	21.0 %	18.0 %	16.9 %
Latvia	10	7	8	11	12	12	12	12	13	13	12	13	26 %	3.9 %	0.5 %	0.6 %
Lithuania	8	4	3	4	5	5	5	6	6	6	6	6	-26 %	1.9 %	0.4 %	0.3 %
Luxembourg	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
Malta	1	2	2	3	3	3	3	3	4	4	3	3	135 %	8.2 %	0.1 %	0.1 %
Netherlands	37	37	38	40	42	40	41	43	45	45	41	31	-15 %	-25.0 %	1.6 %	1.3 %
Poland	215	231	214	248	318	300	325	365	376	372	360	380	77 %	5.5 %	9.6 %	16.3 %
Portugal	26	32	42	45	36	29	29	29	29	30	26	26	1 %	3.8 %	1.2 %	1.1 %
Romania	10	9	7	53	60	63	68	72	75	77	76	79	704 %	3.4 %	0.4 %	3.4 %
Slovakia	12	9	7	8	9	10	11	11	9	9	8	9	-28 %	8.9 %	0.5 %	0.4 %
Slovenia	10	13	13	15	17	16	17	17	18	17	14	16	66 %	14.8 %	0.4 %	0.7 %
Spain	80	92	118	135	133	121	123	126	127	124	104	117	46 %	12.4 %	3.6 %	5.0 %
Sweden	66	52	46	38	38	38	39	40	41	40	38	38	-42 %	1.4 %	2.9 %	1.6 %
EU-27 (a)	**2,239**	**2,154**	**2,202**	**2,440**	**2,451**	**2,429**	**2,424**	**2,460**	**2,493**	**2,489**	**2,190**	**2,332**	**4%**	**6.5%**	**100%**	**100%**
EU-27 (b)	2,239	2,154	2,202	2,440	2,451	2,429	2,424	2,460	2,493	2,489	2,190	2,332				

Notes: Dark blue-shaded cells indicate that no emission values are available. See Appendix 1 for an explanation of the notation keys reported by EU Member States.

([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.17 Nickel emission trends

Between 1990 and 2021, Ni emissions dropped by 79% in the EU. Between 2020 and 2021, they increased by 3.5%, mainly because of increasing emissions in Bulgaria, Poland, France and Italy (countries ranked according to the size of their contributions to the absolute change) (see Table 3.18). In 2021, the EU Member States contributing most (i.e. more than 10%) to Ni emissions were Germany and Poland (countries ranked according to share of the EU total). As Austria and Luxembourg did not provide emission data for Ni, the EU total is an underestimate.

Table 3.18 Member State contributions to EU emissions of Ni

	Ni (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria																
Belgium	77	72	36	29	10	5	5	4	4	4	4	4	-95 %	2.3 %	4.0 %	0.9 %
Bulgaria	84	49	25	25	10	5	5	6	5	5	5	10	-88 %	114.4 %	4.4 %	2.4 %
Croatia	17	14	13	14	8	4	4	4	3	3	2	2	-89 %	-20.3 %	0.9 %	0.4 %
Cyprus	6	7	10	12	7	5	6	6	6	5	5	5	-21 %	-6.8 %	0.3 %	1.1 %
Czechia	55	28	14	12	8	5	5	5	5	5	4	4	-92 %	-2.0 %	2.9 %	1.1 %
Denmark	19	13	8	7	5	3	3	3	3	3	3	3	-84 %	10.2 %	1.0 %	0.7 %
Estonia	26	10	6	3	3	3	3	3	2	2	2	2	-94 %	-7.9 %	1.4 %	0.4 %
Finland	78	47	35	26	23	16	16	15	14	12	10	10	-87 %	4.0 %	4.1 %	2.4 %
France	286	214	176	146	88	40	35	28	23	24	19	22	-92 %	14.0 %	14.8 %	5.3 %
Germany	333	204	161	173	151	135	145	145	148	139	135	131	-61 %	-3.0 %	17.3 %	31.7 %
Greece	42	47	50	56	61	40	35	32	30	27	22	23	-46 %	0.8 %	2.2 %	5.5 %
Hungary	12	20	15	4	3	3	3	3	3	3	2	2	-81 %	-5.1 %	0.6 %	0.5 %
Ireland	22	27	31	21	9	6	6	5	5	6	6	8	-62 %	42.1 %	1.1 %	2.0 %
Italy	116	112	109	114	43	33	32	32	32	31	28	31	-73 %	8.9 %	6.0 %	7.5 %
Latvia	15	8	7	6	6	0	0	1	1	1	1	1	-96 %	11.9 %	0.8 %	0.1 %
Lithuania	32	17	12	11	7	4	4	3	3	3	3	3	-92 %	-18.5 %	1.7 %	0.6 %
Luxembourg	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
Malta	4	6	5	5	5	2	1	0	0	0	0	0	-89 %	10.6 %	0.2 %	0.1 %
Netherlands	76	86	20	11	3	2	2	2	2	2	2	2	-98 %	-2.9 %	3.9 %	0.4 %
Poland	200	166	120	106	102	84	83	82	79	75	74	77	-61 %	5.1 %	10.4 %	18.7 %
Portugal	111	116	106	104	45	23	22	21	21	21	20	18	-84 %	-10.4 %	5.8 %	4.3 %
Romania	113	64	35	25	15	11	10	12	11	12	10	12	-90 %	13.1 %	5.9 %	2.9 %
Slovakia	7	4	2	2	2	1	1	1	1	1	1	1	-84 %	18.4 %	0.4 %	0.3 %
Slovenia	3	2	2	2	2	2	2	2	2	1	1	1	-52 %	-3.4 %	0.2 %	0.3 %
Spain	164	191	197	174	91	45	47	52	51	46	35	37	-77 %	6.1 %	8.5 %	8.9 %
Sweden	28	30	17	15	14	7	7	7	7	6	5	6	-79 %	11.1 %	1.5 %	1.5 %
EU-27 (a)	**1,926**	**1,554**	**1,213**	**1,105**	**721**	**486**	**481**	**474**	**462**	**433**	**399**	**413**	**-79%**	**3.5%**	**100%**	**100%**
EU-27 (b)	1,926	1,554	1,213	1,105	721	486	481	474	462	433	399	413				

Notes: Dark blue-shaded cells indicate that no emission values are available. See Appendix 1 for an explanation of the notation keys reported by EU Member States.

([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.18 *Selenium emission trends*

Between 1990 and 2021, Se emissions dropped by 57% in the EU. Between 2020 and 2021, they increased by 5.6% (see Table 3.19), mainly because of increases in Bulgaria, France, Czechia, Romania and Italy (countries ranked according to the size of their contributions to the absolute change). In 2021, the EU Member States contributing most (i.e. more than 10%) to Se emissions were Czechia, France and Bulgaria (countries ranked according to their shares of the EU total). As Austria, Luxembourg and Poland did not provide emission data for Se, the EU total is an underestimate.

Finland reported emission data at the sectoral level but used the notation key 'NE' (not estimated) for the national total of Se emissions, because the inventory is not yet fully complete (personal communication from Finland in 2021). As envisaged by the gap-filling procedure, the national total for Finland was calculated using the sum of sector totals.

In 2005, Belgium reported high Se emissions in the category '2A3 — Glass production'. This was caused by one glass plant in Wallonia, which gives annual emissions based on measurements; the concentration of Se was very high in 2005 (personal communication from Belgium in 2014). Likewise, Belgium's high emissions in 2010 were mainly attributable to the operations of a particular company in Wallonia's glass industry (personal communication from Belgium in 2012).

Table 3.19 Member State contributions to EU emissions of Se

	Se (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria																
Belgium	5.2	6.4	6.5	27.2	11.6	4.2	3.8	3.7	2.8	2.5	2.2	1.9	-63 %	-13.9 %	2.9 %	2.4 %
Bulgaria	35.4	33.5	29.9	29.7	17.8	0.8	0.9	0.9	0.9	9.4	8.2	9.3	-74 %	13.4 %	19.3 %	11.7 %
Croatia	0.5	0.3	0.3	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.3	0.3	-29 %	-0.5 %	0.2 %	0.4 %
Cyprus	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-39 %	-3.1 %	0.0 %	0.1 %
Czechia	32.6	29.3	28.3	30.2	25.8	21.9	22.3	22.2	22.5	20.6	17.2	18.1	-44 %	5.1 %	17.7 %	22.8 %
Denmark	4.2	3.9	2.3	1.5	1.4	0.7	0.7	0.6	0.5	0.4	0.4	0.5	-89 %	21.2 %	2.3 %	0.6 %
Estonia	9.2	4.9	3.6	1.4	1.8	1.0	1.2	1.3	1.2	0.7	0.6	0.6	-94 %	4.1 %	5.0 %	0.7 %
Finland	1.8	0.4	0.5	0.5	0.6	0.5	0.4	0.9	0.5	0.4	0.4	0.5	-73 %	36.4 %	1.0 %	0.6 %
France	12.9	12.8	12.9	12.5	10.8	10.2	9.8	9.9	9.9	9.7	8.6	9.5	-26 %	11.5 %	7.0 %	12.0 %
Germany	5.7	10.7	8.5	4.9	4.3	3.2	3.2	3.2	2.9	2.9	2.7	2.8	-52 %	3.7 %	3.1 %	3.5 %
Greece	13.7	14.1	16.4	17.3	15.1	11.4	8.9	10.0	9.5	7.1	3.8	3.6	-74 %	-6.3 %	7.4 %	4.5 %
Hungary	6.5	5.8	5.8	4.1	3.6	3.3	3.2	3.0	2.8	2.5	2.4	2.1	-68 %	-11.5 %	3.5 %	2.6 %
Ireland	9.3	7.0	5.6	5.2	4.4	4.6	4.5	3.9	3.6	3.0	2.7	2.9	-69 %	5.2 %	5.1 %	3.6 %
Italy	7.7	7.8	8.5	8.9	8.1	8.5	7.3	7.3	7.2	6.6	6.0	6.6	-15 %	9.1 %	4.2 %	8.3 %
Latvia	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-83 %	-26.5 %	0.2 %	0.1 %
Lithuania	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-44 %	8.8 %	0.2 %	0.3 %
Luxembourg	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
Malta	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-97 %	-9.7 %	0.1 %	0.0 %
Netherlands	0.4	0.4	0.5	2.6	1.6	1.0	0.7	0.3	0.2	0.2	0.2	0.2	-53 %	-8.4 %	0.2 %	0.2 %
Poland															0.0 %	0.0 %
Portugal	1.9	2.5	2.9	3.2	3.4	3.4	3.3	3.4	3.7	3.4	3.2	3.3	74 %	5.1 %	1.0 %	4.2 %
Romania	19.7	15.7	11.7	12.5	12.0	10.6	9.4	9.5	9.3	8.7	6.2	6.8	-65 %	10.2 %	10.7 %	8.6 %
Slovakia	5.6	3.0	3.1	3.2	2.6	1.6	1.1	1.0	0.9	0.8	0.9	0.9	-84 %	-1.4 %	3.0 %	1.1 %
Slovenia	2.9	2.5	2.4	2.6	2.5	1.9	2.0	2.0	2.0	1.9	1.8	1.7	-42 %	-6.8 %	1.6 %	2.2 %
Spain	6.6	6.9	8.1	8.1	6.0	6.5	6.4	6.5	6.6	6.4	6.0	6.4	-4 %	6.5 %	3.6 %	8.0 %
Sweden	1.0	1.2	1.0	1.1	1.2	1.0	1.1	1.1	1.1	1.1	1.1	1.1	9 %	3.6 %	0.6 %	1.4 %
EU-27 (a)	**184**	**170**	**160**	**178**	**135**	**97**	**91**	**91**	**89**	**89**	**75**	**79**	**-57%**	**5.6%**	**100%**	**100%**
EU-27 (b)	184	170	160	178	135	97	91	91	89	89	75	79				

Notes: Dark blue-shaded cells indicate that no emission values are available. See Appendix 1 for an explanation of the notation keys reported by EU Member States.

Light blue-shaded cells denote gap-filled data. For more detailed information, see Annex D.

([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.19 Zinc emission trends

Between 1990 and 2021, Zn emissions dropped by 48% in the EU. However, between 2020 and 2021, they increased by 7.3%, mainly because of increases in Italy, France, Finland and Germany (countries ranked according to the size of their contributions to the absolute change) (see Table 3.20). In 2021, the EU Member States contributing most (i.e. more than 10%) to Zn emissions were Italy, Poland, Spain and France (countries ranked according to their shares of the EU total). As Austria and Luxembourg did not provide emission data for Zn, the EU total is an underestimate.

Table 3.20 Member State contributions to EU emissions of Zn

	Zn (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria																
Belgium	243	194	192	143	122	93	84	79	80	84	69	77	-68 %	10.5 %	3.5 %	2.1 %
Bulgaria	53	41	41	46	40	37	38	40	41	42	43	45	-15 %	5.5 %	0.8 %	1.3 %
Croatia	38	31	29	36	35	33	32	32	31	31	31	30	-22 %	-2.6 %	0.6 %	0.9 %
Cyprus	4	5	6	7	6	4	5	5	5	4	4	4	4 %	1.3 %	0.1 %	0.1 %
Czechia	105	79	64	60	56	45	42	42	42	42	39	40	-61 %	4.1 %	1.5 %	1.2 %
Denmark	75	68	58	63	67	65	67	68	68	65	61	64	-15 %	3.5 %	1.1 %	1.8 %
Estonia	106	61	44	27	32	26	29	30	31	26	26	24	-77 %	-5.4 %	1.5 %	0.8 %
Finland	683	403	128	119	129	119	127	120	118	130	117	140	-79 %	19.7 %	9.9 %	3.5 %
France	2,089	1,291	902	500	446	408	411	404	406	398	357	388	-81 %	8.7 %	30.4 %	10.7 %
Germany	474	266	277	259	289	293	294	299	298	298	266	281	-41 %	5.6 %	6.9 %	8.0 %
Greece	67	71	74	90	86	80	74	75	75	73	65	70	4 %	8.1 %	1.0 %	1.9 %
Hungary	82	63	67	64	70	72	72	71	66	64	61	65	-21 %	5.8 %	1.2 %	1.8 %
Ireland	59	55	65	38	30	32	33	31	30	28	26	30	-50 %	14.7 %	0.9 %	0.8 %
Italy	975	967	930	1,003	903	844	785	833	854	822	726	867	-11 %	19.5 %	14.2 %	21.8 %
Latvia	31	29	27	32	30	25	25	27	29	28	26	28	-11 %	4.0 %	0.5 %	0.8 %
Lithuania	23	18	19	23	24	28	28	29	30	29	29	31	37 %	10.2 %	0.3 %	0.9 %
Luxembourg	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
Malta	2	2	2	3	3	2	2	1	1	1	1	1	-42 %	6.0 %	0.0 %	0.0 %
Netherlands	226	147	96	89	104	103	102	94	356	281	179	152	-33 %	-15.1 %	3.3 %	5.4 %
Poland	794	803	575	525	548	521	529	550	609	578	554	562	-29 %	1.5 %	11.6 %	16.6 %
Portugal	58	59	62	61	55	54	54	55	55	54	51	52	-11 %	0.3 %	0.8 %	1.5 %
Romania	125	98	103	135	132	119	121	123	124	125	121	129	4 %	7.2 %	1.8 %	3.6 %
Slovakia	33	24	24	27	28	31	31	32	30	28	25	29	-12 %	17.2 %	0.5 %	0.8 %
Slovenia	20	19	19	24	23	22	23	22	21	21	19	21	6 %	12.2 %	0.3 %	0.6 %
Spain	314	269	356	349	386	381	367	361	423	352	372	382	22 %	2.6 %	4.6 %	11.2 %
Sweden	190	135	93	99	99	82	79	77	76	74	68	68	-64 %	0.7 %	2.8 %	2.0 %
EU-27 (a)	**6,868**	**5,199**	**4,256**	**3,821**	**3,743**	**3,521**	**3,452**	**3,502**	**3,898**	**3,677**	**3,336**	**3,581**	**-48%**	**7.3%**	**100%**	**100%**
EU-27 (b)	6,868	5,199	4,256	3,821	3,743	3,521	3,452	3,502	3,898	3,677	3,336	3,581				

Notes: Dark blue-shaded cells indicate that no emission values are available. See Appendix 1 for an explanation of the notation keys reported by EU Member States.

([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.20 *Dioxin and furan emission trends and key categories*

Between 1990 and 2021, PCDD/F emissions dropped by 74% in the EU. Between 2020 and 2021, the increase was 1.1% (see Table 3.21), mainly because of increases in Italy, Romania, Spain and Germany (countries ranked according to the size of their contributions to the absolute change).

Table 3.21 Member State contributions to EU emissions of PCDD/Fs

	PCDD/Fs (g I-TEQ)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	124	59	52	36	42	38	37	37	34	34	34	37	-70 %	9.8 %	1.6 %	1.8 %
Belgium	546	366	92	126	51	31	30	31	26	29	28	29	-95 %	3.4 %	6.9 %	1.4 %
Bulgaria	116	122	168	144	67	47	47	49	46	47	73	43	-63 %	-41.4 %	1.5 %	2.1 %
Croatia	89	79	78	117	82	40	33	29	27	26	26	24	-73 %	-7.2 %	1.1 %	1.2 %
Cyprus	17	19	21	0.7	0.6	0.5	0.6	0.6	0.6	0.5	0.5	0.5	-97 %	3.3 %	0.2 %	0.0 %
Czechia	106	76	63	64	49	38	29	28	29	28	27	22	-79 %	-17.0 %	1.3 %	1.1 %
Denmark	70	53	35	33	38	36	39	37	35	32	30	31	-56 %	0.1 %	0.9 %	1.5 %
Estonia	10	7	7	6	6	4	4	4	4	4	4	4	-64 %	-10.1 %	0.1 %	0.2 %
Finland	15	19	18	14	16	14	15	13	13	10	9	11	-27 %	14.9 %	0.2 %	0.5 %
France	1,802	1,743	581	265	175	150	139	136	133	129	120	125	-93 %	4.1 %	22.8 %	6.1 %
Germany	814	343	266	154	138	127	125	123	119	118	110	116	-86 %	5.3 %	10.3 %	5.6 %
Greece	42	42	42	43	28	27	25	26	26	24	23	26	-39 %	12.1 %	0.5 %	1.2 %
Hungary	113	79	82	64	78	78	77	66	59	65	61	58	-49 %	-4.7 %	1.4 %	2.8 %
Ireland	44	34	27	25	25	22	20	19	21	18	18	17	-62 %	-6.6 %	0.6 %	0.8 %
Italy	529	511	434	361	342	310	312	330	311	307	280	314	-41 %	12.2 %	6.7 %	15.3 %
Latvia	30	34	31	35	23	18	17	20	19	19	17	15	-50 %	-10.8 %	0.4 %	0.7 %
Lithuania	26	19	19	24	22	19	18	19	19	18	17	18	-32 %	5.6 %	0.3 %	0.9 %
Luxembourg	44	35	7	3	3	2	3	3	2	2	2	2	-96 %	0.0 %	0.6 %	0.1 %
Malta	0.3	0.2	0.2	0.2	8.0	1.8	1.7	1.6	1.6	0.2	0.2	0.2	-32 %	-3.9 %	0.0 %	0.0 %
Netherlands	746	71	37	36	40	32	32	32	31	31	30	30	-96 %	0.3 %	9.4 %	1.5 %
Poland	371	455	314	366	414	338	342	337	404	352	333	316	-15 %	-4.9 %	4.7 %	15.4 %
Portugal	557	553	357	72	54	52	53	55	60	61	61	60	-89 %	-2.4 %	7.0 %	2.9 %
Romania	266	230	762	756	187	167	170	178	180	186	185	211	-21 %	14.1 %	3.4 %	10.2 %
Slovakia	769	685	905	358	56	65	65	66	66	63	53	40	-95 %	-25.2 %	9.7 %	1.9 %
Slovenia	21	19	19	21	20	18	18	17	16	15	14	14	-33 %	1.2 %	0.3 %	0.7 %
Spain	580	684	604	452	577	541	499	489	519	453	461	477	-18 %	3.4 %	7.3 %	23.2 %
Sweden	60	34	27	26	21	17	18	17	17	17	17	17	-71 %	1.2 %	0.8 %	0.8 %
EU-27 (a)	**7,908**	**6,369**	**5,049**	**3,602**	**2,562**	**2,232**	**2,169**	**2,165**	**2,221**	**2,088**	**2,034**	**2,057**	**-74%**	**1.1%**	**100%**	**100%**
EU-27 (b)	7,908	6,369	5,049	3,602	2,562	2,232	2,169	2,165	2,221	2,088	2,034	2,057				

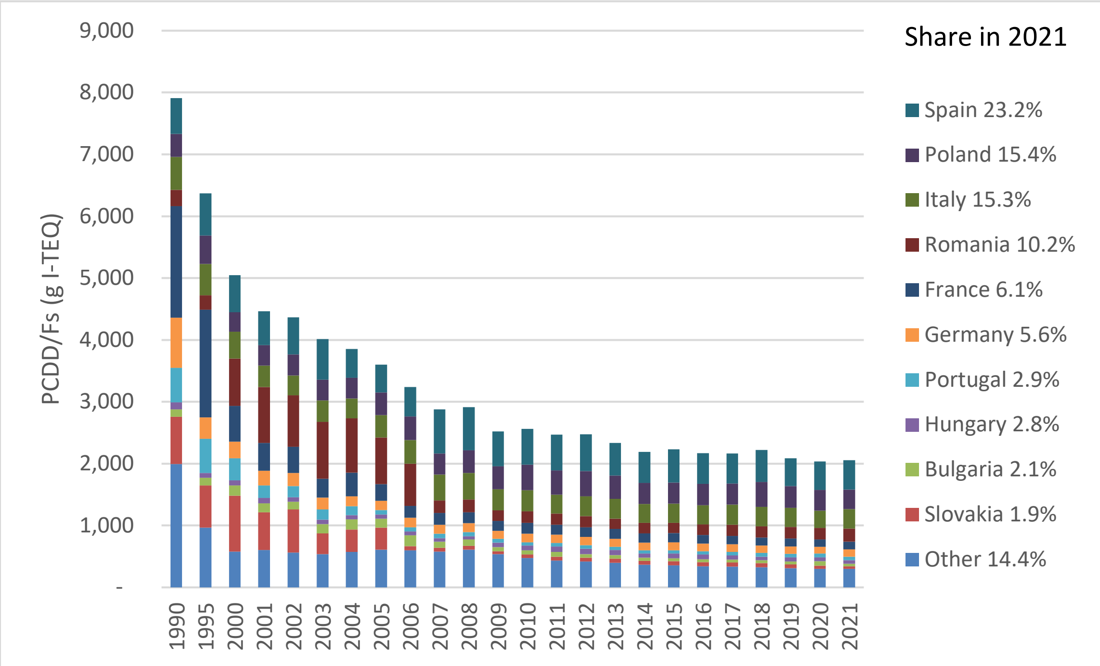
Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

I-TEQ, international toxic equivalent.

In 2021, the Member States contributing most (i.e. more than 10%) to PCDD/F emissions were Spain, Poland, Italy and Romania, with a joint contribution of 64% of EU-27 emissions (see Figure 3.25).

Figure 3.26 Dioxin emission trends in the EU and shares of Member States



Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

In France, the decrease in dioxin emissions between 1990 and 2002 resulted from regulations limiting emissions, especially in the fields of waste incineration, industrial energy processes (steel and metallurgy) and combustion in manufacturing (see France's IIR, listed in Appendix 5). The drop in dioxin emissions between 1995 and 2000 was due to improvements in sinter plants (personal communication from France in 2013).

Slovakia reported in its IIR that the emissions of PCDD/Fs dropped in 1999 because of the technological improvement in facilities that burn industrial waste as a fuel to produce energy. The moderate increase in 2005 was because many facilities did not comply with the stricter emission limits that came into force in 2006 and therefore used the last year of their operation to burn more waste. This was followed by a decrease in 2006. Since then, emissions have shown a slightly increasing trend because of waste management policies in Slovakia, which favour the combustion of waste over its disposal to landfill. The main contributing sectors are energy production (includes incineration of municipal waste with energy recovery) and waste incineration without energy recovery, which includes incineration of industrial and clinical waste (see Slovakia's IIR, listed in Appendix 5).

In Spain, the fall in PCDD/F emissions after 1995 was linked to the adaptation of municipal solid waste incineration facilities with energy recovery (included in the category '1A1a — Public electricity and heat production') to comply with the maximum levels imposed in legislation; it was also related to the implementation of particle and acid gas abatement techniques in 1996 (personal communication from Spain in 2017).

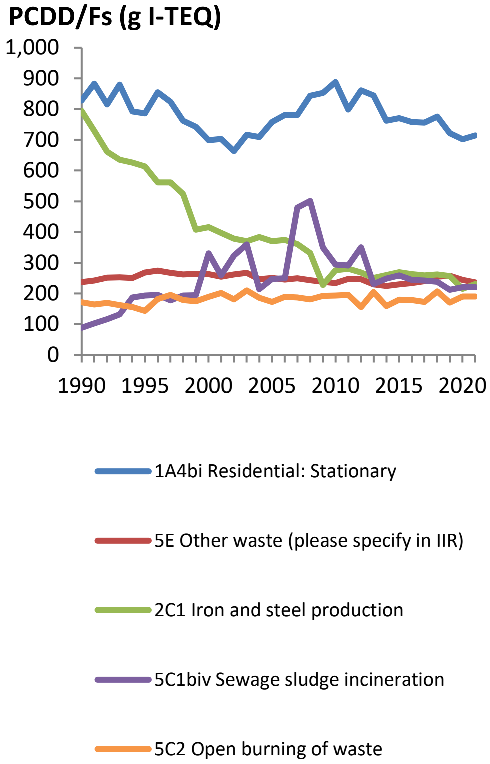
The '5C1biii — Clinical waste incineration' category contributed most to the trend in PCDD/F emissions reported by Portugal. The dramatic drop in emissions between 2000 and 2005 was caused by the closing of 25 incinerators on its mainland; since 2004, just one clinical waste incinerator has remained in operation. Other clinical waste receives alternative treatment or is sent abroad (see Portugal's IIR, listed in Appendix 5).

Categories '1A4bi — Residential: Stationary', '2C1 — Iron and steel production' and '5E — Other waste' were the primary key categories for PCDD/F emissions, together making up 46% of total PCDD/F emissions (see Figure 3.27(a)). Among the top five key categories, the highest relative reductions in emissions between 1990 and 2021 were in the third most important '2C1 — Iron and steel production' (71%) and the most important '1A4bi — Residential: Stationary' (13.6%). Emissions from categories '5C1biv — Sewage sludge incineration' and'5C2 — Open burning of waste' increased (150% and 11%, respectively). PCDD/F emissions from '5E — Other waste' stayed more or less stable (0.8%).

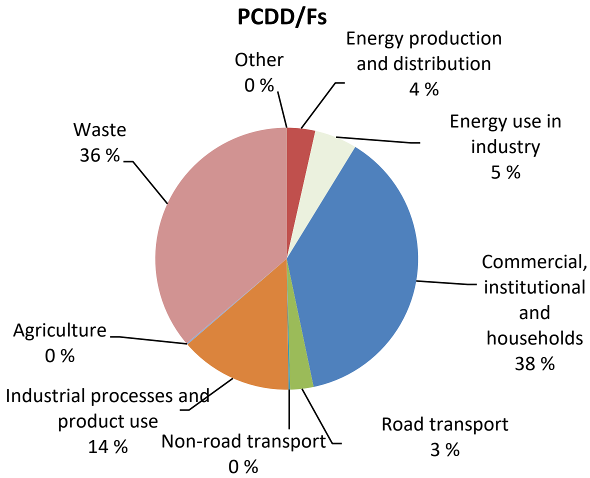
Figure 3.27(b) shows the contribution made by each aggregated sector group to total EU emissions. The sector groups waste, commercial, institutional and households and industrial processes and product use are significant sources of PCDD/F emissions.

Figure 3.27 PCDD/F emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions

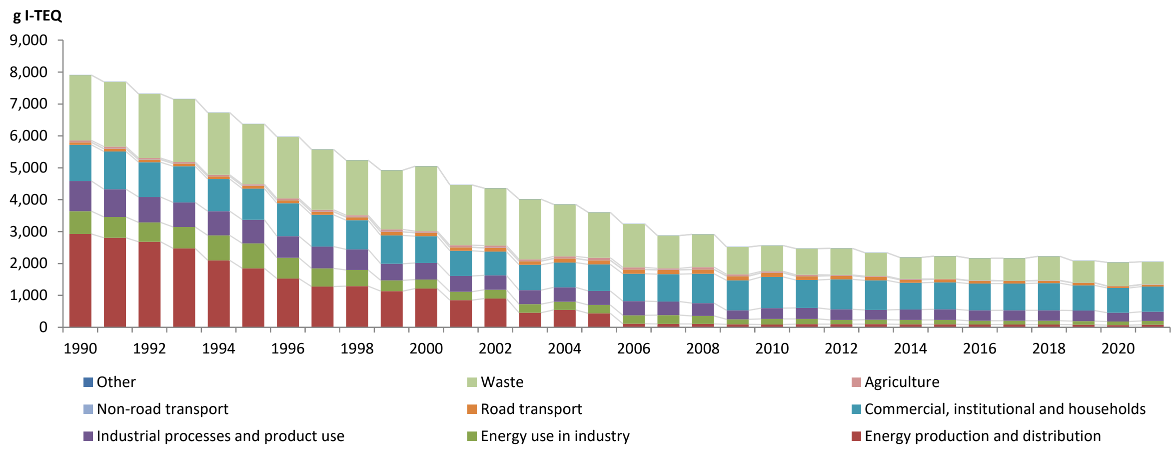
(a)



(b)



(c)



Note: I-TEQ, international toxic equivalent.

3.21 Total polycyclic aromatic hydrocarbon emission trends and key categories

Between 1990 and 2021, PAH emissions dropped by 50% in the EU. However, between 2020 and 2021, they grew by 3.1% (see Table 3.22), mainly because of increases in Germany, Romania, Italy and Slovakia (countries ranked according to their shares of the EU total).

Table 3.22 Member State contributions to EU emissions of total PAHs

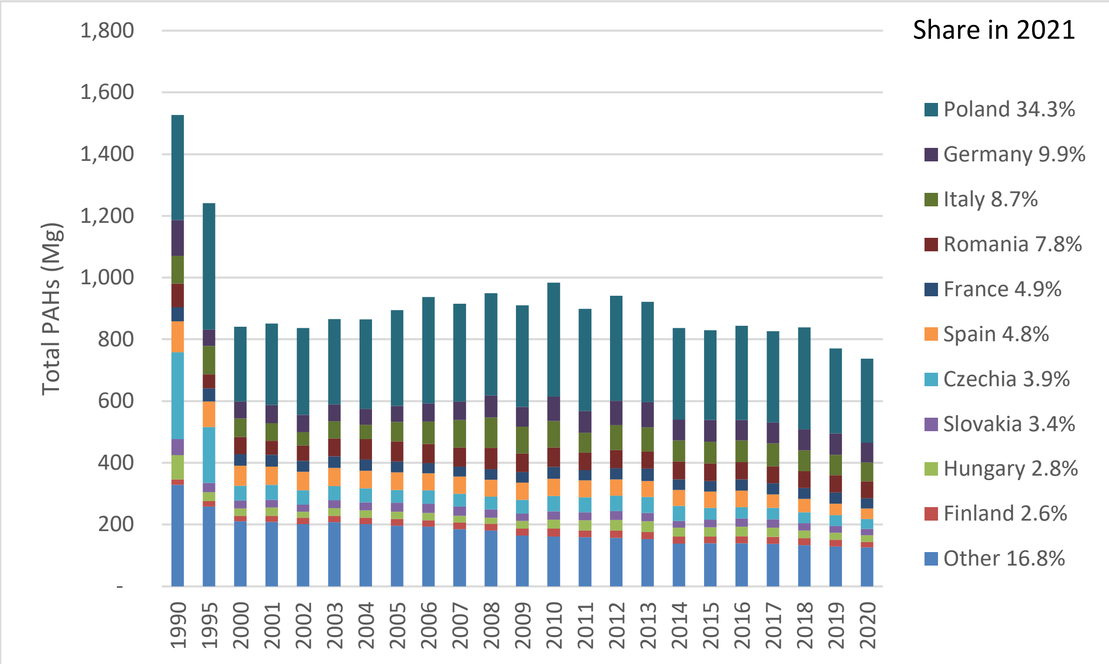
	Total PAHs (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	19	11	9	7	8	7	7	7	6	6	6	7	-61 %	11.4 %	1.2 %	0.9 %
Belgium	51	40	32	25	15	9	8	8	7	7	6	7	-87 %	14.7 %	3.3 %	0.9 %
Bulgaria	29	24	17	18	17	15	16	16	14	14	15	15	-47 %	1.7 %	1.9 %	2.0 %
Croatia	22	17	15	19	18	16	15	15	14	13	13	13	-43 %	-6.2 %	1.4 %	1.6 %
Cyprus	14	11	6	4	0.9	0.9	0.7	0.6	0.7	0.6	0.7	0.7	-95 %	0.6 %	0.9 %	0.1 %
Czechia	282	181	47	42	49	38	36	37	35	34	31	30	-89 %	-4.7 %	18.5 %	3.9 %
Denmark	12	13	10	10	8	7	7	6	6	5	4	4	-65 %	-1.8 %	0.8 %	0.6 %
Estonia	9	10	7	5	5	4	4	4	4	3	3	3	-66 %	-11.0 %	0.6 %	0.4 %
Finland	18	17	18	22	25	22	23	23	23	22	18	20	11 %	12.6 %	1.2 %	2.6 %
France	46	42	38	35	38	35	37	36	35	36	33	37	-19 %	14.0 %	3.0 %	4.9 %
Germany	116	53	55	52	78	70	66	68	68	69	65	75	-35 %	15.7 %	7.6 %	9.9 %
Greece	23	23	23	21	15	18	17	17	17	16	16	17	-27 %	6.5 %	1.5 %	2.2 %
Hungary	78	30	25	23	29	30	30	30	24	22	21	21	-73 %	0.4 %	5.1 %	2.8 %
Ireland	30	21	16	15	15	14	15	13	14	12	13	12	-60 %	-7.0 %	1.9 %	1.6 %
Italy	90	92	60	64	87	71	70	74	67	65	60	67	-26 %	10.2 %	5.9 %	8.7 %
Latvia	18	17	16	13	10	7	7	8	8	8	7	7	-60 %	2.8 %	1.2 %	0.9 %
Lithuania	23	10	9	10	11	9	10	10	10	9	8	9	-61 %	4.8 %	1.5 %	1.2 %
Luxembourg	5	2	0.7	0.7	0.6	0.6	0.7	0.7	0.7	0.6	0.5	0.5	-88 %	0.0 %	0.3 %	0.1 %
Malta	0.8	0.5	0.4	0.03	0.04	0.1	0.1	0.1	0.0	0.0	0.1	0.1	-93 %	7.4 %	0.1 %	0.0 %
Netherlands	20	11	6	6	7	5	5	5	5	5	4	4	-79 %	6.3 %	1.3 %	0.6 %
Poland	341	409	242	310	369	291	305	295	330	276	271	261	-24 %	-4.0 %	22.3 %	34.3 %
Portugal	25	23	22	19	15	13	13	14	15	17	16	17	-34 %	2.7 %	1.6 %	2.2 %
Romania	76	45	56	65	63	57	56	56	55	56	55	59	-22 %	7.4 %	5.0 %	7.8 %
Slovakia	51	30	26	29	28	25	27	27	24	23	21	26	-50 %	22.6 %	3.4 %	3.4 %
Slovenia	9	7	6	7	7	6	6	6	5	5	5	5	-48 %	-0.9 %	0.6 %	0.6 %
Spain	100	83	65	57	56	53	53	44	43	38	35	36	-64 %	4.5 %	6.5 %	4.8 %
Sweden	20	20	15	17	11	9	9	8	7	7	7	7	-65 %	-0.3 %	1.3 %	0.9 %
EU-27 (a)	**1,527**	**1,241**	**841**	**895**	**983**	**829**	**843**	**826**	**839**	**771**	**737**	**760**	**-50%**	**3.1%**	**100%**	**100%**
EU-27 (b)	1,527	1,241	841	895	983	829	843	826	839	771	737	760				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member State contributing most (i.e. more than 10%) to the EU-27 total PAH emissions was Poland, with a share of 34% (see Figure 3.27).

Figure 3.28 Total PAH emission trends in the EU and shares of Member States



Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

Poland explained the decrease in total PAH emissions between 1990 and 2021 by the reductions in the consumption of hard coal and wood in the household sector.

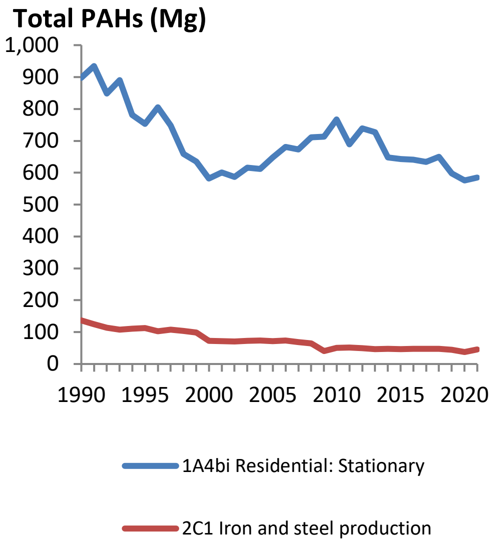
Spain reported that estimated total PAH emissions are mainly driven by category '3F — Field burning of agricultural residues'. This activity and the related emissions have notably decreased because of this practice being gradually abandoned, driven by legislation to prevent forest fires and the entry into force of the EU common agricultural policy's conditionality rules and mitigation programmes to reduce the field burning of agricultural waste, particularly between 1999 and 2003 (personal communication from Spain in 2017).

In 2021, categories '1A4bi — Residential: Stationary' and '2C1 — Iron and steel production' were the principal key categories for these emissions, making up 83% of total PAH emissions (see Figure 3.29(a)). Both categories show decreases in total PAH emissions (34.8% and 66.7%, respectively).

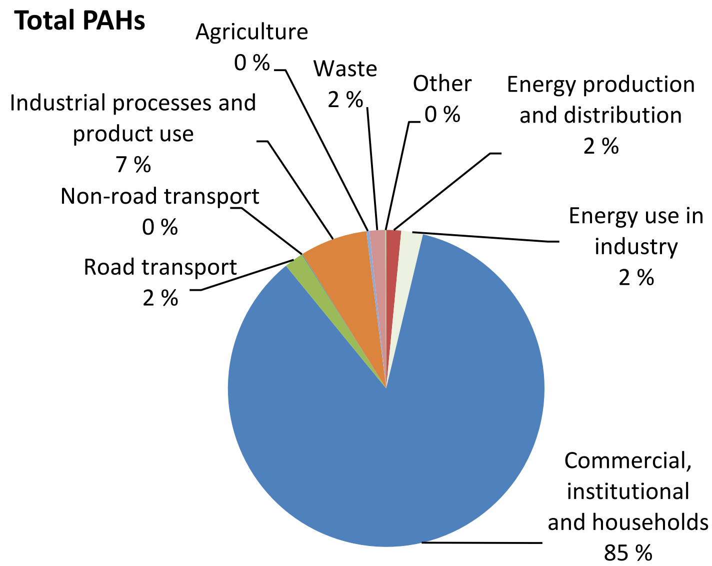
Figure 3.29(b) shows the contribution made by each aggregated sector group to total EU emissions. The commercial, institutional and households sector group is a very significant source of total PAH emissions.

Figure 3.29 Total PAH emissions in the EU: (a) trends in emissions from the two most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions

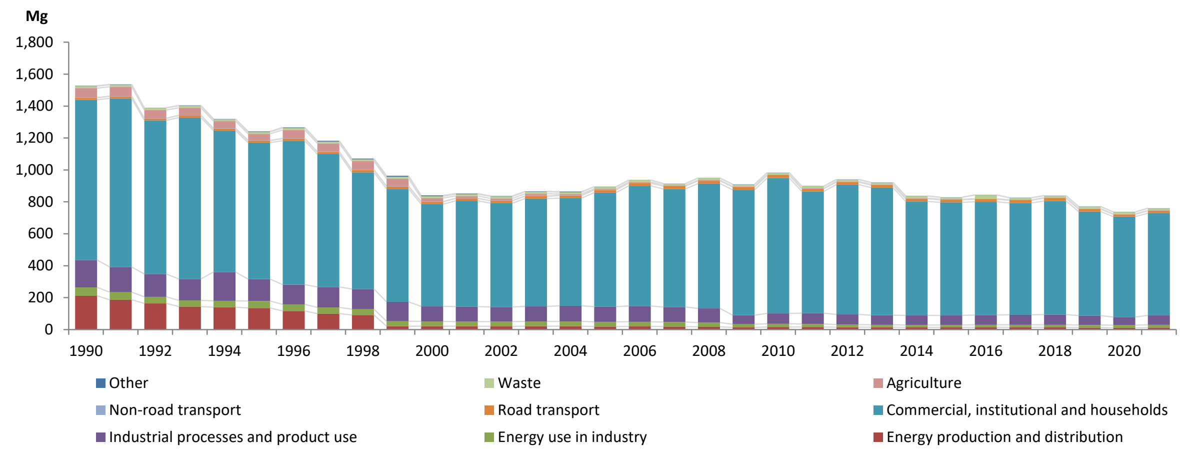
(a)



(b)



(c)



3.22 *Benzo(a)pyrene emission trends and key categories*

Between 1990 and 2021, B(a)P emissions fell by 49% in the EU. Between 2020 and 2021, they increased by 1.5% (see Table 3.23), mainly because emissions grew in Germany, Italy, France and Romania (countries ranked according to the size of their contributions to the absolute change). In 2021, the Member State contributing most (i.e. more than 10%) to B(a)P emissions was Poland, with a share of 38% (Figure 3.30).

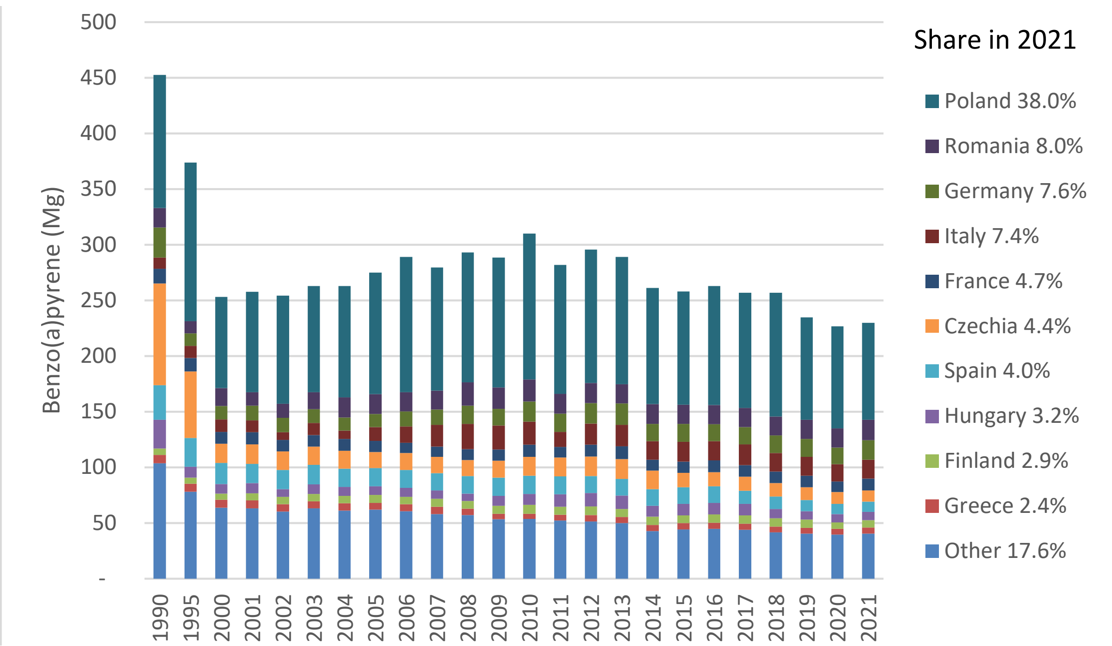
Table 3.23 Member State contributions to EU emissions of B(a)P

Member State	Benzo(a)pyrene (Mg)												Change		Share in EU-27	
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	1990—2021	2020—2021	1990	2021
Austria	6	4	3	2	2	2	2	2	2	2	2	2	-63 %	11.6 %	1.3 %	1.0 %
Belgium	15	12	10	8	5	3	3	2	2	2	2	2	-86 %	14.9 %	3.4 %	0.9 %
Bulgaria	9	7	5	6	6	5	6	6	5	5	5	5	-38 %	3.9 %	1.9 %	2.3 %
Croatia	7	6	5	6	6	6	5	5	5	5	5	4	-39 %	-6.2 %	1.6 %	1.9 %
Cyprus	2	2	1.1	0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-95 %	0.8 %	0.5 %	0.1 %
Czechia	91	60	17	15	17	13	13	13	12	12	11	10	-89 %	-5.6 %	20.2 %	4.4 %
Denmark	3	4	3	3	2	2	2	2	2	1	1	1	-63 %	-2.4 %	0.8 %	0.6 %
Estonia	2	3	2	1	1	1	1	1	1	1	1	1	-66 %	-11.5 %	0.5 %	0.4 %
Finland	6	5	6	7	8	7	8	8	7	7	6	7	15 %	12.2 %	1.3 %	2.9 %
France	13	12	11	10	11	10	11	10	10	10	9	11	-18 %	14.5 %	2.9 %	4.7 %
Germany	27	11	12	12	18	16	15	16	16	16	15	17	-35 %	16.0 %	6.0 %	7.6 %
Greece	7	7	7	6	4	6	5	5	5	5	5	5	-26 %	6.2 %	1.6 %	2.4 %
Hungary	26	10	8	8	10	10	10	10	8	8	7	7	-72 %	0.5 %	5.8 %	3.2 %
Ireland	7	5	4	4	4	4	4	3	3	3	3	3	-56 %	-7.7 %	1.5 %	1.3 %
Italy	10	11	11	12	21	18	17	19	17	17	16	17	70 %	9.1 %	2.2 %	7.4 %
Latvia	6	6	6	5	4	3	3	3	3	3	2	3	-60 %	3.2 %	1.4 %	1.1 %
Lithuania	7	3	3	3	4	3	3	3	3	3	3	3	-55 %	3.8 %	1.5 %	1.3 %
Luxembourg	1.2	0.6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	-90 %	0.0 %	0.3 %	0.1 %
Malta	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.02	-26 %	8.3 %	0.0 %	0.0 %
Netherlands	5	3	2	2	2	2	2	2	2	2	1	2	-72 %	6.0 %	1.2 %	0.7 %
Poland	119	143	82	109	131	102	107	103	111	92	92	87	-27 %	-4.7 %	26.4 %	38.0 %
Portugal	8	7	6	5	4	4	4	4	5	5	5	5	-31 %	3.8 %	1.7 %	2.3 %
Romania	18	11	16	18	20	17	17	17	17	17	17	18	4 %	6.2 %	3.9 %	8.0 %
Slovakia	15	7	6	6	6	5	5	5	4	5	4	5	-67 %	9.3 %	3.3 %	2.1 %
Slovenia	3	3	3	3	3	3	3	2	2	2	2	2	-42 %	-1.0 %	0.7 %	0.8 %
Spain	31	26	19	16	16	15	15	12	11	10	9	9	-70 %	0.2 %	6.8 %	4.0 %
Sweden	6	6	5	5	3	3	3	3	2	2	2	2	-68 %	-1.2 %	1.4 %	0.9 %
EU-27 (a)	**453**	**374**	**253**	**275**	**310**	**258**	**263**	**257**	**257**	**235**	**227**	**230**	**-49%**	**1.5%**	**100%**	**100%**
EU-27 (b)	453	374	253	275	310	258	263	257	257	235	227	230				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

Figure 3.30 Benzo(a)pyrene emission trends in the EU and shares of Member States

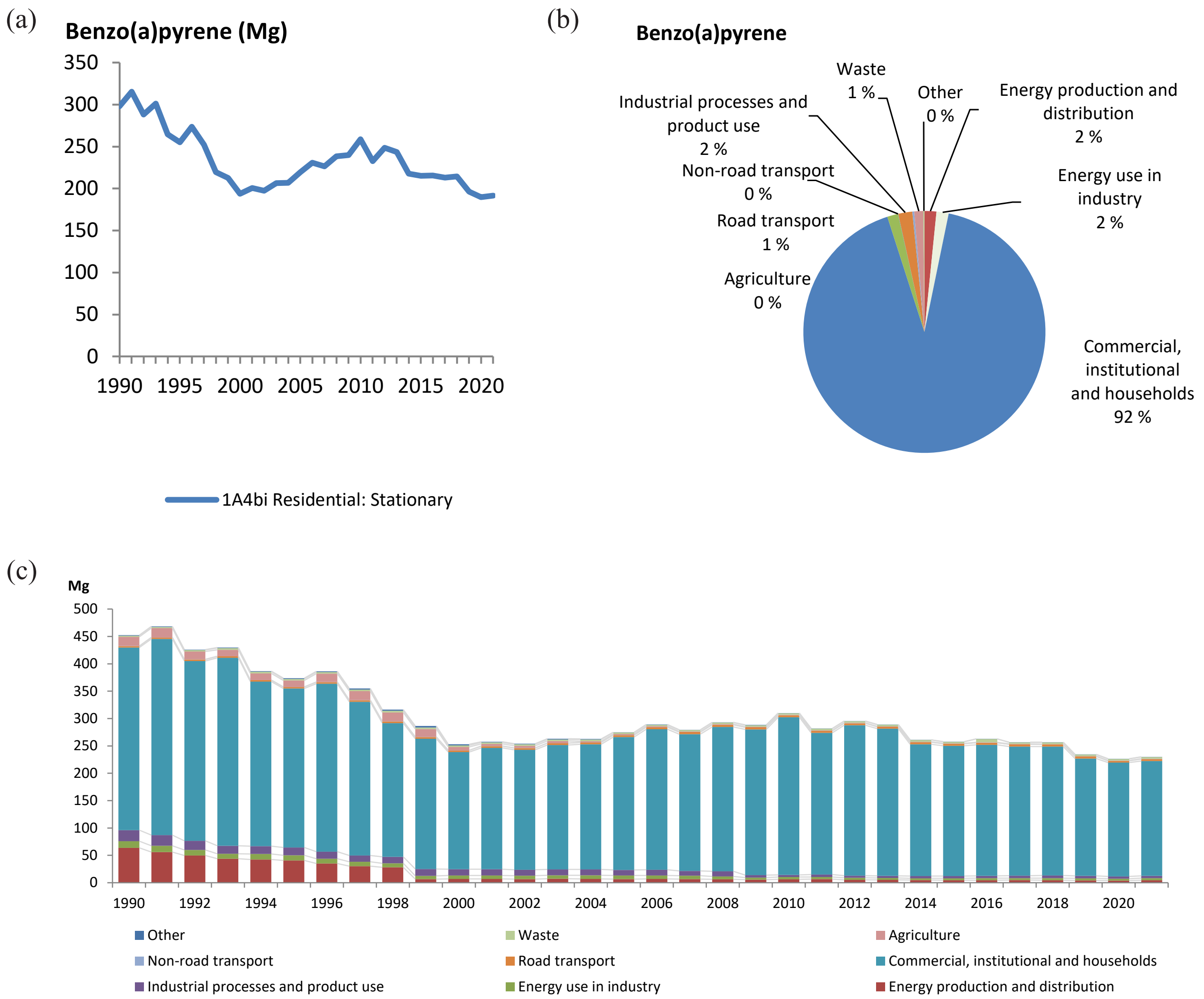


Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

Category '1A4bi — Residential: Stationary' was the principal key category for B(a)P emissions, accounting for 83% of the total. Among the key categories, the largest change could be observed for the most important '1A4bi — Residential: Stationary' (35.7%) (see Figure 3.31(a)).

Figure 3.31(b) shows the contribution made by each aggregated sector group to total EU emissions. The commercial, institutional and households sector group is the main source of B(a)P emissions.

Figure 3.31 B(a)P emissions in the EU: (a) trends in emissions from the most important key category, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



3.23 Benzo(b)fluoranthene emission trends

Between 1990 and 2021, (B(b)F emissions fell by 51% in the EU. Between 2020 and 2021, they increased by 2.1% (see Table 3.24), mainly because of a slight increase in Germany, Italy, France and Romania (countries ranked according to the size of their contributions to the absolute change).

Table 3.24 Member State contributions to EU emissions of B(b)F

	Benzo(b)fluoranthene (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	6	4	3	3	3	2	2	2	2	2	2	3	-59 %	11.7 %	1.3 %	1.1 %
Belgium	18	14	11	9	5	3	3	3	3	2	2	2	-87 %	14.6 %	3.6 %	1.0 %
Bulgaria	11	8	6	6	6	5	5	6	5	5	5	5	-51 %	4.4 %	2.2 %	2.2 %
Croatia	8	6	5	6	6	5	5	5	4	4	4	4	-46 %	-6.1 %	1.5 %	1.7 %
Cyprus	7	5	3	2	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	-95 %	0.6 %	1.3 %	0.1 %
Czechia	91	57	11	10	12	10	9	9	9	9	8	8	-91 %	-3.9 %	18.4 %	3.2 %
Denmark	3	3	3	3	2	2	2	2	2	2	1.4	1.4	-54 %	-0.9 %	0.6 %	0.6 %
Estonia	3	3	2	1.5	1.4	1.0	1.0	1.0	1.0	0.9	0.9	0.8	-73 %	-14.9 %	0.6 %	0.3 %
Finland	5	5	5	6	6	5	6	6	6	6	5	5	9 %	13.0 %	1.0 %	2.2 %
France	15	14	12	12	12	12	12	12	12	12	11	12	-20 %	14.0 %	3.1 %	5.1 %
Germany	36	15	17	17	26	23	22	23	23	23	22	25	-30 %	16.4 %	7.3 %	10.5 %
Greece	9	9	9	8	6	6	6	6	6	6	6	6	-35 %	5.2 %	1.8 %	2.5 %
Hungary	30	11	8	8	10	10	10	10	8	7	7	7	-76 %	0.2 %	6.0 %	3.0 %
Ireland	12	8	7	6	6	6	6	5	6	5	5	5	-57 %	-7.4 %	2.4 %	2.1 %
Italy	13	14	14	15	25	21	21	22	20	20	18	20	55 %	8.9 %	2.6 %	8.2 %
Latvia	6	5	5	4	3	2	2	3	3	3	2	2	-63 %	2.4 %	1.3 %	1.0 %
Lithuania	8	3	3	4	4	4	4	4	4	3	3	3	-59 %	5.5 %	1.6 %	1.4 %
Luxembourg	1.5	0.8	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.2	0.2	-85 %	0.0 %	0.3 %	0.1 %
Malta	0.4	0.2	0.1	0.01	0.02	0.03	0.03	0.02	0.02	0.03	0.02	0.02	-94 %	8.6 %	0.1 %	0.0 %
Netherlands	8	4	2	2	2	2	2	2	2	1	1	1	-83 %	6.5 %	1.6 %	0.6 %
Poland	122	147	85	108	128	101	105	102	114	95	94	90	-27 %	-4.1 %	24.8 %	37.3 %
Portugal	7	6	6	5	4	4	4	4	4	4	4	4	-38 %	2.2 %	1.4 %	1.8 %
Romania	22	12	16	18	19	17	17	16	16	16	16	17	-22 %	6.8 %	4.5 %	7.2 %
Slovakia	11	6	4	5	5	4	4	4	4	4	4	4	-64 %	9.0 %	2.3 %	1.7 %
Slovenia	3	2	2	2	1	1	1	1	1	1	1	1	-62 %	-3.3 %	0.6 %	0.4 %
Spain	32	26	19	15	15	14	14	11	11	10	10	9	-71 %	-2.6 %	6.6 %	3.9 %
Sweden	6	6	5	5	3	3	3	3	2	2	2	2	-65 %	-0.9 %	1.3 %	0.9 %
EU-27 (a)	**494**	**394**	**263**	**279**	**312**	**263**	**267**	**261**	**267**	**245**	**236**	**241**	**-51%**	**2.1%**	**100%**	**100%**
EU-27 (b)	494	394	263	279	312	263	267	261	267	245	236	241				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.24 Benzo(k)fluoranthene emission trends

Between 1990 and 2021, B(k)F emissions in the EU decreased by 51%. Between 2020 and 2021, they grew by 2.4% (see Table 3.25), mainly in Germany, France, Italy and Finland (countries ranked according to the size of their contributions to the absolute change). In 2021, the EU Member State contributing most (i.e. more than 10%) to the EU-27 B(k)F emissions was Poland, with a share of 37.1%.

Table 3.25 Member State contributions to EU emissions of B(k)F

	Benzo(k)fluoranthene (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	3.7	1.5	1.2	1.0	1.1	1.0	1.0	1.0	0.9	1.0	0.9	1.0	-72 %	10.7 %	1.6 %	0.9 %
Belgium	10.0	7.8	6.0	4.7	2.4	1.3	1.3	1.2	1.1	1.0	0.9	1.0	-90 %	13.2 %	4.2 %	0.9 %
Bulgaria	6.0	3.9	2.5	2.5	2.3	2.0	2.1	2.2	1.9	1.8	2.0	2.1	-65 %	5.7 %	2.5 %	1.8 %
Croatia	2.8	2.1	1.9	2.4	2.2	2.0	1.9	1.8	1.7	1.7	1.7	1.6	-45 %	-6.1 %	1.2 %	1.4 %
Cyprus	2.8	2.2	1.3	0.8	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-95 %	0.5 %	1.2 %	0.1 %
Czechia	50.6	33.3	8.4	7.4	8.4	6.7	6.6	6.6	6.3	6.2	5.8	5.5	-89 %	-4.3 %	21.3 %	4.8 %
Denmark	2.4	2.5	2.1	2.2	1.7	1.4	1.4	1.3	1.1	1.0	0.9	0.8	-64 %	-2.8 %	1.0 %	0.7 %
Estonia	1.6	1.8	1.3	1.0	1.0	0.7	0.7	0.7	0.6	0.6	0.6	0.5	-66 %	-9.9 %	0.7 %	0.5 %
Finland	3.6	3.4	3.5	4.3	5.0	4.3	4.6	4.5	4.5	4.4	3.4	3.8	7 %	12.8 %	1.5 %	3.3 %
France	9.4	8.6	7.7	7.3	7.7	7.1	7.4	7.3	7.1	7.2	6.6	7.5	-20 %	13.2 %	4.0 %	6.4 %
Germany	16.3	7.0	7.9	7.7	11.9	10.5	10.0	10.2	10.2	10.4	9.8	11.4	-30 %	16.2 %	6.9 %	9.8 %
Greece	4.2	4.0	4.1	3.6	2.7	3.3	3.1	3.2	3.2	3.2	3.1	3.2	-23 %	2.8 %	1.8 %	2.8 %
Hungary	11.5	4.2	3.3	3.1	3.7	3.8	3.9	3.9	3.2	2.9	2.7	2.8	-76 %	0.2 %	4.9 %	2.4 %
Ireland	6.2	4.1	3.0	2.9	2.8	2.6	2.6	2.3	2.5	2.2	2.3	2.2	-65 %	-5.8 %	2.6 %	1.9 %
Italy	6.0	6.6	6.7	7.5	11.5	9.6	9.4	10.1	9.0	9.0	8.3	9.1	53 %	9.3 %	2.5 %	7.9 %
Latvia	2.4	2.1	2.0	1.7	1.3	0.9	0.9	1.0	1.0	1.0	0.9	0.9	-63 %	2.8 %	1.0 %	0.8 %
Lithuania	3.4	1.5	1.4	1.6	1.8	1.6	1.7	1.7	1.7	1.6	1.5	1.5	-55 %	4.4 %	1.4 %	1.3 %
Luxembourg	1.0	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-88 %	0.0 %	0.4 %	0.1 %
Malta	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-95 %	8.8 %	0.1 %	0.0 %
Netherlands	4.1	2.5	1.0	1.0	1.1	0.9	0.9	0.9	0.8	0.8	0.7	0.7	-83 %	6.3 %	1.7 %	0.6 %
Poland	51.9	63.9	38.6	48.2	56.6	45.5	47.5	45.8	54.3	45.6	44.6	43.0	-17 %	-3.5 %	21.9 %	37.1 %
Portugal	3.0	2.7	2.6	2.3	1.7	1.6	1.6	1.8	2.0	2.3	2.2	2.3	-22 %	4.7 %	1.2 %	2.0 %
Romania	8.6	4.5	5.9	6.8	7.2	6.5	6.4	6.3	6.2	6.3	6.3	6.7	-22 %	6.8 %	3.6 %	5.8 %
Slovakia	6.7	3.4	2.4	2.7	2.6	2.1	2.3	2.3	1.9	1.9	1.9	2.1	-69 %	10.2 %	2.8 %	1.8 %
Slovenia	1.7	1.5	1.5	1.6	1.5	1.4	1.4	1.3	1.2	1.1	1.0	1.0	-42 %	0.0 %	0.7 %	0.9 %
Spain	14.1	11.8	8.8	7.4	7.1	6.7	8.4	5.6	5.6	4.4	4.2	4.2	-71 %	-1.8 %	5.9 %	3.6 %
Sweden	3.0	2.9	2.3	2.9	1.2	1.0	1.0	0.9	0.8	0.8	0.8	0.8	-74 %	-1.3 %	1.3 %	0.7 %
EU-27 (a)	**237**	**190**	**128**	**135**	**147**	**125**	**128**	**124**	**129**	**119**	**113**	**116**	**-51%**	**2.4%**	**100%**	**100%**
EU-27 (b)	237	190	128	135	147	125	128	124	129	119	113	116				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.25 Indeno(1,2,3-cd)pyrene emission trends

Between 1990 and 2021, IP emissions fell by 45% in the EU. Between 2020 and 2021, they increased by 3.3%, mainly because Italy, France and Romania (countries ranked according to the size of their contributions to the absolute change) reported higher emissions (see Table 3.26). In 2021, the EU Member States contributing most (i.e. more than 10%) to IP emissions were Poland and Germany (countries ranked according to their shares of the EU total).

Table 3.26 Member State contributions to EU emissions of IP

	Indeno(123-cd)pyrene (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	2.6	2.1	1.7	1.3	1.4	1.2	1.3	1.2	1.2	1.2	1.2	1.3	-49 %	11.1 %	1.1 %	1.0 %
Belgium	7.4	5.9	4.7	3.9	2.5	1.5	1.5	1.3	1.3	1.2	1.0	1.2	-84 %	16.2 %	3.3 %	1.0 %
Bulgaria	3.8	4.2	2.7	3.0	2.9	2.7	2.8	2.9	2.6	2.5	2.8	2.8	-27 %	-1.1 %	1.7 %	2.2 %
Croatia	3.9	3.3	3.0	3.8	3.5	3.2	3.0	2.9	2.7	2.6	2.6	2.5	-36 %	-6.4 %	1.7 %	2.0 %
Cyprus	2.0	1.6	0.9	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-95 %	0.7 %	0.9 %	0.1 %
Czechia	49.1	30.6	10.3	9.4	11.5	8.2	8.0	8.0	7.7	7.6	6.9	6.6	-87 %	-4.8 %	21.8 %	5.3 %
Denmark	3.5	3.4	2.6	2.5	1.5	1.3	1.3	1.2	1.1	0.9	0.9	0.8	-76 %	-1.5 %	1.6 %	0.7 %
Estonia	1.7	2.6	2.0	1.4	1.5	1.0	1.0	1.0	0.9	0.9	0.9	0.8	-52 %	-7.0 %	0.7 %	0.6 %
Finland	4.1	3.9	4.0	4.9	5.7	4.9	5.3	5.2	5.1	5.0	4.0	4.5	9 %	12.7 %	1.8 %	3.6 %
France	8.1	7.5	6.8	6.4	6.9	6.4	6.7	6.6	6.5	6.5	5.9	6.8	-17 %	14.0 %	3.6 %	5.4 %
Germany	23.0	9.9	11.2	11.1	17.4	15.4	14.7	15.0	15.2	15.5	14.6	17.0	-26 %	16.2 %	10.2 %	13.6 %
Greece	3.4	3.4	3.3	2.9	2.0	2.7	2.4	2.4	2.4	2.3	2.2	2.4	-30 %	9.2 %	1.5 %	1.9 %
Hungary	10.6	4.4	4.4	4.0	5.5	5.8	5.8	5.6	4.6	4.2	4.1	4.2	-61 %	1.3 %	4.7 %	3.3 %
Ireland	5.0	3.3	2.4	2.3	2.3	2.1	2.2	1.9	2.0	1.8	1.9	1.8	-65 %	-5.7 %	2.2 %	1.4 %
Italy	7.1	7.8	7.8	8.5	14.2	11.9	11.5	12.5	11.1	11.1	10.2	11.2	58 %	9.4 %	3.1 %	9.0 %
Latvia	2.9	3.1	3.1	2.6	1.9	1.3	1.3	1.5	1.5	1.5	1.3	1.3	-54 %	2.8 %	1.3 %	1.1 %
Lithuania	5.1	2.1	1.7	1.8	2.0	1.7	1.8	1.8	1.8	1.6	1.5	1.6	-69 %	3.9 %	2.2 %	1.3 %
Luxembourg	0.9	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-91 %	0.0 %	0.4 %	0.1 %
Malta	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-91 %	8.9 %	0.0 %	0.0 %
Netherlands	2.8	1.5	0.9	0.9	1.1	0.8	0.8	0.8	0.7	0.7	0.7	0.7	-74 %	6.7 %	1.3 %	0.6 %
Poland	41.1	51.7	31.1	39.4	47.1	37.3	39.1	37.8	44.3	37.2	36.2	34.7	-15 %	-4.0 %	18.2 %	27.9 %
Portugal	4.4	4.0	3.6	3.1	2.4	2.3	2.3	2.4	2.6	2.9	2.9	2.9	-33 %	3.4 %	2.0 %	2.4 %
Romania	7.9	5.1	8.5	9.6	11.2	9.7	9.6	9.7	9.6	9.7	9.7	10.3	31 %	6.6 %	3.5 %	8.3 %
Slovakia	7.4	3.7	3.0	3.4	3.3	2.7	2.9	2.9	2.4	2.5	2.5	2.7	-64 %	8.8 %	3.3 %	2.2 %
Slovenia	0.8	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	-58 %	-5.6 %	0.4 %	0.3 %
Spain	13.4	11.4	8.7	7.5	7.9	7.5	7.6	5.7	5.5	5.3	5.0	4.9	-63 %	-1.9 %	5.9 %	4.0 %
Sweden	3.1	3.3	2.5	2.4	1.9	1.5	1.4	1.4	1.2	1.2	1.1	1.1	-64 %	-1.3 %	1.4 %	0.9 %
EU-27 (a)	**225**	**181**	**131**	**137**	**158**	**134**	**135**	**132**	**135**	**126**	**121**	**125**	**-45%**	**3.3%**	**100%**	**100%**
EU-27 (b)	225	181	131	137	158	134	135	132	135	126	121	125				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

3.26 Hexachlorobenzene emission trends and key categories

Between 1990 and 2021, HCB emissions fell by 98% in the EU. Between 2020 and 2021, they decreased by 1.4% (see Table 3.27), mainly because of emission reductions in Spain, Czechia, Germany and Hungary (countries ranked according to the size of their contributions to the absolute change).

Table 3.27 Member State contributions to EU emissions of HCB

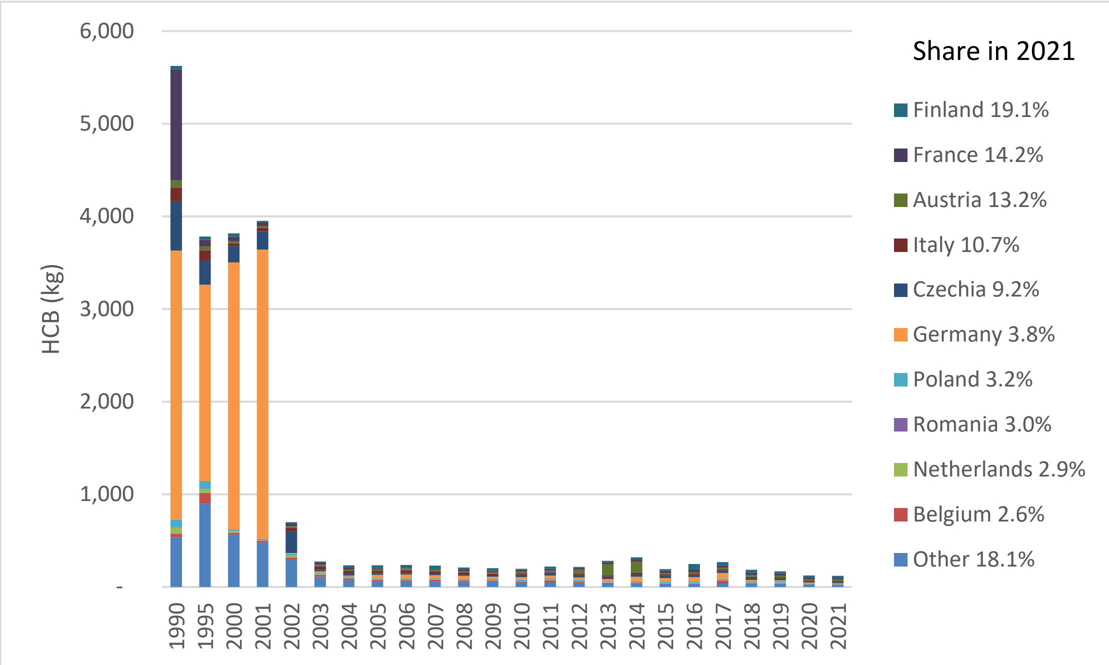
	HCB (kg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	81.7	42.9	20.3	16.7	18.5	15.9	16.5	18.1	15.9	17.1	14.3	15.9	-81 %	11.1 %	1.5 %	13.2 %
Belgium	40.1	114.9	21.1	19.2	11.6	3.6	3.1	33.1	4.0	3.0	3.3	3.1	-92 %	-6.2 %	0.7 %	2.6 %
Bulgaria	0.4	0.3	0.5	0.7	0.7	0.6	0.2	0.3	0.3	0.3	0.4	1.8	371 %	325.6 %	0.0 %	1.5 %
Croatia	7.1	6.4	2.0	0.5	0.9	0.4	0.5	0.5	0.6	0.6	0.4	0.4	-95 %	-0.5 %	0.1 %	0.3 %
Cyprus	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-81 %	-78.8 %	0.0 %	0.0 %
Czechia	536.5	262.9	175.1	14.7	23.5	23.8	22.4	21.9	20.5	18.1	12.7	11.1	-98 %	-12.6 %	9.5 %	9.2 %
Denmark	13.3	11.2	5.5	3.7	2.7	2.2	2.3	2.4	2.4	2.1	2.1	2.3	-83 %	10.3 %	0.2 %	1.9 %
Estonia	0.5	0.8	0.8	0.5	0.5	0.4	0.4	0.5	0.5	0.4	0.5	0.5	-15 %	-2.2 %	0.0 %	0.4 %
Finland	35.7	35.6	38.6	32.4	8.7	16.2	59.7	33.4	31.9	22.6	21.2	23.1	-35 %	8.9 %	0.6 %	19.1 %
France	1,197.4	71.2	47.3	13.2	21.7	24.3	26.5	26.3	27.3	23.3	17.0	17.2	-99 %	1.1 %	21.3 %	14.2 %
Germany	2,900.5	2,118.4	2,883.9	38.1	29.3	39.9	50.3	61.1	12.9	13.4	5.2	4.6	-100 %	-11.6 %	51.6 %	3.8 %
Greece	21.3	21.8	25.4	26.9	11.9	3.1	2.7	3.3	2.7	1.7	1.3	1.0	-95 %	-25.1 %	0.4 %	0.8 %
Hungary	257.2	630.5	366.6	3.3	2.2	3.2	3.2	3.2	2.9	3.2	2.1	1.6	-99 %	-22.2 %	4.6 %	1.4 %
Ireland	47.8	47.9	7.9	2.6	2.6	2.7	2.6	2.6	2.4	2.3	2.4	2.5	-95 %	6.6 %	0.8 %	2.1 %
Italy	142.4	110.2	33.0	27.2	15.7	15.9	15.4	15.8	14.6	14.8	11.2	12.9	-91 %	15.7 %	2.5 %	10.7 %
Latvia	5.7	0.3	0.2	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	-91 %	4.2 %	0.1 %	0.4 %
Lithuania	11.0	4.7	1.9	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.6	-95 %	25.8 %	0.2 %	0.5 %
Luxembourg	1.0	1.5	1.0	0.6	0.9	0.5	0.6	0.6	0.7	0.7	0.7	0.7	-27 %	0.0 %	0.0 %	0.6 %
Malta	0.1	0.01	0.002	0.001	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0.1	21 %	-22.5 %	0.0 %	0.1 %
Netherlands	66.4	40.5	17.1	3.4	3.5	4.1	4.3	4.1	4.0	3.8	3.4	3.5	-95 %	0.6 %	1.2 %	2.9 %
Poland	84.1	84.0	13.7	12.0	11.7	12.1	13.1	14.2	14.4	15.0	3.5	3.8	-95 %	10.3 %	1.5 %	3.2 %
Portugal	60.4	75.7	100.8	1.7	1.4	1.7	1.9	2.0	2.4	2.4	1.4	1.3	-98 %	-10.1 %	1.1 %	1.1 %
Romania	2.8	2.9	3.9	4.2	3.2	3.0	2.9	3.1	3.1	3.1	3.0	3.6	26 %	20.0 %	0.1 %	3.0 %
Slovakia	15.2	5.4	5.0	3.5	3.3	3.2	2.9	3.8	3.2	3.3	3.1	3.0	-80 %	-1.8 %	0.3 %	2.5 %
Slovenia	21.4	17.7	19.5	0.9	1.3	0.6	0.6	0.5	0.5	0.5	0.5	0.5	-98 %	1.5 %	0.4 %	0.4 %
Spain	57.5	59.7	15.6	4.6	12.3	10.4	12.3	12.4	13.4	13.3	9.0	2.1	-96 %	-77.2 %	1.0 %	1.7 %
Sweden	16.6	16.8	10.6	4.5	6.6	3.8	2.7	3.1	2.8	2.7	2.6	3.1	-82 %	17.6 %	0.3 %	2.5 %
EU-27 (a)	**5,624**	**3,784**	**3,817**	**235**	**195**	**192**	**248**	**267**	**184**	**169**	**122**	**121**	**-98%**	**-1.4%**	**100%**	**100%**
EU-27 (b)	5,624	3,784	3,817	235	195	192	248	267	184	169	122	121				

Notes: ([a]) Sum of national totals, as reported by EU Member States.

([b]) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to HCB emissions were Finland, France, Austria and Italy (countries ranked according to their shares of the EU total) (see Figure 3.30).

Figure 3.32 HCB emission trends in the EU and shares of Member States



Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

In 1990, **Germany** had a share of 51% of the EU-27 HCB emissions, which fell notably to a share of 3.8% in 2021. The drop in HCB emissions was mainly attributed to data reported in the category '2C3 — Aluminium production' (see Figure 3.33). Emission estimates were reported up to 2001, after which the notation key 'NA' (not applicable) was used.

Austria explained that the increase in HCB emissions from 2012 to 2013 reflects the data reported in the category '1A2f — Stationary combustion in manufacturing industries and construction: Non-metallic minerals'. As a result of unintentional releases in 2012, 2013 and 2014, emissions rose to a very high level: HCB-contaminated material (lime) was co-incinerated in a cement plant at temperatures that were too low to destroy the HCB. Thus, the sharp 74.2% decrease in emissions between 2014 and 2015 marked a return to usual levels (see Austria's IIR, listed in Appendix 5).

Czechia explained its decrease in emissions as being due to the prohibition of precursors of HCB in aluminium production.

The data reported by **Finland** show a 266% increase from 2015 to 2016, followed by a fall in HCB emissions. This was mainly caused by emissions from the category '2B10a — Chemical industry: Other'. The emission trend reported by Finland is dominated by fluctuations in the industrial processes and product use sector and may be overestimated for the other sources because of the highly uncertain methods (see Finland's IIR's, listed in Appendix 5).

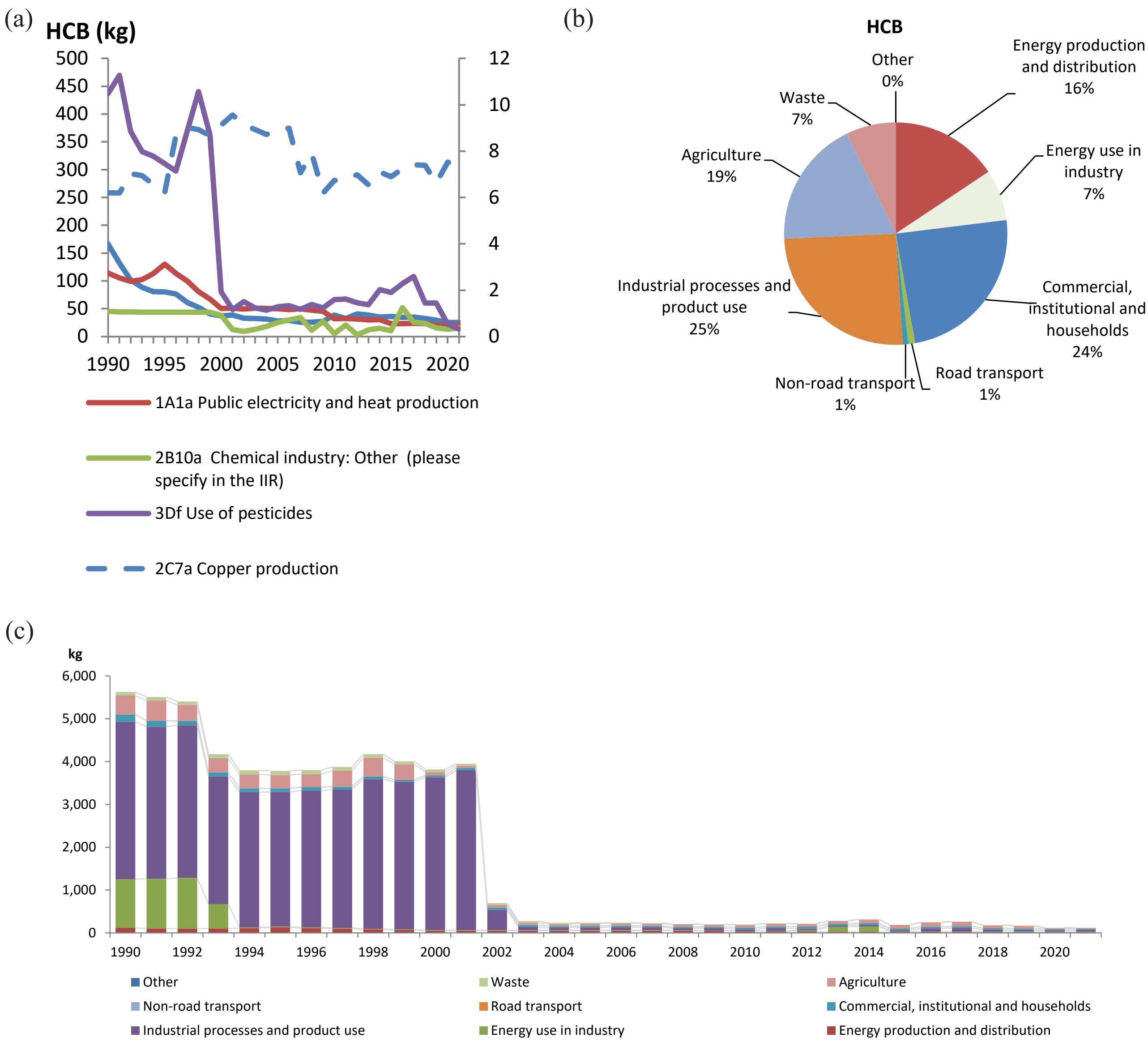
France reported a pronounced drop in HCB emissions between 1990 and 1995. The decrease in the category '1Ab2 — Stationary combustion in manufacturing industries and construction: Non-ferrous metals' was mainly due to the aluminium industry, which used chlorine to refine aluminium by eliminating magnesium traces. Until the early 1990s, it used hexachloroethane (HCE) as a core source, which resulted in HCB emissions, the main HCB source in the national inventory. In 1993, France banned HCE in secondary aluminium refining, as a result of which this industry no longer emits HCB (personal communication from France in 2015).

Ireland reported a marked decrease in HCB emissions between 1995 and 2000. HCB emissions from the category '2C2 — Ferroalloys production' dominated the inventory for the period up to and including 1996, contributing 40kg per year. However, this is no longer a source of HCB emissions in Ireland because of the banning of HCE-based cover gas use (HCB was present as a contaminant in such cover gases) (see Ireland's IIR, listed in Appendix 5).

In 2021, '1A4bi — Residential: Stationary', '1A1a — Public electricity and heat production', '2B10a — Chemical industry: Other ' and '3Df — Use of pesticides' were the main key categories for HCB emissions, together accounting for 62% of the total (see Figure 3.33(a)). Among the top five key categories, the highest relative reductions in emissions between 1990 and 2021 were in the fourth most important '3Df — Use of pesticides' (96.8%) and in the most important '1A4bi — Residential: Stationary' (84.7%).

Figure 3.33(b) shows the contribution made by each aggregated sector group to total EU emissions. For HCB, the primary emission sources are the commercial, institutional and households, agriculture, and the industrial processes and product use sectors.

Figure 3.33 HCB emissions in the EU: (a) trends in emissions from the five most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



Note: In (a), the right-hand axis shows values for '2C1 — Iron and steel production'.

3.27 *Polychlorinated biphenyl emission trends and key categories*

Between 1990 and 2021, PCB emissions dropped by 75% in the EU. Between 2020 and 2021, they grew by 4.8%, mainly because of increases reported by Italy, Poland, Greece and Germany (countries ranked according to the size of their contributions to the absolute change) (see Table 3.28).

Table 3.28 Member State contributions to EU emissions of PCBs

	Indeno(123-cd)pyrene (Mg)												Change		Share in EU-27	
Member State	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**1990—2021**	**2020—2021**	**1990**	**2021**
Austria	2.6	2.1	1.7	1.3	1.4	1.2	1.3	1.2	1.2	1.2	1.2	1.3	-49 %	11.1 %	1.1 %	1.0 %
Belgium	7.4	5.9	4.7	3.9	2.5	1.5	1.5	1.3	1.3	1.2	1.0	1.2	-84 %	16.2 %	3.3 %	1.0 %
Bulgaria	3.8	4.2	2.7	3.0	2.9	2.7	2.8	2.9	2.6	2.5	2.8	2.8	-27 %	-1.1 %	1.7 %	2.2 %
Croatia	3.9	3.3	3.0	3.8	3.5	3.2	3.0	2.9	2.7	2.6	2.6	2.5	-36 %	-6.4 %	1.7 %	2.0 %
Cyprus	2.0	1.6	0.9	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-95 %	0.7 %	0.9 %	0.1 %
Czechia	49.1	30.6	10.3	9.4	11.5	8.2	8.0	8.0	7.7	7.6	6.9	6.6	-87 %	-4.8 %	21.8 %	5.3 %
Denmark	3.5	3.4	2.6	2.5	1.5	1.3	1.3	1.2	1.1	0.9	0.9	0.8	-76 %	-1.5 %	1.6 %	0.7 %
Estonia	1.7	2.6	2.0	1.4	1.5	1.0	1.0	1.0	0.9	0.9	0.9	0.8	-52 %	-7.0 %	0.7 %	0.6 %
Finland	4.1	3.9	4.0	4.9	5.7	4.9	5.3	5.2	5.1	5.0	4.0	4.5	9 %	12.7 %	1.8 %	3.6 %
France	8.1	7.5	6.8	6.4	6.9	6.4	6.7	6.6	6.5	6.5	5.9	6.8	-17 %	14.0 %	3.6 %	5.4 %
Germany	23.0	9.9	11.2	11.1	17.4	15.4	14.7	15.0	15.2	15.5	14.6	17.0	-26 %	16.2 %	10.2 %	13.6 %
Greece	3.4	3.4	3.3	2.9	2.0	2.7	2.4	2.4	2.4	2.3	2.2	2.4	-30 %	9.2 %	1.5 %	1.9 %
Hungary	10.6	4.4	4.4	4.0	5.5	5.8	5.8	5.6	4.6	4.2	4.1	4.2	-61 %	1.3 %	4.7 %	3.3 %
Ireland	5.0	3.3	2.4	2.3	2.3	2.1	2.2	1.9	2.0	1.8	1.9	1.8	-65 %	-5.7 %	2.2 %	1.4 %
Italy	7.1	7.8	7.8	8.5	14.2	11.9	11.5	12.5	11.1	11.1	10.2	11.2	58 %	9.4 %	3.1 %	9.0 %
Latvia	2.9	3.1	3.1	2.6	1.9	1.3	1.3	1.5	1.5	1.5	1.3	1.3	-54 %	2.8 %	1.3 %	1.1 %
Lithuania	5.1	2.1	1.7	1.8	2.0	1.7	1.8	1.8	1.8	1.6	1.5	1.6	-69 %	3.9 %	2.2 %	1.3 %
Luxembourg	0.9	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-91 %	0.0 %	0.4 %	0.1 %
Malta	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-91 %	8.9 %	0.0 %	0.0 %
Netherlands	2.8	1.5	0.9	0.9	1.1	0.8	0.8	0.8	0.7	0.7	0.7	0.7	-74 %	6.7 %	1.3 %	0.6 %
Poland	41.1	51.7	31.1	39.4	47.1	37.3	39.1	37.8	44.3	37.2	36.2	34.7	-15 %	-4.0 %	18.2 %	27.9 %
Portugal	4.4	4.0	3.6	3.1	2.4	2.3	2.3	2.4	2.6	2.9	2.9	2.9	-33 %	3.4 %	2.0 %	2.4 %
Romania	7.9	5.1	8.5	9.6	11.2	9.7	9.6	9.7	9.6	9.7	9.7	10.3	31 %	6.6 %	3.5 %	8.3 %
Slovakia	7.4	3.7	3.0	3.4	3.3	2.7	2.9	2.9	2.4	2.5	2.5	2.7	-64 %	8.8 %	3.3 %	2.2 %
Slovenia	0.8	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	-58 %	-5.6 %	0.4 %	0.3 %
Spain	13.4	11.4	8.7	7.5	7.9	7.5	7.6	5.7	5.5	5.3	5.0	4.9	-63 %	-1.9 %	5.9 %	4.0 %
Sweden	3.1	3.3	2.5	2.4	1.9	1.5	1.4	1.4	1.2	1.2	1.1	1.1	-64 %	-1.3 %	1.4 %	0.9 %
EU-27 (a)	**225**	**181**	**131**	**137**	**158**	**134**	**135**	**132**	**135**	**126**	**121**	**125**	**-45%**	**3.3%**	**100%**	**100%**
EU-27 (b)	225	181	131	137	158	134	135	132	135	126	121	125				

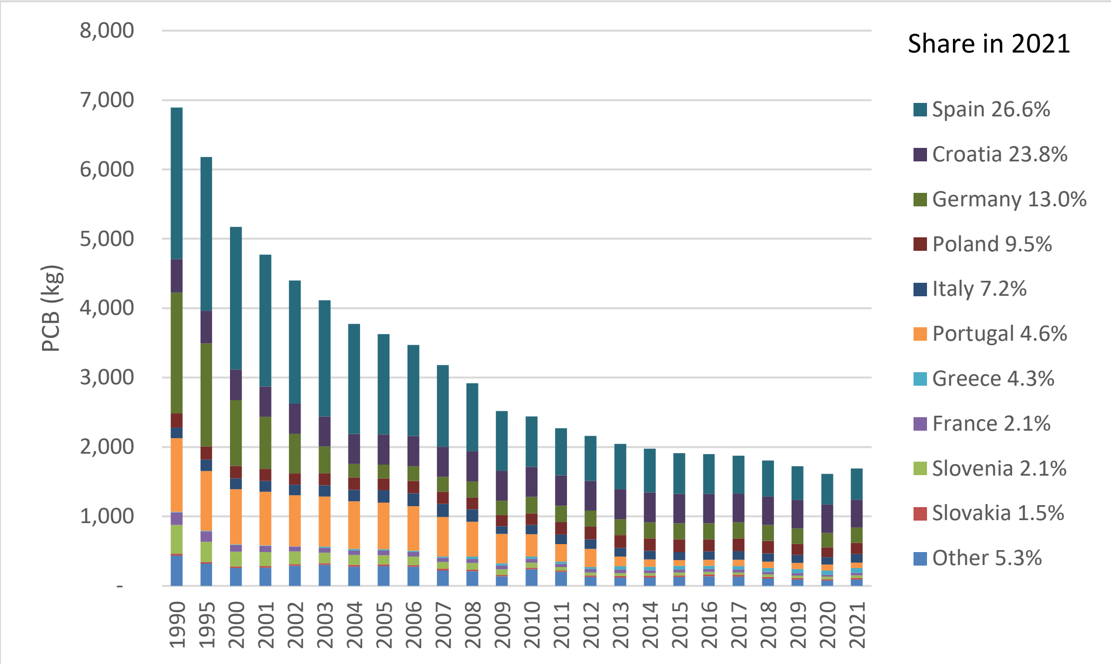
Notes: (a) Sum of national totals, as reported by EU Member States.

(b) Sum of sectors: differences arise when only national totals and no sectoral data are available.

In 2021, the EU Member States contributing most (i.e. more than 10%) to PCB emissions were Spain, Croatia (22) and Germany (countries ranked according to their shares of the EU total) (see Figure 3.32).

(22) Croatia had not submitted data on time, and hence the data for this Member State have entirely been gap filled.

Figure 3.34 PCB emission trends in the EU and shares of Member States



Notes: Countries are sorted by their contribution to the EU total for the last year. The top 10 countries are displayed. Data for the other 17 reporting countries are summed under 'Other'.

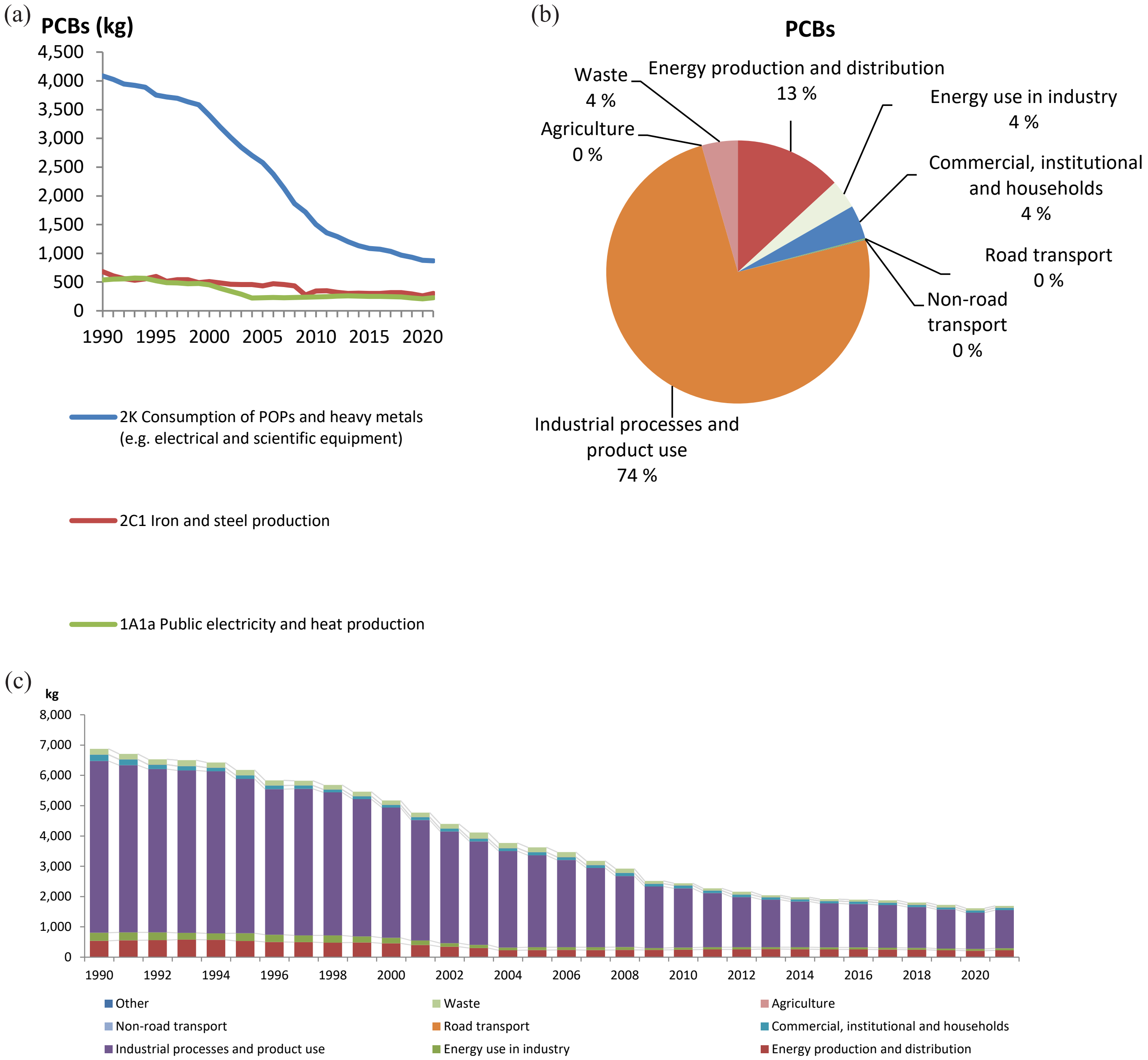
Belgium stated that PCB emissions reported in the category '2A1 — Cement production' from one of its plants were very high in 2010 and 2011 because of the use of an alternative raw material containing high concentrations of PCBs. Having removed this raw material at the end of 2011, emissions decreased significantly (see Belgium's IIR, listed in Appendix 5).

Lithuania explained that the high PCB emissions in 2005 occurred because emissions from electrical transformer oil were estimated (personal communication from Lithuania in 2017).

The category '2K — Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)' was the main key category for PCB emissions, making up 51% of the total. Among the top three key categories, the highest relative reductions in emissions between 1990 and 2021 were in the principal most important '2K — Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)' (78.7%), the second most important '2C1 — Iron and steel production' (55.5%) and the third most important '1A1a — Public electricity and heat production' (57.8%) (see Figure 3.35(a)).

Figure 3.35(b) shows the contribution made by each aggregated sector group to total EU emissions. For PCBs, the most significant emission source is the industrial processes and product use sector group.

Figure 3.35 PCB emissions from key categories in the EU: (a) trends in emissions from the three most important key categories, 1990-2021, (b) share by sector group, 2021 and (c) sectoral trends in emissions



4. Sectoral analysis and emission trends for key pollutants

This chapter sets out emission trends in and detailed methodologies for the key pollutants, aggregated into the following main sector groups:

- energy production and distribution;
- energy use in industry;
- industrial processes and product use;
- commercial, institutional and households;
- road transport;
- non-road transport;
- agriculture;
- waste.

Appendix 4 of this report provides a conversion chart showing how the aggregated sector groups include the individual nomenclature for reporting (NFR) source categories (see Table A4.1). Box 4.1 gives some general explanations relevant to the figures in this chapter.

Table 4.2, Table 4.4, Table 4.6, Table 4.8, Table 4.9, Table 4.10, Table 4.12 and Table 4.14 provide information on the relative and absolute differences between emissions reported in 2022 and 2023. Big changes in absolute terms originate from the fact that some EU Member States carried out major recalculations (e.g. France,

Box 4.1 Explanations of the figures in this chapter

- The Convention on Long-range Transboundary Air Pollution (Air Convention) formally requests Parties to report emissions of particulate matter (PM) for 2000 and thereafter. The figures in this chapter show data from only 2000 onwards.
- The figures showing indexed values (in percentages) use 1990 as the index year (1990=100%), except for total suspended particulates (TSPs), black carbon (BC), PM with a diameter of 10µm or less (PM_{10}) and PM with a diameter of 2.5µm or less ($PM_{2.5}$), for which the index year is 2000 (2000=100%).

Bulgaria, Germany, Poland, Spain). Detailed information can be found in Section 5.1.

4.1 Sectoral analysis and emission trends for energy production and distribution

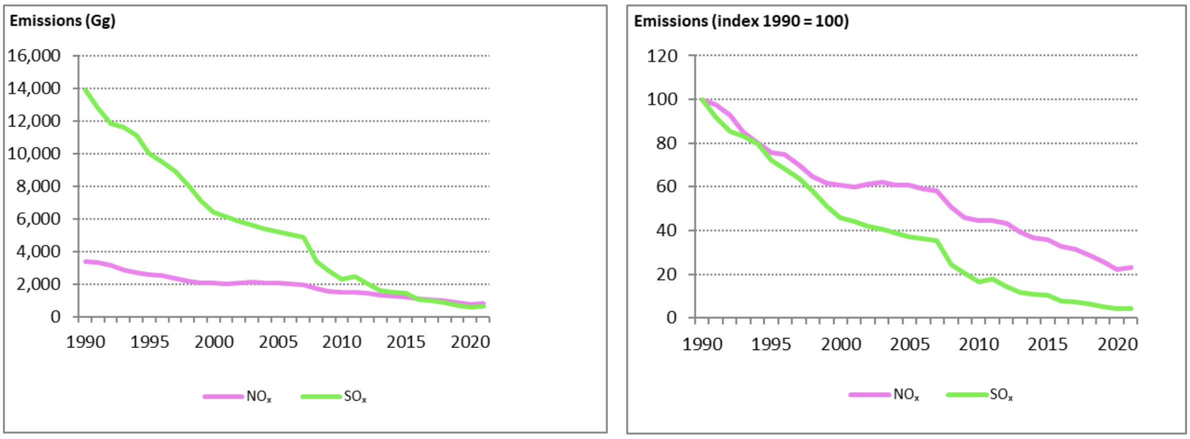
The energy production and distribution sector grouping comprises emissions from a number of activities that employ fuel combustion to produce energy products and electricity, for instance. It is a primary source of many pollutants, especially sulphur oxides (SO_X) and mercury (Hg). Despite considerable previous reductions, this sector group contributes 44% of the total EU emissions of SO_X and 38% of Hg emissions.

The sector is a significant source of SO_X, Hg, hexachlorobenzene (HCB), cadmium (Cd), nitrogen oxides (NO_X) and polychlorinated biphenyls (PCBs). Countries are ranked according to the size of the absolute values that they reported. In 2021, Poland, Germany, Spain and Romania contributed most (in absolute terms) to the emissions of SO_X for this sector. Poland and Germany reported the highest emissions of Hg in the same year. The Netherlands and France reported the highest emissions of HCB. Poland and Germany primarily accounted for Cd emissions in this sector in 2021. In addition, in 2021, Germany, Poland and Greece contributed most to NO_X emissions.

For emissions of the main pollutants (see Figure 4.1), between 1990 and 2021, the highest absolute and relative reductions within this aggregated sector were for SO_X (96%). Between 1990 and 2021, NO_X emissions dropped by 77%.

The declining trend in SO_X emissions between 1990 and 2021 mainly reflects data from Germany, Poland and Spain in category '1A1a — Public electricity and heat production'. Since 1990, several measures have been combined to reduce emissions from these main emitting sources: switching fuel in energy-related sectors away from high-sulphur solid and liquid fuels to low-sulphur fuels such as natural gas, fitting flue gas

Figure 4.1 EU emission trends in the energy production and distribution sector for NO_X and SO_X between 1990 and 2021

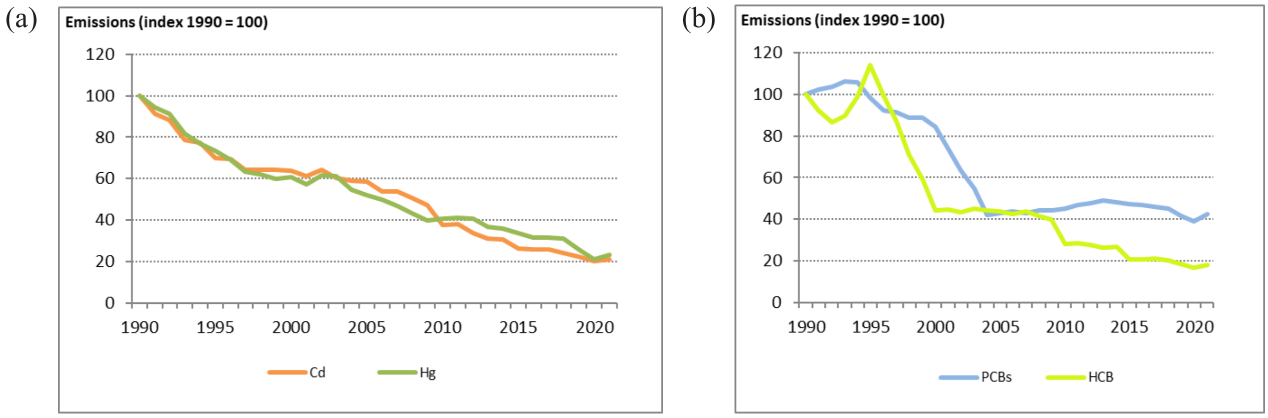


desulphurisation (FGD) abatement technology in industrial facilities and introducing EU directives relating to the sulphur content of certain liquid fuels (EEA, 2022b).

High reductions in relative terms were achieved for the heavy metals (HMs) Cd (79%) and Hg (77%) (see Figure 4.2(a)).

HCB showed a relative reduction of 82%, while PCB emissions dropped by 58% between 1990 and 2021 (see Figure 4.2(b)). The peak in HCB emissions in 1995 reflects high emission values reported by Belgium

Figure 4.2 **EU emission trends in the energy production and distribution sector group: (a) HMs (Cd and Hg) and (b) persistent organic pollutants (POPs) (PCB and HCB) between 1990 and 2021**



in the category '1A1a — Public electricity and heat production'. The Member State explained that these high HCB emissions were the result of higher levels of sludge burning in Flanders in 1995 (personal communication from Belgium in 2017).

Table 4.1 **Number of EU Member States reporting notation keys within the key categories of the energy production and distribution sector group**

Key categories		NA	NO	NR	NE
Cd	1A1b	0	6	0	0
HCB	1A1a	1	0	0	v
PCB	1A1a	1	0	0	0
SO_x	1A1b	0	6	0	0
SO_x	1B2aiv	1	5	0	0

Note: Only the key categories where notation keys were reported are considered.

Table 4.2 (a) Relative difference (relative data, percentage of EU national totals) and (b) absolute difference between reported emissions when comparing the EU's 2022 and 2023 submissions for the energy production and distribution sector group

(a)

Relative difference																			
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NMVOCs	0%	0%	0%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%
SO_x	-1%	0%	-1%	-1%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-3%	-3%	-3%	-4%	-4%
NH_3	6%	2%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	-3%
TSPs	3%	5%	5%	5%	2%	1%	2%	2%	3%	1%	2%	1%	1%	0%	0%	-2%	-2%	-3%	-2%
CO	7%	4%	2%	1%	1%	1%	1%	1%	2%	2%	2%	2%	2%	1%	-1%	-2%	0%	0%	0%
Pb	0%	0%	0%	-2%	-2%	-2%	-2%	-2%	-3%	-2%	-8%	-4%	-5%	-3%	-3%	-2%	-2%	-2%	-3%
Cd	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-1%	-1%	-2%
Hg	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-1%	-1%	-2%	-1%	-1%	-4%
As	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-4%
Cr	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-2%
Cu	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	0%	-1%
Ni	2%	2%	2%	3%	2%	3%	3%	3%	2%	2%	3%	2%	3%	1%	1%	0%	0%	0%	-1%
Se	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-2%	-3%	-3%	-3%	-4%	-4%	-4%	-3%	-3%
Zn	0%	0%	0%	0%	-1%	-1%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%
PCDD/Fs	0%	0%	0%	-2%	-8%	-7%	-6%	-6%	-9%	-4%	-4%	0%	-3%	-3%	-14%	-14%	-14%	-4%	-4%
B(a)P	0%	0%	-3%	-3%	-3%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	-4%	-5%	-5%	-5%	-6%	-6%	-7%
B(b)F	1%	0%	-4%	-6%	-5%	-4%	-6%	-7%	-6%	-6%	-6%	-6%	-6%	-8%	-8%	-8%	-9%	-9%	-9%
B(k)F	1%	0%	-3%	-5%	-4%	-4%	-6%	-7%	-6%	-6%	-6%	-6%	-8%	-9%	-10%	-10%	-11%	-11%	-11%
IP	8%	3%	1%	-4%	-4%	-4%	-6%	-7%	-6%	-6%	-6%	-6%	-7%	-9%	-9%	-9%	-10%	-11%	-11%
Total PAHs	0%	-1%	-9%	-8%	-8%	-8%	-9%	-11%	-10%	-10%	-11%	-10%	-11%	-12%	-12%	-12%	-12%	-13%	-13%
HCB	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	-1%	-1%	-1%	-1%	-2%	-1%	0%	1%
PCBs	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			-9%	-7%	-6%	-6%	-3%	-2%	-2%	-2%	-2%	-1%	-1%	-2%	-4%	-4%	-4%	-5%	-6%
PM_{10}			-5%	-2%	-2%	-2%	0%	0%	1%	0%	0%	0%	0%	0%	-1%	-2%	-2%	-3%	-3%
BC			-1%	-3%	-3%	-3%	-2%	-2%	-1%	-1%	-1%	-4%	0%	2%	-4%	-2%	-7%	-12%	-10%

(b)

Absolute difference																			
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	6	4	1	-3	-2	-2	0	0	6	6	5	5	5	5	2	1	1	0	0
NMVOCs	1	0	3	5	4	5	4	4	4	1	0	0	-1	-1	-2	-2	-2	-4	-3
SO_x	-89	-22	-37	-31	-25	-28	-23	-25	-21	-16	-21	-22	-19	-15	-27	-29	-30	-27	-26
NH_3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TSPs	76	42	26	19	7	5	5	6	8	3	4	1	1	0	-1	-3	-3	-3	-2
CO	70	34	19	7	6	6	7	9	16	15	14	15	16	9	-6	-18	0	0	-2
Pb	0	0	0	-4	-4	-4	-4	-4	-4	-3	-10	-5	-6	-3	-3	-2	-2	-2	-2
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
As	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1
Cr	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1
Cu	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	0	-1
Ni	16	17	12	15	13	13	12	10	8	6	10	5	5	3	2	1	1	0	-1
Se	0	0	0	0	0	0	0	0	-1	-1	-2	-2	-2	-2	-2	-2	-2	-2	-1
Zn	1	1	0	-1	-2	-2	-1	-2	-2	-2	-3	-2	-2	-3	-4	-4	-6	-4	-6
PCDD/Fs	-1	-5	-6	-9	-9	-8	-7	-6	-9	-5	-5	0	-3	-3	-14	-15	-14	-4	-3
B(a)P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(b)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(k)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IP	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total PAHs	0	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
HCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-5
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			-15	-8	-7	-7	-3	-2	-2	-1	-1	-1	-1	-1	-2	-2	-2	-2	-2
PM_{10}			-15	-6	-5	-5	-1	1	1	-1	0	0	0	0	-1	-2	-2	-2	-2
BC			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

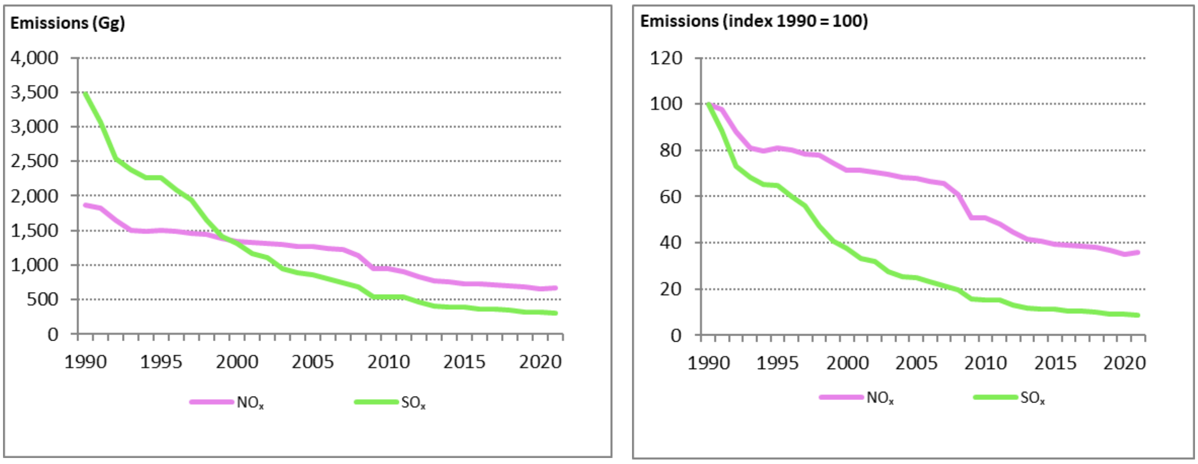
Note: As, arsenic; B(b)F, benzo(b)fluoranthene; BC, black carbon; B(k)F, benzo(k)fluoranthene; Cr, chromium; Cu, copper; IP, indeno(1,2,3-cd)pyrene; NH_3, ammonia; Ni, nickel; PCBs, polychlorinated biphenyls; Se, selenium; TSP, total suspended particulate; Zn, zinc.

Table 4.1 indicates the number of EU Member States reporting the notation keys 'NA' (not applicable), 'NO' (not occurring), 'NR' (not relevant) and 'NE' (not estimated) within the key categories. Table 4.2 shows the recalculations within the energy production and distribution sector group. For explanations of EU recalculations, see Section 5.1.

4.2 Sectoral analysis and emission trends for energy use in industry sector

Energy use in the industry sector is a significant source of the HMs (Pb, Cd, Hg), SO_X and NO_X. According to the size of the absolute values reported, Italy, France and Poland contributed most to Pb emissions in this sector in 2021. For Cd, Poland, Italy and France reported the highest emissions, while Italy and France

Figure 4.3 EU emission trends in the energy use in industry for NO_X and SO_X between 1990 and 2021



contributed most to Hg emissions. In addition, in 2021, Spain, Poland and France contributed most to SO_X emissions. The main emitters of NO_X emissions within the industry sector were Spain, Germany and France.

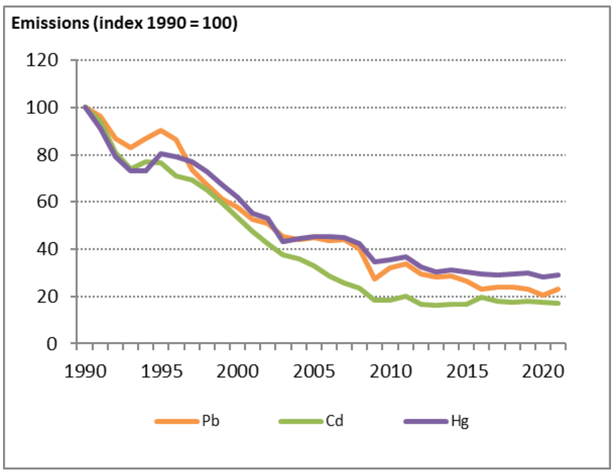
Energy use (fuel combustion) in industry is a significant source of many pollutants. For the main ones, the highest absolute and relative reduction (91%) between 1990 and 2021 was for SO_X (see Figure 4.3).

Of the three HMs, Cd shows the biggest reduction in relative terms (83% decrease) (see Figure 4.4).

Pb emissions fell between 1996 and 1997 after a minor peak in 1995, decreased considerably between 2008 and 2009, and increased again afterwards. This pattern was mainly the result of data reported by Italy and France in the categories '1A2a — Stationary combustion in manufacturing industries and construction: Iron and steel', '1A2b — Stationary combustion in manufacturing industries and construction: Non-ferrous metals' and '1A2f — Stationary combustion in manufacturing industries and construction: Non-metallic minerals'.

The increase in Hg emissions between 1994 and 1995 can be linked to higher emissions reported by Spain

Figure 4.4 EU emission trends in the energy use in industry sector group for HMs (Pb, Cd and Hg) between 1990 and 2021



for the category ‘1A2f — Stationary combustion in manufacturing industries and construction: Non-metallic minerals’.

Table 4.3 **Number of EU Member States reporting notation keys within the key categories of the energy use in industry sector group**

Key categories		NA	NO	NR	NE
Cd	1A2f	0	1	0	0
Cd	1A2a	1	1	0	0
CO	1A2a	0	1	0	0
Dioxin	1A2b	0	2	0	0
HCB	1A2b	3	3	0	4
Hg	1A2f	0	1	0	0
Hg	1A2a	0	1	0	0
Hg	1A2d	1	1	0	0
NO_X	1A2f	0	1	0	0
Pb	1A2f	0	1	0	0
Pb	1A2a	1	1	0	0
SO_X	1A2f	0	1	0	0
SO_X	1A2a	0	1	0	0

Note: Only the key categories where notation keys were reported are considered. CO, carbon monoxide; NMVOC, non-methane volatile organic compound.

Table 4.4 **(a) Relative difference (relative data, percentage of EU national totals) and (b) absolute difference between reported emissions when comparing the EU's 2022 and 2023 submissions for the energy use in industry sector group**

(a)

Relative difference																			
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
NMVOCs	1%	0%	0%	-1%	-1%	-2%	-2%	-2%	-3%	-3%	-5%	-6%	-6%	-6%	-6%	-7%	-6%	-7%	-8%
SOx	0%	0%	0%	0%	0%	0%	-1%	-2%	-2%	-3%	-4%	-5%	-6%	-6%	-8%	-9%	-10%	-11%	-6%
NH_3	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-2%	-2%	-1%	-2%	0%	0%	0%	2%	2%
TSPs	0%	0%	0%	-2%	-2%	-3%	-5%	-4%	-5%	-7%	-10%	-13%	-12%	-12%	-14%	-15%	-15%	-17%	-17%
CO	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%
Pb	0%	0%	-1%	-1%	-1%	-1%	-1%	-2%	-1%	6%	-2%	-2%	-1%	-1%	-1%	-2%	-2%	-1%	0%
Cd	-1%	-1%	-2%	-3%	-4%	-5%	-6%	-7%	-8%	0%	-8%	-8%	-7%	-4%	-5%	-6%	-7%	-6%	-6%
Hg	-1%	-1%	-1%	1%	1%	2%	2%	1%	1%	4%	1%	1%	2%	3%	3%	3%	3%	3%	7%
As	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	1%	2%
Cr	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-1%	-3%	-3%	-2%	-2%	-2%	-2%	-2%	-1%	0%
Cu	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	-1%	-1%	0%	0%	0%	-1%	-1%	0%	0%
Ni	0%	0%	-1%	-2%	-2%	-2%	-2%	-3%	-3%	-4%	-6%	-6%	-4%	-4%	-6%	-6%	-3%	-4%	-3%
Se	1%	1%	1%	2%	2%	2%	2%	2%	1%	1%	2%	1%	2%	2%	1%	2%	2%	2%	2%
Zn	-1%	-1%	-1%	-2%	-2%	-3%	-3%	-4%	-3%	-2%	-4%	-4%	-4%	-2%	-4%	-4%	-4%	-3%	-3%
PCDD/Fs	-2%	-2%	-4%	-4%	-5%	-4%	-4%	-4%	-5%	-4%	-7%	-6%	-6%	-5%	-6%	-7%	-7%	-7%	-5%
B(a)P	-7%	-9%	-14%	-16%	-16%	-16%	-18%	-23%	-17%	-16%	-23%	-23%	-22%	-19%	-18%	-20%	-22%	-21%	-22%
B(b)F	-7%	-8%	-11%	-14%	-14%	-14%	-16%	-19%	-15%	-15%	-21%	-21%	-20%	-18%	-18%	-19%	-20%	-19%	-20%
B(k)F	-7%	-8%	-13%	-14%	-15%	-14%	-17%	-20%	-15%	-15%	-20%	-20%	-20%	-17%	-16%	-17%	-20%	-19%	-18%
IP	-8%	-8%	-13%	-14%	-15%	-14%	-17%	-19%	-14%	-15%	-21%	-21%	-20%	-18%	-17%	-18%	-20%	-19%	-19%
Total PAHs	-6%	-7%	-10%	-12%	-13%	-12%	-14%	-17%	-13%	-13%	-19%	-19%	-19%	-16%	-16%	-17%	-19%	-18%	-17%
HCB	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	1%	0%	1%	1%	1%	1%
PCBs	-1%	-1%	-2%	-3%	-3%	-3%	-3%	-4%	-2%	-2%	-4%	-4%	-3%	-4%	-3%	-4%	-4%	-4%	0%
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			0%	-3%	-3%	-4%	-6%	-7%	-9%	-11%	-14%	-17%	-16%	-16%	-18%	-19%	-20%	-21%	-22%
PM_{10}			0%	-3%	-3%	-4%	-6%	-6%	-8%	-10%	-13%	-15%	-15%	-15%	-17%	-18%	-19%	-20%	-21%
BC			1%	-1%	0%	-1%	-2%	-1%	-2%	-4%	-5%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%

(b)

Absolute difference																			
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	12	9	9	7	11	10	8	7	6	4	1	1	1	3	3	2	1	1	9
NMVOCs	1	1	-1	-2	-2	-3	-4	-3	-4	-5	-7	-8	-8	-8	-9	-10	-10	-11	-11
SOx	-2	-1	-1	-2	-3	-2	-9	-11	-13	-16	-19	-22	-24	-25	-32	-34	-38	-40	-22
NH_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TSPs	1	0	0	-4	-4	-5	-8	-5	-7	-9	-12	-14	-13	-14	-15	-17	-17	-18	-18
CO	9	4	3	6	10	10	6	-9	3	4	0	-1	7	4	5	4	0	2	30
Pb	-3	-3	-4	-4	-4	-3	-3	-3	-3	12	-4	-3	-3	-3	-2	-3	-3	-2	-1
Cd	0	0	0	0	0	0	-1	-1	-1	0	-1	-1	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Cr	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0
Cu	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Ni	-2	-1	-2	-3	-3	-3	-3	-3	-3	-5	-5	-5	-3	-3	-4	-4	-2	-2	-1
Se	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	-8	-8	-10	-12	-12	-13	-14	-15	-15	-9	-17	-18	-15	-9	-14	-14	-14	-12	-11
PCDD/Fs	-11	-13	-11	-12	-13	-12	-12	-7	-8	-7	-9	-8	-9	-8	-8	-9	-9	-8	-6
B(a)P	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
B(b)F	-1	-1	-1	-2	-2	-2	-2	-2	-1	-1	-2	-2	-1	-1	-1	-1	-2	-2	-2
B(k)F	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	0	0	0	-1	-1	-1
IP	0	0	0	-1	-1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0
Total PAHs	-3	-3	-3	-4	-4	-4	-4	-4	-3	-3	-4	-4	-3	-3	-3	-3	-4	-4	-3
HCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	-3	-3	-3	-3	-3	-3	-3	-3	-2	-2	-3	-3	-2	-2	-2	-2	-3	-2	0
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			0	-4	-4	-5	-7	-7	-8	-10	-11	-13	-12	-13	-14	-15	-16	-17	-16
PM_{10}			0	-4	-4	-5	-7	-6	-8	-10	-12	-13	-13	-14	-14	-16	-16	-18	-17
BC			0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

Note: As, arsenic; B(b)F, benzo(b)fluoranthene; BC, black carbon; B(k)F, benzo(k)fluoranthene; Cr, chromium; Cu, copper; IP, indeno(1,2,3-cd)pyrene; NH_3, ammonia; Ni, nickel; PCBs, polychlorinated biphenyls; Se, selenium; TSP, total suspended particulate; Zn, zinc.

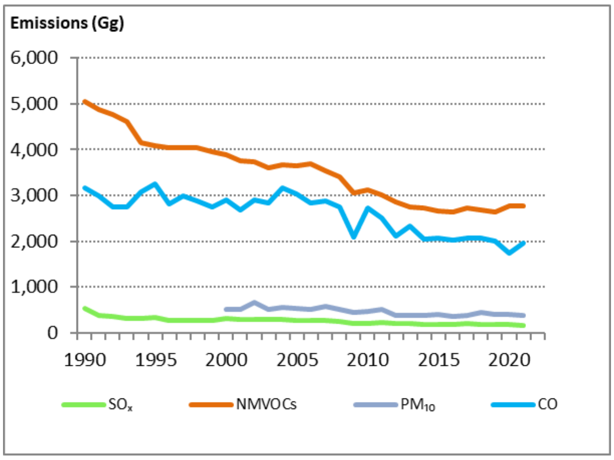
The development of Cd emissions over the past 30 years mainly reflects data reported by Spain in the category '1A2f — Stationary combustion in manufacturing industries and construction: Non-metallic minerals', including the rise in emissions from 1994 to 1995.

Table 4.3 presents the number of EU Member States reporting the notation keys 'NA', 'NO', 'NR' and 'NE' within the key categories. Table 4.4 shows the recalculations within the energy use in industry sector group. For explanations of EU recalculations, see Section 5.1.

4.3 Sectoral analysis and emission trends for the industrial processes and product use sector

The industrial processes and product use sector grouping refers to emissions from industrial sources other than those arising from fuel combustion within the industrial sector. This is the primary sector group for PCB, non-methane volatile organic compound (NMVOC), Pb and Cd emissions, as well as a significant source of total HCB, Hg, particulate matter with a diameter of 10µm or less (PM_{10}), polychlorinated dibenzodioxin/dibenzofuran (PCDD/F), SO_X and carbon monoxide (CO) emissions. Countries are ranked according to the size of the absolute values they reported. Spain contributed most to PCB emissions in this sector in 2021. Of all the countries, Germany, France and Italy contributed most to NMVOC emissions. For Pb, the greatest contributions came from Poland, Germany and Italy. The EU Cd emission value is mainly driven by data reported by Germany, Poland and Spain. Figure 4.5 shows previous trends in the emissions of the relevant main pollutants.

Figure 4.5 **EU emission trends in the industrial processes and product use sector group for NMVOCs, SO_X, PM_{10} and CO between 1990 (2000) and 2021**



Data from France and Germany for the category '2C1 — Iron and steel production' have a great influence on the trend in CO emissions. In France, CO emissions from the 2C1 category have fluctuated over the years, depending on the amount of blast furnace gas that has been produced, reused or flared. These amounts depend on the operating conditions and how feasible it is for iron and steel or colliery plants to reuse the gas being produced continuously by blast furnaces. This may fluctuate a great deal from one year to another, resulting in peaks (1995, 2004 and 2010) or troughs (2001 and 2009) (personal communication from France in 2013). The negative peak in 2009 was also influenced by the data reported by several countries, mainly Germany, Belgium and France, in the category '2C1 — Iron and steel production'.

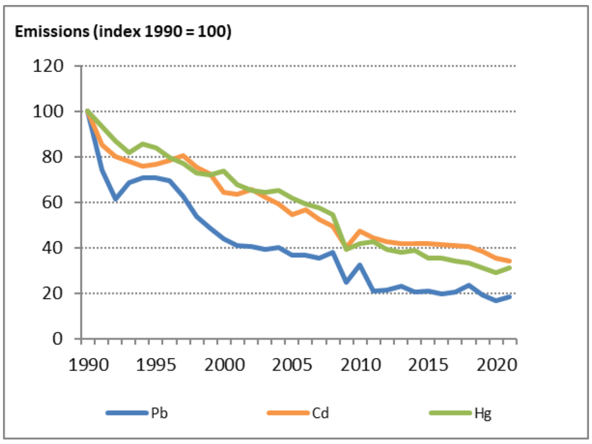
Despite considerable reductions since 1990, the industrial processes and product use sector continues to contribute significantly to total EU emissions of HMs. Figure 4.6(a) presents previous emission trends for these pollutants. Pb shows the highest relative reduction in emissions between 1990 and 2021 (82%).

The trend in Cd emissions between 1990 and 2007 mainly reflects data reported by Germany in the categories '2C1 — Iron and steel' and '2C7a — Copper production'.

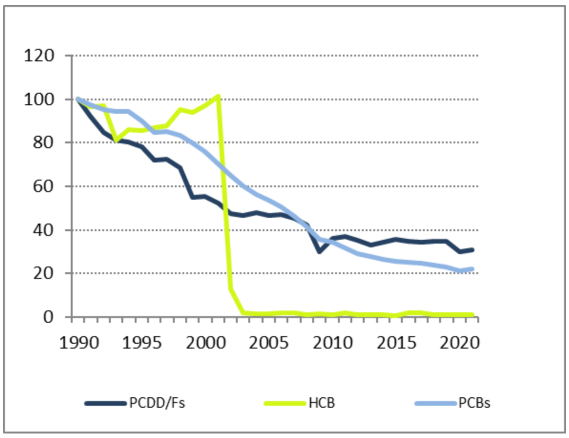
The dip in Pb emissions between 2008 and 2009 was mainly caused by reductions in the category '2C5 — Lead production' reported by Bulgaria. The reduction in Pb emissions between 2010 and 2011 reflected the

Figure 4.6 **EU emission trends in the industrial processes and product use sector group: (a) HMs (Pb, Cd, Hg) and (b) POPs (PCDD/Fs, HCB, PCBs) between 1990 and 2021**

(a)



(b)



drastic drop in emissions reported by Latvia in category '2C1 — Iron and steel production', resulting from a change in the type of furnace used in metal production. Overall, between 2010 and 2011, Latvia's total Pb emissions (national total) fell by 97.5% (see Latvia's IIR, listed in Appendix 5).

Table 4.5 Number of EU Member States reporting notation keys within the key categories of the industrial processes and product use sector group

Key categories		NA	NO	NR	NE
Cd	2C1	0	4	0	0
Cd	2C7a	1	11	0	0
Cd	2C6	1	12	0	0
Cd	2A3	2	3	0	2
CO	2C1	1	4	0	2
Dioxin	2C1	0	4	0	1
HCB	2B10a	12	6	0	7
HCB	2C7a	4	12	0	5
HCB	2C1	0	4	0	5
Hg	2C1	0	4	0	0
Hg	2A1	6	1	0	5
Hg	2C6	2	12	0	0
NMVOC	2D3g	0	0	0	1
NMVOC	2D3i	0	1	0	0
NMVOC	2D3e	0	1	0	1
Pb	2C1	0	4	0	0
Pb	2C5	0	9	0	0
Pb	2A3	2	3	0	0
PCB	2K	8	7	0	4
PCB	2C1	0	4	0	0
PM_{10}	2A5b	1	0	0	0
PM_{10}	2A5a	1	2	0	0
PM_{10}	2L	5	14	0	1
$PM_{2.5}$	2A5b	1	0	0	0
SO_X	2B10a	2	5	0	1
SO_X	2C1	1	4	0	2
Total PAH	2C1	1	4	0	2

Note: Only the key categories where notation keys were reported are considered.

Table 4.6 **(a) Relative difference (relative data, percentage of EU national totals) and (b) absolute difference between reported emissions when comparing the EU's 2022 and 2023 submissions for the industrial processes and product use sector group**

(a)

Relative difference																			
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	-1%	-1%	-1%	0%	0%
NMVOCs	0%	1%	1%	1%	1%	1%	2%	2%	2%	3%	3%	3%	3%	3%	2%	3%	3%	2%	5%
SOx	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%	-2%	1%	-2%	-2%	-2%	1%	1%
NH_3	-9%	-4%	-6%	-7%	-6%	-8%	-6%	-6%	-6%	-8%	-7%	-6%	-7%	-7%	-7%	-6%	-6%	-7%	-7%
TSPs	11%	16%	11%	16%	10%	29%	12%	18%	29%	41%	14%	13%	9%	19%	12%	16%	29%	15%	17%
CO	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%
Pb	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cd	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	0%	0%	0%	-1%	0%	0%	0%	0%	0%
Hg	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	0%	1%	1%	1%	1%	1%
As	0%	0%	0%	1%	0%	0%	0%	0%	0%	-3%	1%	1%	0%	1%	0%	0%	0%	0%	0%
Cr	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cu	0%	0%	0%	1%	1%	1%	1%	1%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%
Ni	0%	0%	0%	0%	-1%	-1%	-1%	0%	0%	-1%	0%	0%	0%	0%	0%	-1%	0%	0%	1%
Se	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Zn	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PCDD/Fs	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	-5%
B(a)P	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	1%	1%	1%	2%	2%	2%	3%	2%	-36%
B(b)F	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	1%	2%	3%	3%	4%	2%	-29%
B(k)F	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	2%	1%	2%	3%	3%	4%	2%	-28%
IP	0%	0%	0%	0%	2%	2%	2%	2%	2%	3%	5%	9%	6%	11%	16%	14%	14%	6%	-46%
Total PAHs	-2%	-4%	-4%	-4%	-4%	-4%	-2%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	0%	-1%	0%	-1%	-11%
HCB	-8%	-4%	-5%	-69%	-21%	-30%	-37%	-15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PCBs	62%	74%	88%	85%	77%	75%	66%	67%	53%	55%	57%	63%	63%	59%	59%	56%	54%	53%	53%
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			1%	3%	2%	6%	3%	5%	6%	9%	3%	3%	2%	5%	3%	4%	8%	5%	5%
PM_{10}			8%	14%	8%	24%	12%	16%	25%	36%	12%	13%	10%	19%	11%	14%	27%	15%	17%
BC			-100%	-100%	-100%	-63%	-75%	-58%	-63%	-64%	-69%	-56%	-41%	-54%	-53%	-59%	-74%	-58%	-53%

(b)

Absolute difference																			
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	-1	-1	0	-1	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1
NMVOCs	17	21	47	39	35	39	51	57	75	79	76	76	75	74	53	70	68	44	137
SOx	0	-1	2	1	1	1	1	1	1	1	-2	-3	-3	2	-3	-3	-3	1	2
NH_3	-6	-2	-3	-4	-3	-4	-3	-2	-3	-3	-3	-2	-3	-3	-3	-2	-3	-3	-3
TSPs	168	182	148	219	131	380	164	203	319	431	138	130	87	189	109	145	284	144	167
CO	-5	-1	-1	-7	-6	-6	-5	-5	-5	-5	-5	-5	-5	-3	-3	-3	-2	-4	48
Pb	1	0	0	1	0	1	0	1	1	-15	0	0	0	0	0	0	0	0	1
Cd	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	2	1	1	2	2	2	2	2	3	1	1	1	1	0	0	0	0	-1	0
Ni	-1	0	0	0	-1	0	-1	0	0	-1	0	0	0	0	0	0	0	0	0
Se	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	7	3	3	5	4	4	4	3	3	-6	1	0	0	-1	0	-1	-1	-1	-1
PCDD/Fs	0	0	0	0	0	0	0	-2	-2	-2	0	0	0	0	-1	-1	-1	-1	-14
B(a)P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2
B(b)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
B(k)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
IP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
Total PAHs	-4	-6	-4	-4	-4	-4	-2	-1	-1	-1	-1	0	0	0	0	0	0	0	-6
HCB	-324	-148	-177	-131	-18	-28	-27	-9	0	0	0	0	0	0	0	0	0	0	0
PCBs	2,158	2,171	2,010	1,392	1,255	1,117	928	813	674	636	600	606	585	542	531	505	475	446	418
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			1	5	3	9	5	6	8	11	4	4	3	6	3	4	9	5	6
PM_{10}			36	66	41	110	53	63	94	133	43	45	34	67	37	47	95	50	58
BC			-2,043	-2,531	-2,010	-8	-15	-7	-8	-8	-8	-4	-2	-4	-4	-4	-9	-4	-3

Note: As, arsenic; B(b)F, benzo(b)fluoranthene; BC, black carbon; B(k)F, benzo(k)fluoranthene; Cr, chromium; Cu, copper; IP, indeno(1,2,3-cd)pyrene; NH_3, ammonia; Ni, nickel; Se, selenium; TSP, total suspended particulate; Zn, zinc.

Among the persistent organic pollutants (POPs), HCB recorded the highest relative reduction (99%) between 1990 and 2021 (Figure 4.6(b)).

The massive decrease in HCB from 2001 to 2002 (87%) is a result of Germany's reporting the notation key 'NA' in category '2C3 — Aluminium production'. Secondary aluminium production in Germany has been prohibited by law since 2002, resulting in the omission of the source of HCB (see Germany's IIR, listed in Appendix 5).

Table 4.5 presents the number of EU Member States reporting the notation keys 'NA', 'NO', 'NR' and 'NE' within the key categories. Table 4.6 shows the recalculations within the industrial processes and product use sector group. For explanations of EU recalculations, see Section 5.1.

4.4 Sectoral analysis and emission trends for the commercial, institutional and households sector

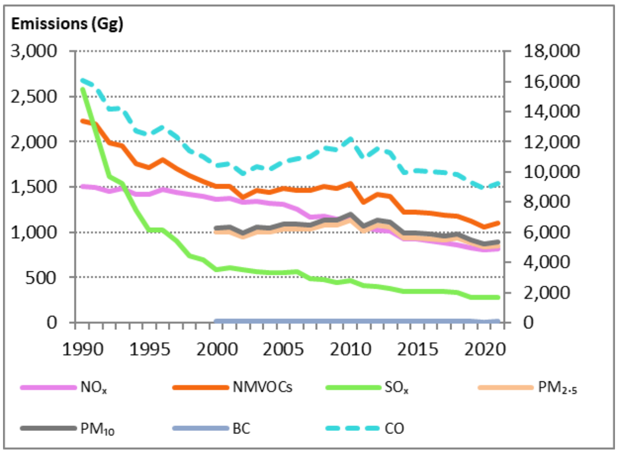
As indicated in Chapter 2, fuel combustion in commercial and institutional facilities and households makes a significant contribution to the total emissions of many pollutants.

The commercial, institutional and households sector is the primary sector group for benzo(a)pyrene (B(a)

P), polycyclic aromatic hydrocarbons (PAHs), particulate matter with a diameter of 2.5µm or less ($PM_{2.5}$), CO, PM_{10}, black carbon (BC) and PCDD/Fs, and is an important sector group for Cd, HCB, SO_X, NO_X and NMVOC emissions. Countries are ranked according to the size of the absolute values that they reported. For B(a)P and PAHs, the greatest contributions were reported by Poland. For primary $PM_{2.5}$ and PM_{10}, Poland, France and Romania reported the highest emissions. Poland, France and Italy contributed most to CO emissions. Poland, Romania and Italy emitted the largest proportion of PCDD/Fs in 2021.

Of the main pollutants, once again the highest relative reduction between 1990 and 2021 for the sector grouping was for SO_X (89%). In contrast, particulate matter (PM) emissions have changed little since 2000 (see Figure 4.7).

Figure 4.7 **EU emission trends in the commercial, institutional and households sector group for NO_X, NMVOCs, SO_X, $PM_{2.5}$, PM_{10}, BC and CO between 1990 (2000) and 2021**



Notes: The right-hand axis shows values for CO.

The trend for CO within the commercial, institutional and households sector is mainly influenced by emissions reported by France, Poland and Italy in category '1A4bi — Residential: Stationary'.

Lower SO_X emissions from 1990 onwards were the result of reductions in emissions of this air pollutant in Germany. The Member State explained that lower SO_X emissions resulted from the fuel switch from coal (especially lignite, with a high emission factor) to natural gas (with a lower emission factor). From 2008 onwards, a further reduction in sulphur dioxide (SO_2) emissions can be explained by the increasing use of fuel oil with a low sulphur content (see Germany's IIR 2021, listed in Appendix 5).

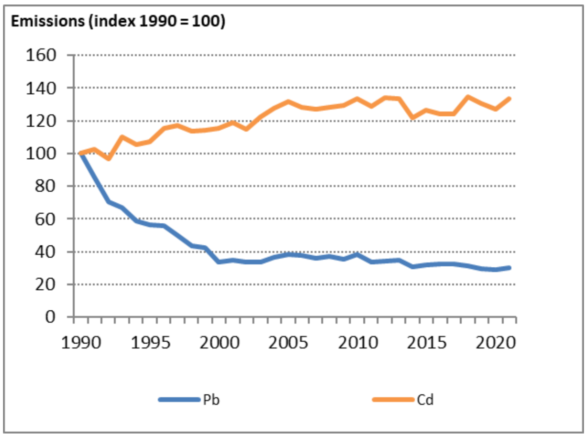
The trend for NMVOC emissions mainly follows the development of data reported by France for category '1A4bi — Residential: Stationary'.

Of the three HMs in the commercial, institutional and households sector, Pb shows the largest reduction, both absolute and relative (70%) (see Figure 4.8(a)).

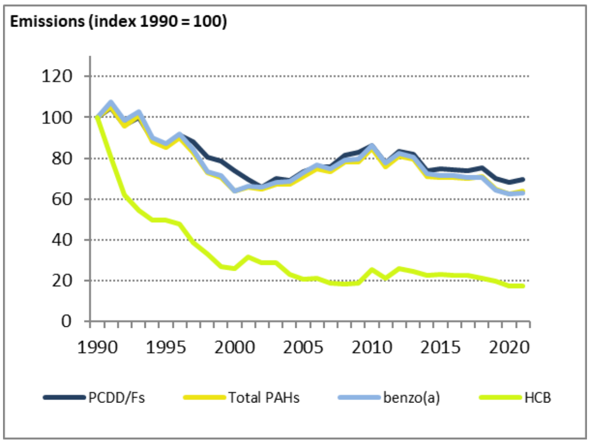
Since 1990, the trend in Cd emissions has shown an increasing trend in category '1A4bi — Residential: Stationary', with some fluctuations, mainly related to emissions reported by Poland and Romania.

Figure 4.8 EU emission trends in the commercial, institutional and households sector group: (a) HMs (Pb and Cd) and (b) POPs (PCDD/Fs, total PAHs, B(a)P and HCB) between 1990 and 2021

(a)



(b)



Poland and Germany contribute most to the trend in Pb emissions. The fall in Pb emissions from 1990 to 1992 is the result of emission reductions reported by several countries, especially Germany and Italy, which reduced their emissions considerably in categories '1A5b — Other, mobile (including military, land based

Table 4.7 Number of EU Member States reporting notation keys within the key categories of the commercial, institutional and households sector group

Key categories		NA	NO	NR	NE
PM_{10}	1A4ci	0	1	0	0
$PM_{2.5}$	1A4ci	0	1	0	0

Note: Only the key categories where notation keys were reported are considered.

Table 4.8 **(a) Relative difference (relative data, percentage of EU national totals) and (b) absolute difference between reported emissions when comparing the EU's 2022 and 2023 submissions for the commercial, institutional and households sector group**

(a)

Relative difference

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	2%	2%
NMVOCs	2%	2%	7%	14%	15%	14%	15%	15%	16%	14%	13%	13%	12%	11%	11%	10%	16%	16%	13%
SOx	0%	-1%	-2%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	0%	0%	0%	0%	0%	4%	4%	4%
NH_3	-5%	-4%	-5%	-6%	-7%	-7%	-8%	-10%	-11%	-12%	-13%	-14%	-15%	-16%	-16%	-17%	-18%	-19%	-19%
TSPs	4%	4%	7%	10%	9%	9%	9%	10%	10%	9%	9%	10%	9%	8%	8%	8%	18%	18%	15%
CO	1%	1%	3%	6%	6%	6%	6%	6%	6%	5%	5%	5%	4%	4%	5%	4%	10%	10%	8%
Pb	9%	7%	2%	4%	5%	5%	5%	6%	6%	5%	6%	6%	6%	6%	7%	7%	9%	9%	8%
Cd	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	14%	13%	11%
Hg	0%	0%	1%	1%	1%	1%	2%	2%	2%	1%	2%	2%	2%	2%	2%	2%	4%	4%	3%
As	1%	0%	4%	9%	10%	12%	12%	13%	14%	12%	13%	14%	13%	14%	14%	14%	14%	15%	13%
Cr	1%	0%	3%	7%	8%	8%	9%	9%	10%	8%	9%	9%	8%	8%	9%	9%	15%	15%	13%
Cu	1%	0%	1%	3%	3%	3%	4%	4%	4%	4%	4%	4%	3%	4%	4%	4%	5%	5%	4%
Ni	7%	0%	1%	0%	0%	0%	0%	1%	2%	1%	1%	2%	1%	2%	2%	2%	2%	2%	2%
Se	0%	0%	3%	9%	10%	11%	11%	12%	13%	11%	12%	12%	10%	11%	12%	13%	12%	12%	10%
Zn	1%	0%	2%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	14%	13%	12%
PCDD/Fs	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	9%	8%	6%
B(a)P	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	0%	-1%	-2%	-2%	-2%	4%	4%	2%
B(b)F	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	0%	-1%	-2%	-2%	-2%	7%	6%	4%
B(k)F	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%	-2%	-2%	8%	8%	6%
IP	0%	-1%	-1%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-4%	-4%	-4%	3%	4%	2%
Total PAHs	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	0%	-1%	-2%	-2%	-2%	5%	5%	4%
HCB	-1%	0%	-1%	-1%	-2%	-2%	-2%	-2%	-1%	-2%	-1%	-1%	-1%	-3%	-3%	-5%	-5%	-5%	-6%
PCBs	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			7%	10%	10%	10%	10%	10%	11%	9%	10%	10%	9%	8%	8%	8%	20%	20%	17%
PM_{10}			7%	10%	9%	9%	10%	10%	10%	9%	9%	10%	9%	8%	8%	8%	19%	19%	16%
BC			4%	7%	7%	7%	8%	9%	10%	9%	10%	11%	10%	9%	11%	11%	15%	16%	14%

(b)

Absolute difference

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	0	-2	-1	0	-1	-1	0	0	2	1	3	4	3	1	1	3	13	14	17
NMVOCs	39	29	93	181	186	185	197	197	209	161	168	165	133	118	120	111	165	155	122
SOx	-1	-9	-13	-8	-6	-4	-7	-3	-3	-3	-2	-1	-1	0	-1	-1	12	10	10
NH_3	-3	-3	-3	-4	-4	-5	-6	-7	-8	-8	-9	-11	-10	-11	-11	-11	-11	-12	-12
TSPs	60	55	70	101	100	98	105	108	118	93	103	108	85	77	79	73	162	150	124
CO	211	183	342	583	588	574	607	599	640	496	533	542	427	385	435	414	893	832	650
Pb	36	15	3	7	7	7	8	8	10	8	8	9	7	8	9	9	12	11	9
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cr	1	0	2	4	4	4	4	4	5	4	4	4	4	4	4	4	7	6	5
Cu	1	0	1	2	2	2	3	3	3	2	3	3	2	3	3	3	3	3	3
Ni	10	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Se	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Zn	3	3	12	26	27	27	30	30	33	26	30	32	26	28	31	31	97	90	75
PCDD/Fs	6	7	6	5	5	4	4	4	3	2	3	4	3	2	1	1	69	60	47
B(a)P	0	-1	-1	-1	-1	-1	-1	-2	-2	-2	-2	-1	-2	-6	-5	-6	9	8	5
B(b)F	0	-1	-1	-1	-1	-1	-1	-1	-2	-2	-2	-1	-2	-5	-4	-4	15	13	9
B(k)F	2	-1	0	0	0	0	0	0	0	-1	0	0	-1	-2	-2	-2	9	8	5
IP	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-5	-5	-5	4	4	2
Total PAHs	1	-4	-3	-2	-2	-3	-3	-4	-5	-5	-5	-4	-6	-18	-16	-17	37	33	22
HCB	-1	0	0	0	-1	-1	-1	-1	-1	-1	0	0	0	-1	-1	-2	-2	-2	-2
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			65	93	92	90	97	100	109	86	95	99	78	71	73	68	155	144	119
PM_{10}			67	96	95	93	100	102	112	88	97	102	80	73	74	69	157	146	120
BC			5	8	8	8	9	9	11	9	10	12	9	9	10	9	12	12	11

Note: As, arsenic; BC, black carbon; B(b)F, benzo(b)fluoranthene; B(k)F, benzo(k)fluoranthene; Cr, chromium; Cu, copper; IP, indeno(1,2,3-cd)pyrene; NH_3, ammonia; Ni, nickel; Se, selenium; TSP, total suspended particulate; Zn, zinc.

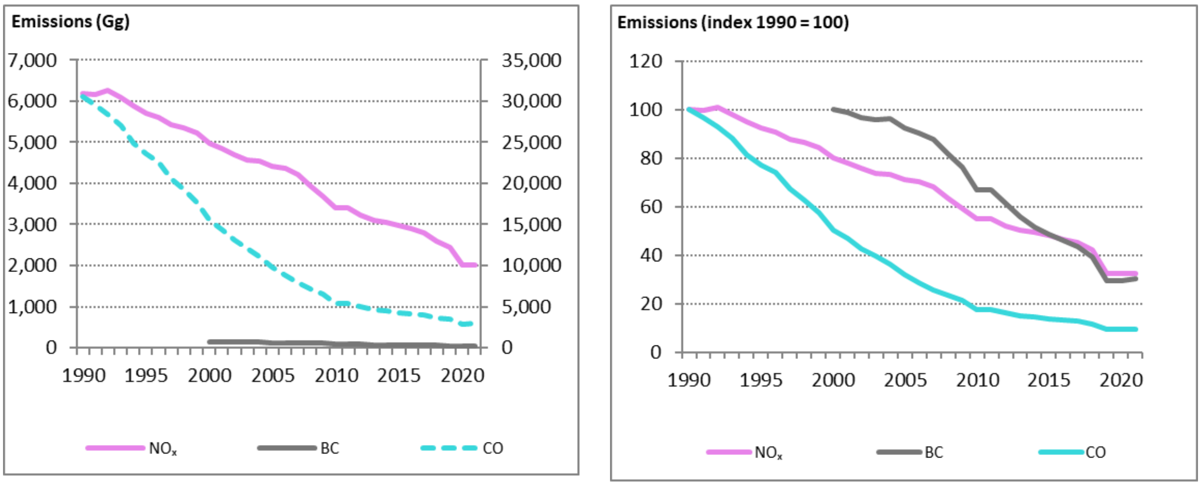
and recreational boats)' and '1A4cii — Agriculture/forestry/fishing: Off-road vehicles and other machinery'.

Among the POPs relevant to the commercial, institutional and households sector, the highest absolute and relative reduction occurred for HCB (83%) (Figure 4.8(b)).

The trend in total emissions of PAHs largely reflects data from Poland, Germany and Italy in category '1A4bi — Residential: Stationary'. The peaks in 2010 and 2012 reflect data reported by Germany and Poland in category '1A4bi — Residential: Stationary'. Emissions from Poland reported in the same category caused the peak in total PAHs and B(a)P total emissions in 1993.

Table 4.7 presents the number of EU Member States reporting the notation keys 'NA', 'NO', 'NR' and

Figure 4.9 EU emission trends in the road transport sector group for NO_X, BC and CO between 1990 (2000) and 2021



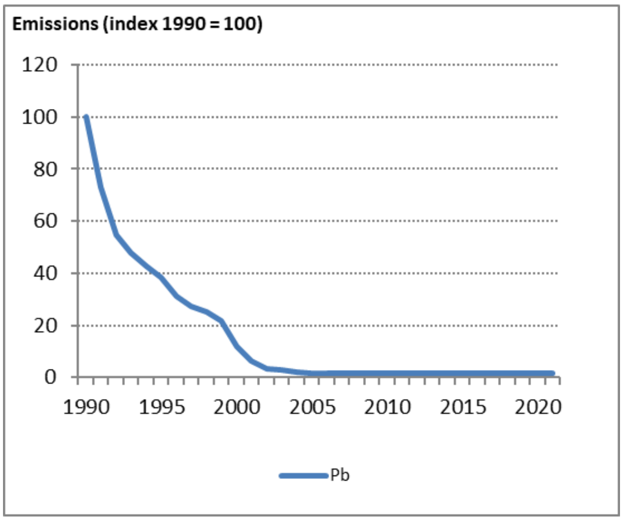
Note: In the left-hand panel the right-hand axis shows values for CO.

'NE' within the key categories. Table 4.8 shows the recalculations within the commercial, institutional and households sector group. For explanations of EU recalculations, see Section 5.1.

4.5 Sectoral analysis and emission trends for the road transport sector

The road transport sector group is the primary sector group for NO_X emissions. Together, the individual NFR sources that make up the road transport sector group contribute considerably to the emissions of several pollutants, including Pb, BC and CO. Figure 4.9 and Figure 4.10 show the previous emission trends for these

Figure 4.10 EU emission trends in the road transport sector group for the priority HM Pb between 1990 and 2021



pollutants in this sector.

Countries are ranked according to the size of the absolute values that they reported. For primary NO_X,

Table 4.9 **(a) Relative difference (relative data, percentage of EU national totals) and (b) absolute difference between reported emissions when comparing the EU's 2022 and 2023 submissions for the road transport sector group**

(a)

Relative difference

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	0%	0%	-1%	0%	0%	0%	0%	1%	1%	1%	1%	1%	2%	2%	2%	3%	1%	0%	0%
NMVOCs	1%	1%	0%	1%	2%	2%	2%	3%	3%	3%	2%	2%	5%	7%	9%	11%	7%	8%	10%
SOx	1%	0%	0%	1%	1%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-2%	0%	-2%	-2%	-1%	-1%
NH_3	2%	1%	2%	1%	1%	2%	2%	2%	2%	2%	2%	2%	1%	2%	2%	1%	1%	0%	0%
TSPs	0%	1%	1%	2%	2%	2%	2%	2%	2%	3%	2%	2%	3%	3%	3%	3%	2%	2%	3%
CO	0%	0%	-1%	0%	0%	0%	0%	0%	1%	0%	0%	0%	3%	4%	5%	6%	1%	0%	1%
Pb	0%	1%	3%	38%	40%	42%	43%	44%	44%	52%	50%	47%	50%	54%	53%	53%	53%	50%	50%
Cd	17%	17%	17%	21%	22%	22%	23%	23%	23%	23%	23%	22%	23%	23%	23%	24%	24%	24%	24%
Hg	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%	-3%	-3%	-3%	-4%
As	26%	26%	27%	34%	35%	36%	36%	37%	36%	36%	34%	33%	34%	34%	33%	34%	34%	34%	34%
Cr	45%	45%	46%	55%	57%	58%	58%	59%	57%	58%	55%	54%	57%	56%	55%	56%	56%	56%	55%
Cu	47%	47%	48%	59%	60%	62%	63%	63%	62%	63%	60%	59%	62%	62%	61%	61%	62%	61%	60%
Ni	15%	24%	25%	31%	32%	32%	33%	33%	33%	33%	32%	32%	34%	33%	33%	33%	34%	34%	34%
Se	19%	18%	18%	22%	23%	23%	23%	23%	22%	23%	22%	22%	23%	23%	22%	22%	22%	22%	21%
Zn	25%	25%	26%	31%	32%	32%	33%	33%	32%	32%	31%	31%	32%	32%	31%	32%	32%	32%	32%
PCDD/Fs	0%	3%	1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-2%	-2%	-3%	-2%	-2%	-2%	-3%	-3%	-3%
B(a)P	-3%	-2%	-1%	-1%	-1%	-1%	-1%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-3%
B(b)F	-2%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-3%	-4%	-5%	-6%	-7%	-7%
B(k)F	-2%	-2%	-2%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-4%	-6%	-7%	-8%	-9%	-9%
IP	-1%	-1%	-1%	-1%	-1%	0%	-1%	0%	0%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-3%	-3%	-4%
Total PAHs	-2%	-1%	-1%	-1%	-1%	-1%	-1%	0%	-1%	-1%	-1%	-1%	-2%	-3%	-4%	-4%	-5%	-6%	-6%
HCB	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	0%	0%	0%	0%	0%
PCBs	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	0%
			2000	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
$PM_{2.5}$			0%	1%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	3%	3%	1%	1%	1%
PM_{10}			1%	2%	2%	2%	3%	3%	3%	3%	3%	3%	4%	4%	4%	4%	3%	3%	3%
BC			0%	1%	2%	2%	2%	3%	3%	3%	3%	3%	3%	3%	4%	5%	4%	3%	4%

(b)

Absolute difference

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	2	-23	-36	-11	-3	4	11	25	28	32	33	36	59	66	69	75	19	-7	-4
NMVOCs	61	20	9	21	25	25	26	28	25	21	16	13	34	40	49	59	37	41	42
SOx	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH_3	0	0	2	1	1	1	1	2	1	1	1	1	1	1	1	1	0	0	0
TSPs	1	3	3	6	7	7	7	8	8	8	7	7	8	8	8	8	7	6	6
CO	-60	-113	-97	-1	18	26	19	18	35	19	6	4	143	167	202	225	27	13	16
Pb	62	45	59	78	82	85	85	85	83	84	79	77	83	83	82	84	86	86	76
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cr	16	18	21	28	30	31	31	31	30	30	28	28	30	30	30	30	31	31	27
Cu	377	423	484	643	672	699	703	697	686	691	648	630	680	684	677	691	710	713	621
Ni	3	3	3	4	4	5	5	5	5	5	4	4	5	5	5	5	5	5	4
Se	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	110	123	140	184	192	199	199	198	195	197	185	180	191	193	193	198	204	204	179
PCDD/Fs	0	2	1	-1	-2	-2	-2	-2	-2	-2	-3	-3	-3	-2	-2	-2	-2	-2	-2
B(a)P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(b)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(k)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total PAHs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-1
HCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2000	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
$PM_{2.5}$			0	2	3	3	3	4	4	3	3	3	3	3	3	4	2	1	1
PM_{10}			3	6	6	7	7	8	7	7	6	6	7	7	7	8	6	5	5
BC			1	2	2	2	2	3	3	2	2	2	2	2	3	3	2	2	2

Note: As, arsenic; B(b)F, benzo(b)fluoranthene; B(k)F, benzo(k)fluoranthene; Cr, chromium; Cu, copper; IP, indeno(1,2,3-cd)pyrene; NH_3, ammonia; Ni, nickel; Se, selenium; TSP, total suspended particulate; Zn, zinc.

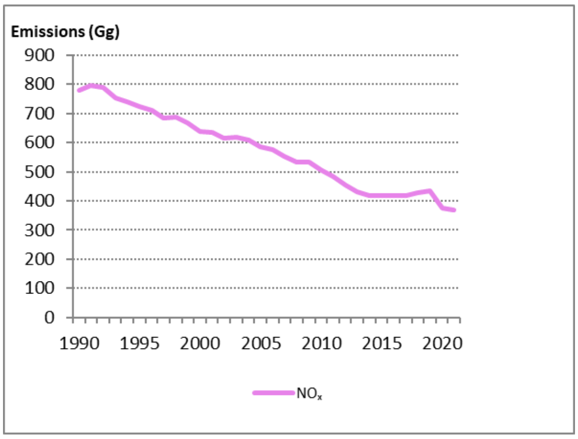
Germany, France and Italy reported the highest emissions. Germany, Italy and Poland contributed most to Pb emissions. France, Spain and Poland contributed most (in absolute terms) to BC emissions in the road transport sector in 2021. For CO, Germany, Italy and Poland reported the highest emissions.

The main HM for the road transport sector is Pb, which shows a high relative reduction in emissions (98%) between 1990 and 2021 (see Figure 4.10). However, in recent years, little progress has been made in further reducing emissions from road transport, and over the last few years total Pb emissions have fluctuated between slight reductions and increases. The promotion of unleaded petrol in the EU and other EEA member countries, by means of a combination of fiscal and regulatory measures, has been a success story. For example, EU Member States have completely phased out the use of leaded petrol. Directive 98/70/EC on the quality of petrol and diesel fuels (EU, 1998) achieved that objective. Nevertheless, the road transport sector remains a key source of Pb, contributing around 23% of total Pb emissions in the EU.

Table 4.9 presents the number of EU Member States reporting the notation keys 'NA', 'NO', 'NR' and 'NE' within the key categories. Table 4.9 shows the recalculations within the road transport sector group. For explanations of EU recalculations, see Section 5.1.

4.6 Sectoral analysis and emission trends for the non-road transport sector

Figure 4.11 EU emission trends in the non-road transport sector group for NO_X between 1990 and 2021



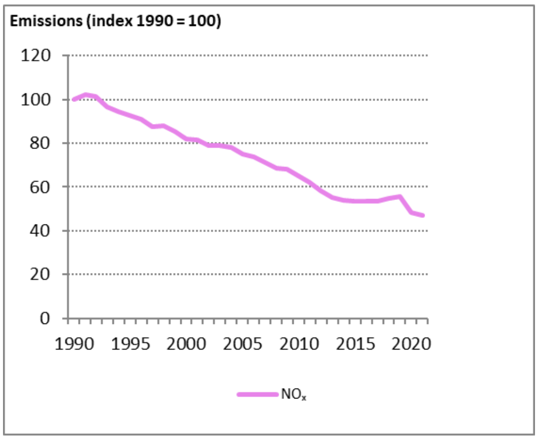


Table 4.10 (a) Relative difference (relative data, percentage of EU national totals) and (b) absolute difference between reported emissions when comparing the EU's 2022 and 2023 submissions for the non-road transport sector group

(a)

Relative difference																				
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	-3%	-4%	-3%	-5%	-5%	-5%	-4%	-4%	-3%	-3%	-4%	-4%	-6%	-7%	-9%	-11%	-10%	-9%	-8%
NMVOCs	-12%	-14%	-17%	-20%	-20%	-20%	-22%	-23%	-22%	-23%	-28%	-28%	-28%	-28%	-26%	-25%	-23%	-20%	-20%
SOx	1%	2%	3%	5%	6%	6%	6%	9%	7%	4%	3%	3%	5%	3%	5%	4%	6%	9%	-36%
NH_3	-24%	1%	-5%	-6%	-7%	-6%	-5%	-6%	-2%	3%	-1%	-3%	0%	2%	-1%	-5%	-6%	-4%	-3%
TSPs	-3%	-3%	-3%	-3%	-4%	-4%	-3%	-3%	-2%	-2%	-2%	-2%	-1%	-2%	-1%	-2%	0%	1%	-1%
CO	-25%	-30%	-35%	-37%	-36%	-35%	-36%	-36%	-35%	-35%	-38%	-36%	-34%	-31%	-31%	-31%	-31%	-31%	-36%
Pb	-31%	-28%	-1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	1%	1%	4%
Cd	-9%	-11%	-13%	-14%	-14%	-14%	-15%	-15%	-15%	-16%	-17%	-18%	-18%	-18%	-17%	-16%	-16%	-15%	-17%
Hg	-3%	-3%	-3%	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-4%	-4%	-5%	-4%	-4%	-4%	-3%	-6%
As	8%	7%	6%	3%	5%	5%	5%	4%	4%	6%	6%	7%	7%	7%	9%	12%	12%	12%	8%
Cr	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	3%	7%
Cu	1%	1%	1%	1%	1%	2%	2%	3%	5%	4%	5%	6%	6%	7%	8%	8%	9%	9%	-2%
Ni	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	3%	2%	4%
Se	25%	26%	21%	22%	23%	22%	19%	16%	21%	17%	17%	17%	22%	20%	26%	28%	31%	33%	29%
Zn	-14%	-20%	-23%	-25%	-26%	-26%	-28%	-28%	-29%	-30%	-33%	-34%	-34%	-34%	-33%	-33%	-33%	-33%	-36%
PCDD/Fs	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	0%	-1%
B(a)P	-1%	-2%	-2%	-3%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-5%	-5%	-5%	-5%	-6%	-6%	-6%
B(b)F	-1%	-1%	-1%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	-4%	-4%	-4%	-4%	-5%	-4%	-6%
B(k)F	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-4%	-4%	-5%	-5%	-5%	-4%	-6%
IP	-5%	-6%	-7%	-8%	-9%	-9%	-9%	-10%	-10%	-10%	-11%	-11%	-12%	-14%	-14%	-14%	-15%	-12%	-15%
Total PAHs	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-2%	-2%
HCB	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	2%	2%	2%	2%
PCBs	-5%	-7%	-9%	-9%	-8%	-8%	-8%	-7%	-8%	-9%	-10%	-9%	-9%	-8%	-8%	-8%	-7%	-8%	-10%
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			-4%	-4%	-4%	-4%	-4%	-3%	-2%	-2%	-3%	-2%	-1%	-2%	-1%	-2%	0%	1%	2%
PM_{10}			-3%	-4%	-4%	-4%	-4%	-3%	-2%	-2%	-3%	-2%	-2%	-2%	-1%	-2%	0%	1%	0%
BC			-8%	-10%	-10%	-10%	-8%	-8%	-7%	-7%	-7%	-6%	-7%	-7%	-7%	-8%	-8%	0%	2%

(b)

Absolute difference																				
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	-22	-28	-23	-29	-30	-29	-21	-21	-17	-13	-19	-17	-26	-32	-42	-51	-49	-45	-34
NMVOCs	-16	-18	-20	-22	-22	-21	-21	-21	-20	-19	-20	-20	-19	-19	-17	-16	-14	-12	-10
SOx	3	5	5	6	7	7	6	10	6	3	2	2	2	2	3	3	4	6	-14
NH_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TSPs	-2	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	0	0	0
CO	-140	-163	-182	-199	-192	-186	-185	-180	-170	-154	-151	-137	-123	-109	-111	-114	-114	-116	-115
Pb	-43	-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Cu	2	2	1	1	2	4	4	5	8	7	8	9	10	11	12	12	14	14	-2
Ni	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	3	2	3
Se	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	-2	-2	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3
PCDD/Fs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(a)P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(b)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(k)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total PAHs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			-1	-1	-1	-1	-1	-1	-1	0	-1	-1	0	-1	0	0	0	0	0
PM_{10}			-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	0	0	0
BC			-1	-1	-1	-1	-1	-1	0	0	0	0	0	0	0	-1	0	0	0

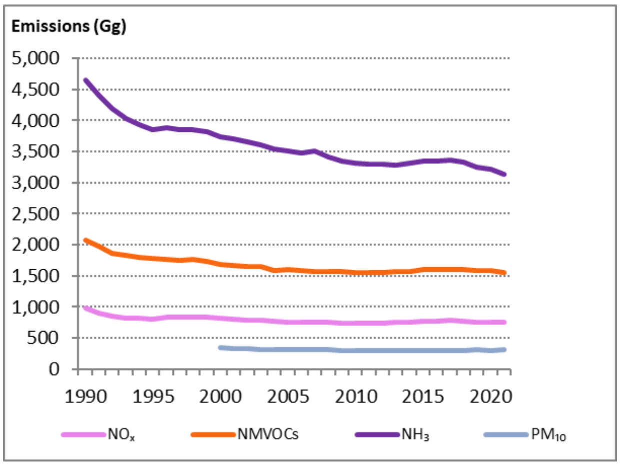
Note: As, arsenic; B(b)F, benzo(b)fluoranthene; B(k)F, benzo(k)fluoranthene; Cr, chromium; Cu, copper; IP, indeno(1,2,3-cd)pyrene; NH_3, ammonia; Ni, nickel; Se, selenium; TSP, total suspended particulate; Zn, zinc.

In this report, emissions from international/domestic aviation and shipping are reported as a simple sum of the emissions from each of the EU Member States. Accordingly, emissions from international/domestic aviation and shipping are not divided into those occurring within the EU and those that cross its geographical boundaries. However, as the guidelines (UNECE, 2022c) define international emissions as those that start in one country and finish in another, the reporting matches the guidelines.

The non-road transport sector is not a key sector for any pollutant but is a source of NO_X emissions. Emissions of this pollutant show a downwards trend between 2020 and 2021, mainly influenced by reductions in international and domestic aviation as a result of the health crisis (see Figure 4.11).

Within the non-road transport sector group, NO_X is the most relevant pollutant. The countries are ranked according to the size of the absolute values that they reported. Italy, Germany and Greece contributed most (in absolute terms) to emissions of NO_X.

Figure 4.12 EU emission trends in the agriculture sector group for NH_3, PM_{10}, NMVOCs and NO_X between 1990 (2000) and 2021

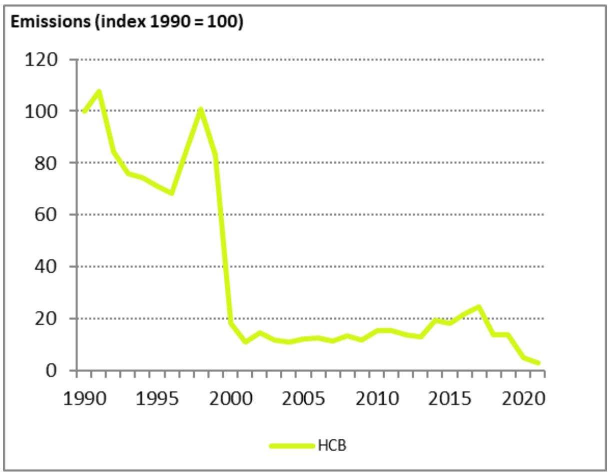


As the non-road transport sector group does not contribute very much to HM and POP emissions, trends in pollutants from these two groups of substances are not shown.

Table 4.10 shows the recalculations within the non-road transport sector group. For explanations of EU recalculations, see Section 5.1.

4.7 *Sectoral analysis and emission trends for the agriculture sector*

Figure 4.13 EU emission trends in the agriculture sector group for HCB between 1990 and 2021



This sector group is responsible for the vast majority of ammonia (NH_3) emissions in the EU — namely 94%. With regard to the size of the absolute values that the countries reported, France, Germany and Spain contributed most to NH_3 emissions in 2021.

Table 4.11 Number of EU Member States reporting notation keys within the key categories of the agriculture sector group

Key categories		NA	NO	NR	NE
HCB	3Df	3	1	0	3
NH_3	3Da3	0	1	0	0
NMVOC	3Da2a	3	0	0	2
NO_X	3Da3	0	1	0	0

Note: Only the key categories where notation keys were reported are considered.

Table 4.12 (a) Relative difference (relative data, percentage of EU national totals) and (b) absolute difference between reported emissions when comparing the EU's 2022 and 2023 submissions (relative data, percentage of EU national totals) for the agriculture sector group

(a)

Relative difference																			
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	11%	13%	15%	15%	14%	14%	15%	15%	14%	15%	14%	14%	14%	14%	14%	13%	13%	13%	12%
NMVOCs	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%
SOx	-3%	-6%	-7%	-14%	-14%	-16%	-19%	-18%	-18%	-18%	-19%	-21%	-18%	-21%	-24%	-22%	-22%	-22%	-25%
NH_3	1%	2%	2%	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
TSPs	2%	2%	2%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	2%	2%	2%	2%	2%	2%
CO	-4%	-6%	-8%	-16%	-16%	-18%	-20%	-19%	-20%	-20%	-21%	-23%	-21%	-24%	-27%	-26%	-27%	-28%	-30%
Pb	-3%	-4%	-5%	-6%	-6%	-6%	-7%	-7%	-8%	-8%	-9%	-10%	-12%	-16%	-19%	-22%	-25%	-28%	-29%
Cd	-4%	-7%	-8%	-16%	-18%	-19%	-22%	-20%	-21%	-21%	-21%	-24%	-20%	-22%	-25%	-23%	-22%	-22%	-26%
Hg	-3%	-6%	-7%	-16%	-17%	-19%	-21%	-20%	-20%	-20%	-21%	-24%	-20%	-22%	-24%	-22%	-21%	-22%	-25%
As	-1%	-2%	-2%	4%	3%	1%	0%	-3%	-4%	-4%	-4%	-4%	-5%	-9%	-11%	-12%	-14%	-15%	-15%
Cr	-2%	-4%	-5%	-11%	-12%	-13%	-15%	-15%	-16%	-16%	-16%	-18%	-16%	-18%	-20%	-18%	-18%	-18%	-20%
Cu	-3%	-5%	-6%	-8%	-8%	-9%	-11%	-11%	-12%	-12%	-13%	-14%	-14%	-17%	-20%	-20%	-21%	-23%	-25%
Ni	-3%	-6%	-7%	-14%	-15%	-16%	-19%	-18%	-18%	-18%	-19%	-21%	-18%	-20%	-22%	-20%	-20%	-20%	-23%
Se	-2%	-3%	-4%	-6%	-6%	-7%	-9%	-10%	-10%	-11%	-11%	-13%	-12%	-15%	-16%	-17%	-17%	-18%	-20%
Zn	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-1%	-1%	-1%	-2%	-4%	-7%	-10%	-12%	-16%	-19%	-19%
PCDD/Fs	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-2%	-5%	-15%	-19%	-23%	-28%	-29%
B(a)P	-1%	-1%	-2%	-7%	-7%	-9%	-13%	-12%	-13%	-13%	-14%	-16%	-14%	-15%	-19%	-18%	-17%	-17%	-21%
B(b)F	-1%	-2%	-4%	-9%	-10%	-13%	-17%	-16%	-17%	-17%	-17%	-20%	-17%	-18%	-21%	-20%	-19%	-19%	-24%
B(k)F	-1%	-2%	-4%	-9%	-9%	-12%	-16%	-16%	-16%	-16%	-16%	-19%	-16%	-17%	-21%	-20%	-18%	-19%	-24%
IP	-1%	-2%	-3%	-9%	-9%	-12%	-16%	-16%	-16%	-16%	-16%	-19%	-17%	-18%	-21%	-20%	-19%	-19%	-24%
Total PAHs	-3%	-4%	-7%	-19%	-21%	-26%	-33%	-35%	-35%	-33%	-34%	-38%	-33%	-33%	-40%	-39%	-36%	-35%	-39%
HCB	0%	0%	0%	-3%	-2%	-2%	-4%	-3%	0%	0%	-1%	-2%	-1%	-1%	1%	-1%	7%	1%	-35%
PCBs	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			0%	1%	2%	2%	1%	1%	1%	1%	1%	0%	1%	0%	0%	0%	0%	-1%	-1%
PM_{10}			8%	10%	10%	9%	10%	9%	9%	9%	9%	9%	9%	8%	8%	8%	8%	8%	8%
BC			-3%	-5%	-5%	-6%	-7%	-7%	-8%	-8%	-8%	-10%	-11%	-15%	-18%	-20%	-23%	-26%	-27%

(b)

Absolute difference																			
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	101	96	103	98	95	92	98	96	90	94	93	90	93	94	94	91	92	86	83
NMVOCs	-38	-33	-36	-37	-36	-37	-32	-29	-29	-29	-28	-27	-28	-28	-30	-29	-30	-30	-28
SOx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH_3	55	81	73	39	33	25	27	24	14	28	26	19	20	11	6	4	4	-7	-13
TSPs	24	22	22	27	26	25	26	24	23	23	23	23	22	22	21	21	21	20	19
CO	-31	-35	-33	-29	-27	-27	-32	-30	-30	-31	-31	-32	-31	-34	-35	-35	-35	-36	-38
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Se	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	-2	-2	-2	-2
PCDD/Fs	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1
B(a)P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(b)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B(k)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total PAHs	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-2
HCB	2	0	0	-2	-1	-1	-2	-2	0	0	-1	-1	-1	-1	1	-1	4	0	-12
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PM_{10}			25	28	27	26	27	25	25	24	24	24	24	24	23	23	23	22	21
BC			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: As, arsenic; B(b)F, benzo(b)fluoranthene; B(k)F, benzo(k)fluoranthene; Cr, chromium; Cu, copper; IP, indeno(1,2,3-cd)pyrene; Ni, nickel; Se, selenium; TSP, total suspended particulate; Zn, zinc.

Agricultural emissions of NH_3 have fallen by 33% since 1990 (see Figure 4.12). These reductions are mainly influenced by the decrease in the use of inorganic nitrogen fertilisers and changes in livestock farming practices (see Member State IIRs, listed in Appendix 5).

In addition, the agriculture sector produces considerable emissions of NMVOCs, HCB, PM_{10} and NO_X.

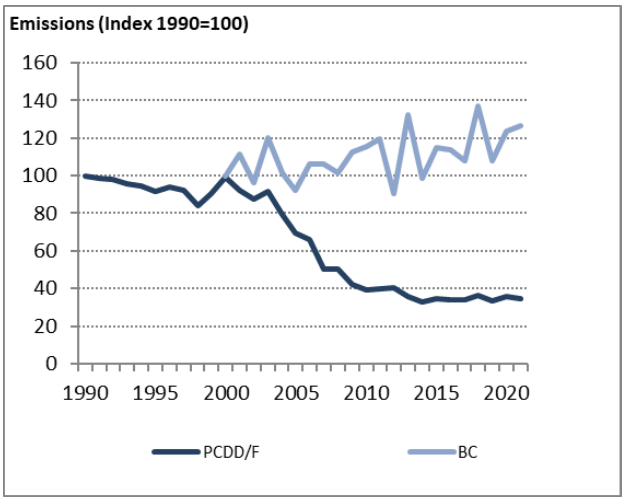
Manure management (categories 3B1a and 3B1b) is the main source of NMVOC emissions in the agriculture sector.

With regard to POPs, the agriculture sector contributes considerably to emissions of HCB. Figure 4.13 shows the emission trends for this pollutant.

The trend in emissions for HCB largely reflects data reported by several countries, namely Germany, Italy, Poland, Spain and the Netherlands, for category '3Df — Use of pesticides'. The sharp decrease between 1999 and 2000 (78%) is due to a reduction in the amount of HCB in chlorothalonil and the prohibition of the use of lindane (see Member State IIRs, listed in Appendix 5).

Table 4.11 presents the number of EU Member States reporting the notation keys 'NA', 'NO', 'NR' and 'NE' within the key categories. Table 4.12 shows the recalculations within the agriculture sector group. For explanations of EU recalculations, see Section 5.1.

Figure 4.14 EU emission trends in the waste sector group for the PCDD/Fs and BC between 1990 (2000) and 2021



4.8 Sectoral analysis and emission trends for the waste sector

This sector group is a primary source of PCDD/Fs and a significant source of BC.

Figure 4.14 shows the emission trends for these pollutants.

With regard to the size of the absolute values that the countries reported, Spain, France and Poland contributed most to PCDD/F emissions in 2021. For BC emissions, Spain, France and Greece are the main contributors within this sector.

The decrease in PCDD/F emissions in the waste sector in the EU (65% between 1990 and 2021) is led by a decreasing trend in category 'Clinical waste incineration' (99% between 1990 and 2021) in Portugal. Other influencing factors were the introduction of municipal waste incineration plants with energy recovery (1A1a) and a progressive reduction in the amount of clinical waste incinerated (5C1biii) in Spain (see Spain's IIRs, listed in Appendix 5).

Table 4.13 Number of EU Member States reporting notation keys within the key categories of the waste sector group

Key categories		NA	NO	NR	NE
BC	5C2	0	0	0	0
Cd	5C2	0	7	0	3
CO	5C2	0	6	0	2
Dioxin	5C1biii	0	0	0	0
Dioxin	5C1biv	2	14	0	0
Dioxin	5C2	0	6	0	2
Dioxin	5E	0	8	0	0
HCB	5C1biii	0	1	0	0
Hg	5C1bv	0	6	0	3
PMio	5C2	0	0	0	0
PMio	5E	0	6	0	3
$PM_{2.5}$	5C2	0	0	0	0

Note: Only the key categories where notation keys were reported are considered.

Open burning of waste (category 5C2) is the most important subcategory with regard to BC emissions. Spain contributes 73% of total BC emissions reported by the EU-27 in the waste category for the year 2021 and is also the major contributor in previous years.

Table 4.13 presents the number of EU Member States reporting the notation keys ‘NA’, ‘NO’, ‘NR’ and ‘NE’ within the key categories. Table 4.14 shows the recalculations within the waste sector group. For explanations of EU recalculations, see Section 5.1.

Table 4.14 (a) Relative difference (relative data, percentage of EU national totals) and (b) absolute difference between reported emissions when comparing the EU’s 2022 and 2023 submissions for the waste sector group

(a)

Relative difference																				
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	2%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%	2%	19%
NMVOCs	6%	4%	3%	1%	1%	0%	0%	1%	2%	4%	4%	4%	6%	4%	5%	4%	5%	5%	8%
SOx	2%	2%	3%	3%	3%	3%	3%	3%	3%	4%	4%	3%	3%	1%	3%	2%	3%	2%	11%
NH_3	-21%	-18%	-16%	-9%	-8%	-6%	-5%	-3%	-3%	1%	-2%	-3%	-3%	-2%	-1%	-1%	-1%	-2%	-1%
TSPs	6%	6%	6%	7%	6%	6%	6%	7%	7%	7%	9%	7%	10%	7%	6%	6%	5%	7%	16%
CO	7%	8%	5%	6%	5%	5%	5%	5%	5%	5%	7%	5%	8%	5%	5%	5%	4%	6%	22%
Pb	0%	3%	11%	11%	13%	28%	28%	19%	20%	22%	30%	17%	18%	17%	19%	11%	21%	16%	33%
Cd	7%	18%	44%	39%	41%	82%	76%	57%	66%	65%	86%	49%	55%	50%	59%	57%	53%	52%	63%
Hg	-7%	-8%	-11%	-8%	-3%	1%	3%	-2%	1%	4%	7%	4%	1%	2%	3%	0%	4%	1%	3%
As	4%	10%	17%	11%	10%	23%	22%	15%	16%	16%	20%	12%	13%	13%	13%	14%	13%	12%	17%
Cr	2%	13%	35%	24%	25%	59%	60%	45%	50%	56%	69%	45%	44%	46%	50%	53%	49%	43%	44%
Cu	4%	12%	32%	30%	37%	80%	77%	54%	61%	62%	81%	46%	48%	46%	53%	56%	46%	46%	61%
Ni	1%	4%	13%	17%	27%	59%	64%	46%	121%	145%	137%	101%	87%	81%	86%	112%	101%	112%	92%
Se	2%	4%	4%	4%	3%	4%	5%	3%	3%	4%	4%	2%	3%	3%	3%	3%	2%	4%	20%
Zn	0%	1%	2%	1%	1%	2%	3%	2%	2%	2%	2%	1%	1%	1%	1%	1%	1%	1%	15%
PCDD/Fs	4%	11%	19%	13%	16%	68%	64%	-27%	52%	54%	67%	43%	47%	45%	52%	51%	43%	39%	51%
B(a)P	17%	13%	14%	15%	15%	15%	14%	17%	19%	20%	20%	20%	23%	18%	7%	15%	16%	18%	15%
B(b)F	12%	12%	12%	12%	12%	12%	11%	12%	13%	14%	14%	14%	15%	13%	7%	11%	12%	13%	11%
B(k)F	5%	5%	6%	5%	5%	5%	5%	5%	6%	6%	6%	6%	6%	5%	3%	5%	5%	6%	6%
IP	36%	35%	36%	37%	38%	39%	37%	46%	49%	53%	55%	57%	65%	50%	11%	41%	42%	46%	34%
Total PAHs	35%	36%	37%	37%	37%	38%	34%	36%	39%	40%	40%	39%	40%	37%	16%	35%	34%	38%	35%
HCB	0%	0%	4%	2%	-1%	-1%	-4%	-8%	-4%	6%	6%	7%	9%	10%	14%	4%	25%	7%	11%
PCBs	3%	3%	0%	0%	0%	0%	0%	-1%	-1%	0%	0%	0%	1%	1%	1%	1%	1%	1%	-4%
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			6%	7%	6%	6%	6%	7%	7%	7%	9%	7%	10%	7%	7%	6%	5%	11%	16%
PM_{10}			6%	7%	6%	6%	6%	7%	7%	7%	9%	7%	10%	7%	6%	6%	5%	7%	17%
BC			4%	5%	4%	5%	5%	6%	6%	6%	8%	6%	9%	6%	5%	5%	4%	8%	24%

(b)

Absolute difference																				
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	12
NMVOCs	6	4	3	1	1	0	0	1	2	3	3	4	5	4	4	4	4	4	6
SOx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH_3	-16	-13	-10	-5	-4	-3	-2	-1	-1	1	-1	-1	-2	-1	-1	0	0	-1	-1
TSPs	6	6	6	6	6	6	6	7	7	7	8	8	8	7	7	6	6	6	15
CO	44	42	42	40	40	40	39	45	45	47	48	49	55	45	45	41	43	46	179
Pb	0	1	3	2	2	5	5	3	3	3	4	3	2	2	3	2	3	2	5
Cd	0	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Hg	-1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cu	1	1	3	2	2	4	4	3	3	3	3	2	2	2	2	2	2	2	2
Ni	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0
Se	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	1	3	5	3	4	7	7	5	5	5	5	4	3	3	4	3	4	3	40
PCDD/Fs	82	186	322	161	184	418	401	-321	276	288	334	221	215	222	239	238	227	193	248
B(a)P	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
B(b)F	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	1	0
B(k)F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total PAHs	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3
HCB	0	0	2	0	0	0	0	-1	0	0	0	1	1	1	1	0	2	0	1
PCBs	5	6	0	0	0	0	-1	-1	-1	0	0	0	0	0	1	1	1	0	-3
			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$			5	6	5	6	5	6	6	7	7	7	8	6	6	5	6	10	14
PM_{10}			6	6	6	6	6	7	7	7	7	7	8	7	6	5	6	6	15
BC			1	1	1	1	1	2	2	2	2	2	3	2	2	2	2	3	8

Note: As, arsenic; B(b)F, benzo(b)fluoranthene; B(k)F, benzo(k)fluoranthene; Cr, chromium; Cu, copper; IP, indeno(1,2,3-cd)pyrene; Ni, nickel; Se, selenium; TSP, total suspended particulate; Zn, zinc.

5. Recalculations and implemented or planned improvements

5.1 Recalculations

Recalculations are changes made to previous emission estimates (for one or more years) to eliminate errors, consider additional factors and incorporate new data. The inventory guidebook (EMEP/EEA, 2019) stipulates that it is good practice to change or refine data and/or methods when:

- available data have changed;
- the method previously used is not consistent with good practice for a certain category;
- an emission source category has become a key category;
- the method previously used does not reflect mitigation activities transparently;
- the capacity (resources) for inventory preparation has increased;
- new inventory methods become available;
- the correction of errors is necessary.

It is important to identify inventory recalculations and to understand their origin in order to evaluate officially reported emission data properly. EU Member States often do not document why they report numbers that differ from those of the previous year.

5.1.1 Recalculations of the EU inventory

Table 5.1 compares total emissions from the EU submitted in 2022 with those submitted in 2023.

Details of recalculations that influenced the EU recalculations are given below. In some cases, recalculations reflect changes in gap filling (see also Section 1.4.5) rather than ‘true’ recalculations by the countries themselves. Often, high recalculations for EU Member States are compensated for by low recalculations for other EU Member States, and therefore overall EU recalculations are only moderate.

Recalculations of nitrogen oxide emissions
Figure 5.1 shows the recalculations for nitrogen oxide (NO_X) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 2020, recalculations of NO_X emissions for the EU-27 add up to an increase of 1.5% (83kt).

High recalculations occur mainly in the agriculture sector in France (categories 3Da1, 3Da2a and 3Da3). Other sectors influencing the EU recalculations for NO_X are road transport in France (1A3di(i)), Germany (1A3bi, 1A3biii) and Italy (1A3biii), non-road transport (Spain: 1A3dii, 1A4ciii; Italy: 1A3dii), energy use in industry in the Netherlands (1A2gvii) and commercial, institutional and households in Poland (1A4bi).

Table 5.1 Comparison of data submitted in 2022 and 2023 by EU Member States: (a) relative difference, percentage of EU national total and (b) absolute data

(a)

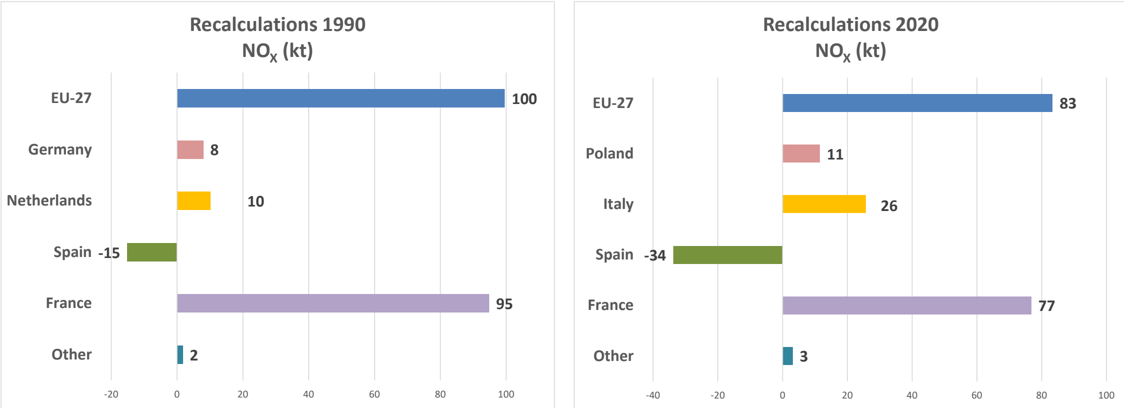
Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	Gg	1 %	0.4 %	0 %	0.6 %	1 %	1.5 %	1.5 %	1.6 %	1.9 %	1.9 %	1.8 %	2 %	1 %	0.8 %	2 %
NMVOCs	Gg	0.5 %	0.2 %	1 %	2 %	3 %	3 %	3 %	3 %	3 %	2.7 %	2.6 %	2.8 %	3.4 %	3 %	4 %
SO_x	Gg	-0.4 %	-0.4 %	-1 %	-1 %	-1 %	-1 %	-1 %	-2 %	-2 %	-2 %	-3 %	-3 %	-3 %	-3 %	-3 %
NH_3	Gg	0.7 %	2 %	2 %	1 %	0.3 %	1 %	1 %	0.3 %	0.3 %	0.1 %	-0.03 %	-0.1 %	-0.1 %	-0.5 %	-0.7 %
TSPs	Gg			6 %	9 %	12 %	15 %	7 %	7 %	6 %	8 %	6 %	7 %	13 %	9 %	10 %
CO	Gg	0.2 %	-0.1 %	0.3 %	1 %	2 %	2 %	2 %	2 %	3 %	2 %	3 %	3 %	4 %	4 %	5 %
Pb	Mg	0.3 %	0.5 %	2 %	5 %	6 %	7 %	7 %	7 %	8 %	8 %	9 %	9 %	9 %	10 %	10 %
Cd	Mg	0.1 %	0 %	1 %	0 %	1 %	1 %	1 %	0.6 %	1 %	1 %	1 %	0.8 %	3.9 %	4 %	3 %
Hg	Mg	-0.9 %	-0.8 %	-1 %	-0.4 %	-0.1 %	-0.2 %	0.03 %	-0.2 %	-0.4 %	-0.03 %	-0.01 %	-0.2 %	0.1 %	0.3 %	0.02 %
As	Mg	0 %	0 %	1 %	2 %	2 %	2 %	2 %	2 %	2 %	2 %	2 %	2 %	2 %	2 %	3 %
Cr	Mg	2 %	2.9 %	5 %	8 %	10 %	10 %	10 %	10 %	11 %	11 %	11 %	11 %	12 %	13 %	13 %
Cu	Mg	20 %	25 %	29 %	36 %	40 %	41 %	39 %	39 %	41 %	40 %	40 %	40 %	41 %	42 %	40 %
Ni	Mg	1 %	1 %	1 %	1 %	2 %	1 %	2 %	1 %	2 %	1 %	1 %	1 %	2 %	1 %	2 %
Se	Mg	0.3 %	0.4 %	1 %	1 %	1 %	0.02 %	-0.2 %	-0.4 %	-0.4 %	-0.2 %	-1 %	-1 %	-1 %	-0.4 %	0.02 %
Zn	Mg	2 %	2 %	4 %	6 %	6 %	6 %	6 %	6 %	6 %	6 %	6 %	6 %	8 %	8 %	9 %
PCDD/Fs	g I-Teq	1 %	3 %	7 %	4 %	11 %	13 %	15 %	10 %	10 %	10 %	11 %	11 %	14 %	13 %	15 %
B(a)P	Mg	-0.3 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-3 %	-2 %	-2 %	3 %	3 %	1 %
B(b)F	Mg	-0.2 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-2 %	-2 %	-2 %	5 %	5 %	2 %
B(k)F	Mg	1 %	-1 %	-0.7 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-2 %	-2 %	-3 %	6 %	6 %	3 %
IP	Mg	1 %	-0.4 %	-0.7 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-4 %	-3 %	-4 %	3 %	3 %	0 %
Total PAHs	Mg	-0.3 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-1 %	-3 %	-2 %	-3 %	4 %	4 %	2 %
HCB	kg	-5 %	-4 %	-4 %	-36 %	-1 %	-0.1 %	-0.4 %	-0.4 %	-0.3 %	-0.8 %	0.01 %	-1 %	2 %	-0.4 %	-10 %
PCBs	kg	46 %	54.2 %	63.4 %	62.0 %	38.0 %	38.7 %	38.2 %	42 %	42 %	39 %	39 %	37 %	36 %	35 %	34 %
				2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$	Gg			3 %	5 %	7 %	6 %	6 %	6 %	6 %	5 %	5 %	5 %	12 %	11 %	10 %
PM_{10}	Gg			4 %	7 %	10 %	11 %	7 %	8 %	7 %	8 %	7 %	7 %	14 %	11 %	11 %
BC	Gg			-86 %	-89 %	2 %	1 %	2 %	4 %	5 %	3 %	4 %	4 %	3 %	6 %	9 %

(b)

Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NO_x	Gg	100	56	55	61	116	126	117	120	136	138	127	121	78	50	83
NMVOCs	Gg	72	22	97	186	260	212	208	203	190	179	170	185	218	186	252
SO_x	Gg	-84	-57	-70	-69	-30	-32	-43	-47	-45	-37	-60	-66	-55	-49	-50
NH_3	Gg	36	69	64	34	9	24	19	11	12	4	-1	-3	-4	-17	-23
TSPs	Gg			275	372	476	556	269	261	198	287	208	233	459	306	311
CO	Gg	99	-51	93	400	535	391	415	435	490	464	532	514	812	738	767
Pb	Mg	54	43	61	80	90	89	77	80	84	88	89	90	95	95	88
Cd	Mg	0.2	0.5	1	0.4	1	1	1	0.4	0.5	0.5	1	0.5	2	2	2
Hg	Mg	-1	-1	-1	-0.3	0.0	-0.1	0.0	-0.1	-0.2	-0.01	-0.004	-0.1	0.1	0.1	0.01
As	Mg	1	1	1	2	2	2	2	1	1	2	1	1	1	1	1
Cr	Mg	17	19	23	32	35	34	32	31	33	33	33	33	38	37	33
Cu	Mg	380	427	489	650	702	704	662	644	695	699	694	707	728	731	623
Ni	Mg	27	18	14	16	11	7	11	6	8	6	4	3	7	5	6
Se	Mg	1	1	1	1	1	0.0	-0.2	-0.4	-0.4	-0.2	-1	-1	-1	-0.4	0.01
Zn	Mg	111	121	147	201	216	208	198	193	199	207	206	209	279	274	271
PCDD/Fs	g I-Teq	76	177	312	144	257	274	320	212	203	211	214	213	270	237	269
B(a)P	Mg	-1	-2	-2	-2	-2	-2	-2	-2	-3	-7	-6	-6	8	7	1
B(b)F	Mg	-1	-3	-3	-3	-3	-3	-3	-3	-3	-6	-6	-6	13	11	5
B(k)F	Mg	2	-1	-1	-1	-1	-1	-1	-1	-1	-3	-3	-3	8	7	3
IP	Mg	1	-1	-1	-1	-1	-1	-1	-1	-2	-5	-5	-5	4	3	0.4
Total PAHs	Mg	-5	-14	-12	-11	-9	-9	-9	-7	-10	-22	-21	-22	32	28	11
HCB	kg	-323	-147	-175	-133	-1	-0.3	-1	-1	-1	-2	0.02	-3	3	-1	-13
PCBs	kg	2,160	2,174	2,007	1,388	672	634	597	603	583	541	529	503	474	445	411
				2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$PM_{2.5}$	Gg			56	93	117	95	95	99	79	72	69	63	154	141	122
PM_{10}	Gg			119	190	237	248	165	170	141	162	133	135	268	211	201
BC	Gg			-2,038	-2,521	7	4	5	10	10	7	9	8	5	10	16

Note: As, arsenic; B(a)P, benzo(b)pyrene; B(b)F, benzo(b)fluoranthene; BC, black carbon; B(k)F, benzo(k)fluoranthene; Cd, cadmium; CO, carbon monoxides; Cr, chromium; Cu, copper; HCB, hexachlorobenzene; Hg, mercury; IP, indeno(1,2,3-cd)pyrene; NH_3, ammonia; Ni, nickel; NMVOC, non-methane volatile organic compound; NO_X, nitrogen oxides; PAH, polycyclic aromatic hydrocarbon; Pb, lead; PCB, polychlorinated biphenyl; PCDD/F, polychlorinated dibenzodioxin/dibenzofuran; $PM_{2.5}$, particulate matter with a diameter of 2.5µm or less; PM_{10}, particulate matter with a diameter of 10µm or less; Se, selenium; SO_X, sulphur oxides; TSP, total suspended particulate; Zn, zinc.

Figure 5.1 Recalculations for NO_x emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

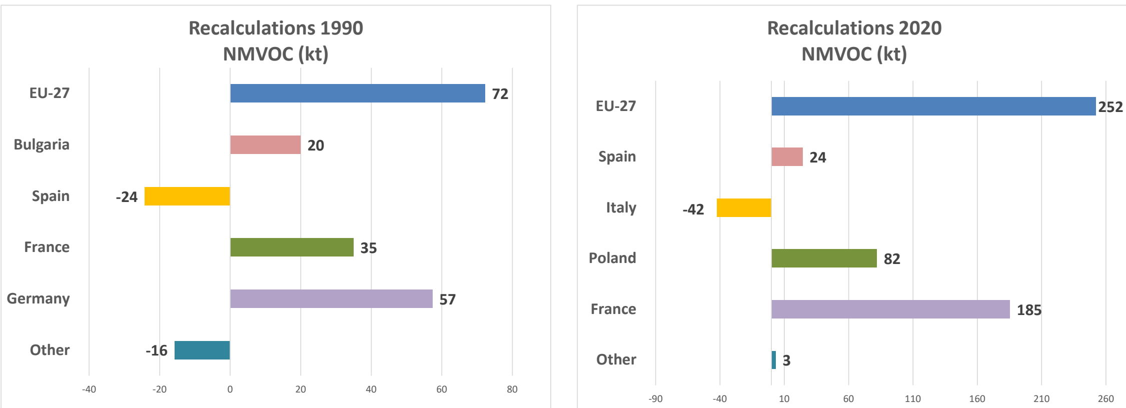
Recalculations of non-methane volatile organic compound emissions

Figure 5.2 shows the recalculations for non-methane volatile organic compound (NMVOC) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 2020, recalculations of NMVOC emissions for the EU-27 add up to an increase of 4% (252kt), while recalculations for the year 1990 result in an increase of 0.5% (72kt) in total NMVOC emissions.

In the road transport sector, high recalculations occur in Germany (categories 1A3bi and 1A3bv) and Italy (1A3bi). Major recalculations were performed in the industrial processes and product use sector in France (2D3a, 2D3g, 2D3i), Spain (2D3e, 2D3a), Poland (2D3a, 2H2) and Italy (2D3d). Spain (1A4bi), France (1A4bi, 1A5b), Poland (1A4bi) and Bulgaria (1A4cii) also performed high recalculations in the commercial, institutional and households sector. In addition, France (3B1b) and Spain (3Da2a) reported high recalculations in the agriculture sector, and Bulgaria also recalculated NMVOC emissions in the waste sector (5D1).

Figure 5.2 Recalculations for NMVOC emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

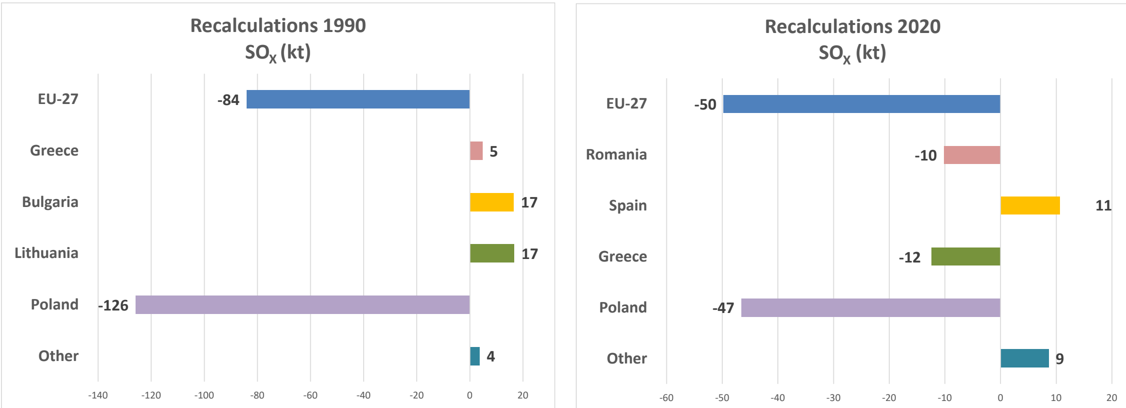
Recalculations of sulphur oxide emissions

Figure 5.3 shows the recalculations for sulphur oxide (SO_X) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990 and 2020, recalculations of SO_X emissions for the EU-27 add up to decreases of 0.4% and 3.4%, respectively.

Recalculations of SO_X emissions in the EU are mainly influenced by major recalculations in the energy production and distribution sector in Poland (category 1A1a) and Bulgaria (1A1b) and the energy use in industry sector in Poland (1A2c), Romania (1A2f) and Spain (1A2a). In addition, recalculations of SO_X emissions in the non-road transport sector in Greece (1A3dii) and commercial, institutional and households sector in Bulgaria and Lithuania (both 1A4ai) contributed to the EU recalculations.

Figure 5.3 Recalculations for SO_X emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

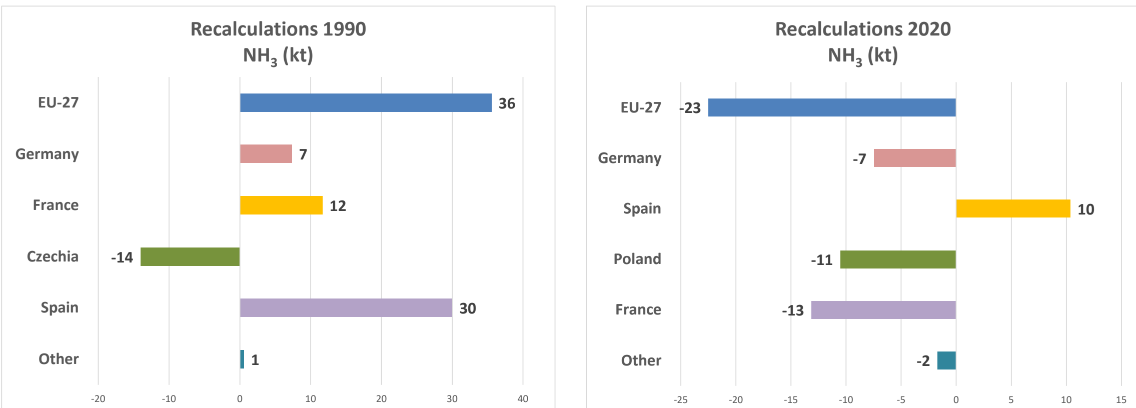
Recalculations of ammonia emissions

Figure 5.4 shows the recalculations for ammonia (NH_3) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990, recalculations of NH_3 emissions for the EU-27 add up to an increase of 0.7% (36kt) and in 2020 to a decrease of 0.7% (23kt).

Significant recalculations of NH_3 emissions were made by all Member States, mainly in the sector 'Agriculture'.

Figure 5.4 Recalculations for NH_3 emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

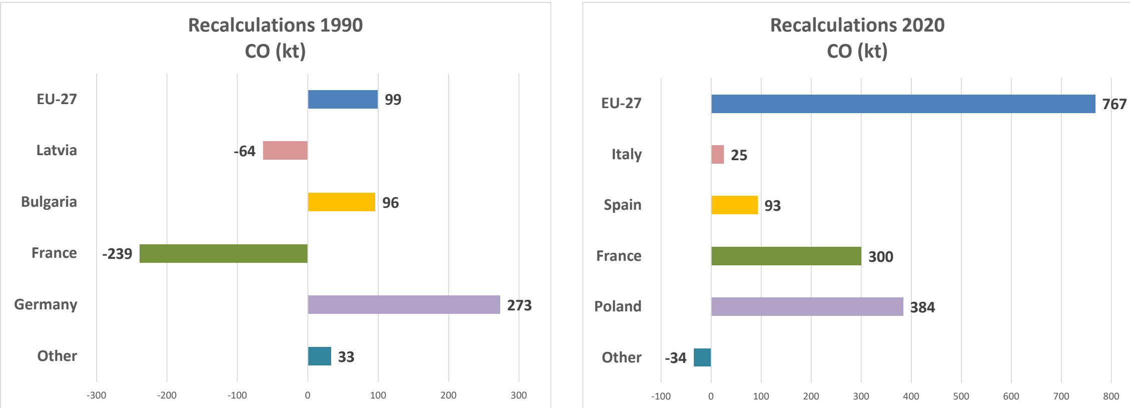
Recalculations of carbon monoxide emissions

Figure 5.5 shows the recalculations for carbon monoxide (CO) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990 and 2020, recalculations of CO emissions for the EU-27 add up to an increase of 0.2% (99kt) and 4.7% (767kt), respectively.

Major recalculations of CO emissions were reported for the road transport sector in Latvia, Bulgaria, Germany, Italy (all category 1A3bi) and France (1A3bii) and the non-road transport sector (France - 1A3dii). In addition, recalculations for the commercial, institutional and households sector were performed in Bulgaria (1A4cii), France (1A4bi, 1A5b), Spain and Poland (both 1A4bi). Spain also substantially recalculated emissions from open burning of waste (5C2).

Figure 5.5 Recalculations for CO emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

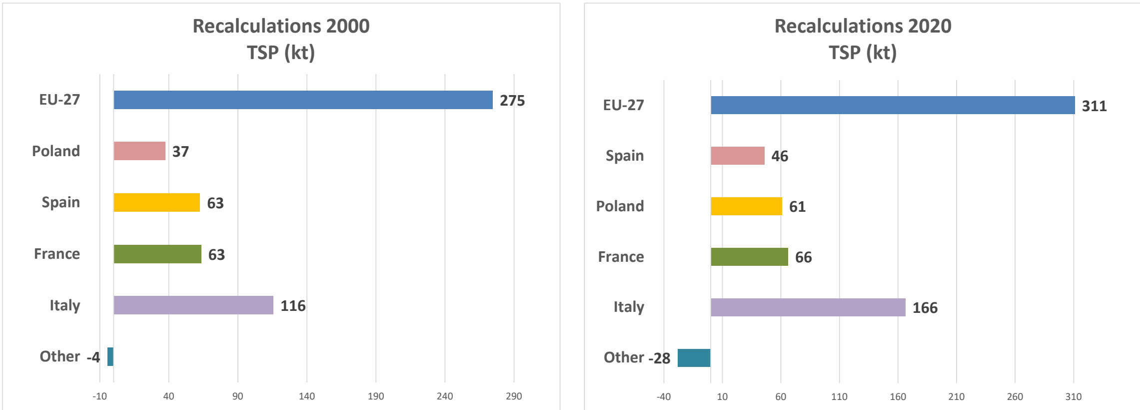
Recalculations of total suspended particle emissions

Figure 5.6 shows the recalculations for total suspended particulate (TSP) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 2000 and 2020.

In 2000 and 2020, recalculations of TSP emissions for the EU-27 add up to increases of 6% (275kt) and 10% (311kt), respectively.

Recalculations in the industrial processes and product use sector in Italy and Spain (both category 2A5b) had the biggest impact on the EU recalculations of TSP emissions in both 1990 and 2020. In addition, major recalculations were reported in the energy production and distribution sector (Poland: 1A1a), agriculture sector (Spain: 3Dc) and commercial, institutional and households sector (France and Poland both in 1A4bi).

Figure 5.6 Recalculations for TSP emissions for the years 2000 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

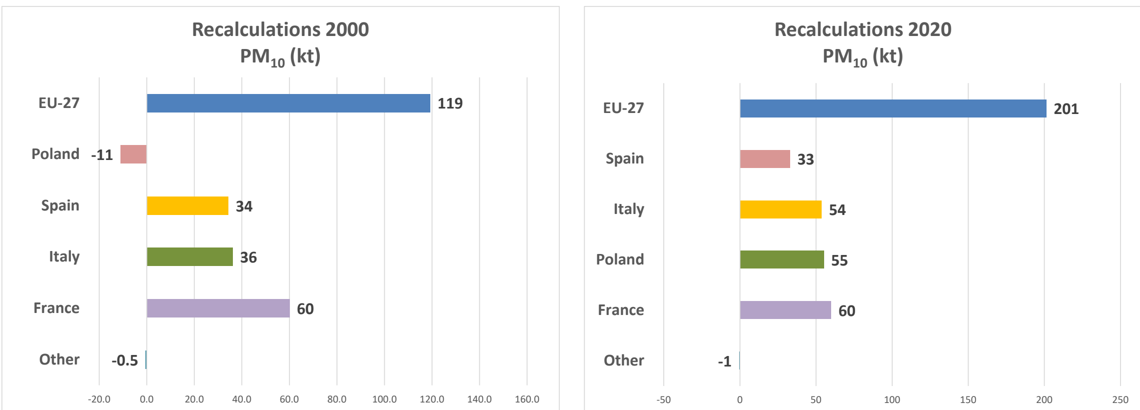
Recalculations for PM_{10} emissions

Figure 5.7 shows the recalculations for emissions of particulate matter with a diameter of 10µm or less (PM_{10}) for the EU-27 and the four biggest contributors to these recalculations for the years 2000 and 2020.

In 2000 and 2020, recalculations of PM_{10} emissions for the EU-27 add up to increases of 4% (119kt) and 11% (201kt), respectively.

These increases are mainly dominated by recalculations performed in Italy in the sector industrial processes and product use (category 2A5b). Other sectors affected by major recalculations are energy production and distribution (Poland: 1A1a), commercial, institutional and households (Poland, Spain and France: all 1A4bi), agriculture (Spain: 3Dc) and waste (Spain: 5C2).

Figure 5.7 Recalculations of PM_{10} emissions for the years 2000 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

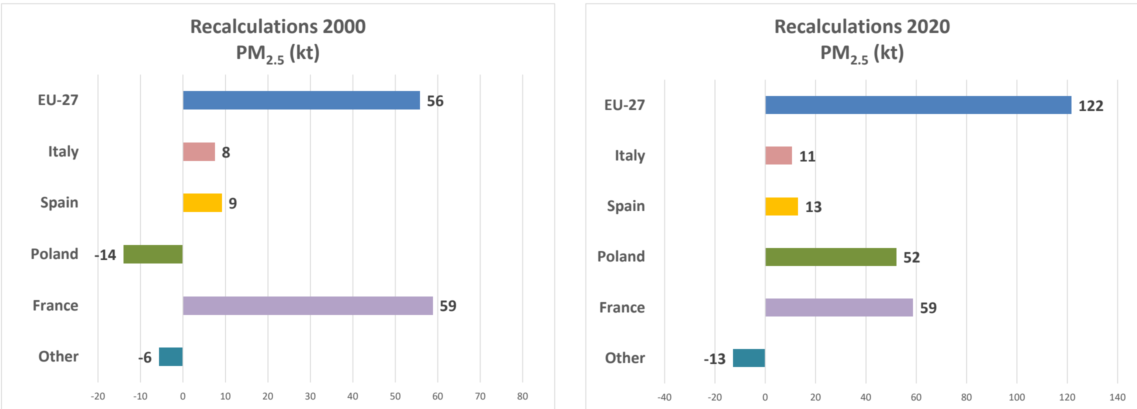
Recalculations of $PM_{2.5}$ emissions

Figure 5.8 shows the recalculations for emissions of particulate matter with a diameter of 2.5µm or less ($PM_{2.5}$) for the EU-27 and the four biggest contributors to these recalculations for the years 2000 and 2020.

In 2000 and 2020, recalculations of $PM_{2.5}$ emissions for the EU-27 led to increases of 3% (56kt) and 10% (122kt), respectively.

As for TSP and PM_{10} emissions, the increase in $PM_{2.5}$ emissions is mainly dominated by recalculations performed in the sectors commercial, institutional and households (France, Poland and Spain: category 1A4bi), energy production and distribution (Poland: 1A1a), industrial processes and product use (Italy: 2A5b) and waste (Spain: 5C2).

Figure 5.8 Recalculations for $PM_{2.5}$ emissions for the years 2000 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

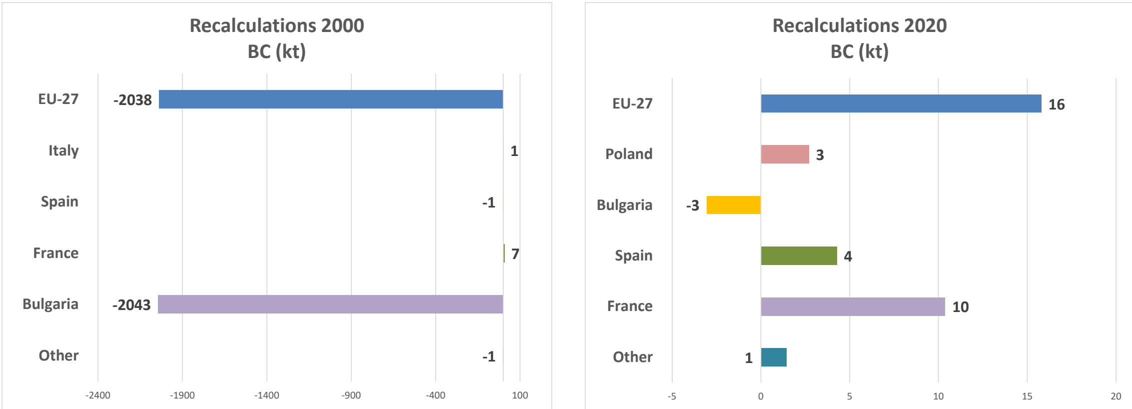
Recalculations of black carbon emissions

Figure 5.9 shows the recalculations for black carbon (BC) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 2000 and 2020.

In 2000 and 2020, recalculations of BC emissions for the EU-27 led to a decreases of 86% (2,038kt) and 9% (16kt), respectively.

Major recalculations of BC emissions were performed by Bulgaria in sector 'Industrial processes and product use' (2D3c). Additionally, recalculations of BC emissions mainly occurred in the sector 'Commercial, institutional and households' in category 1A4bi in Spain, France and Poland, road transport (Italy: 1A3bvi) and waste (Spain and France: both 5C2).

Figure 5.9 Recalculations for BC emissions for the years 2000 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the impact on recalculations from all other Member States.

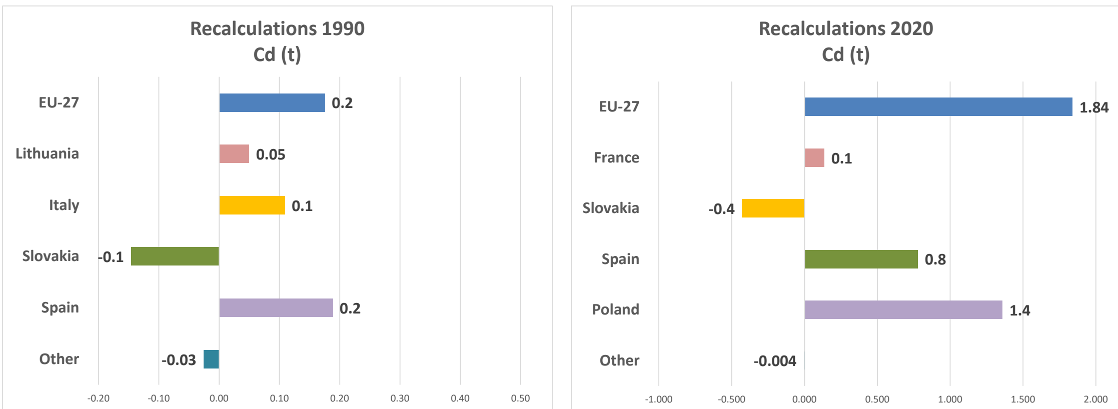
Recalculations of cadmium emissions

Figure 5.10 shows the recalculations for cadmium (Cd) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990 and 2020, recalculations of Cd emissions for the EU-27 add up to increases of 0.1% (0.2t) and 3% (1.84t), respectively.

Recalculations of Cd emissions were performed in sectors 'Energy production and distribution' (Lithuania: 1A1a), 'Energy use in industry' (Slovakia: 1A2d), 'Road transport' (Italy: 1A3bvi), 'Commercial, institutional and households' (France and Poland: 1A4bi), 'Industrial processes and product use' (Lithuania: 2D3i) and 'Waste' (Spain: 5C1biv, 5C2).

Figure 5.10 Recalculations for Cd emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

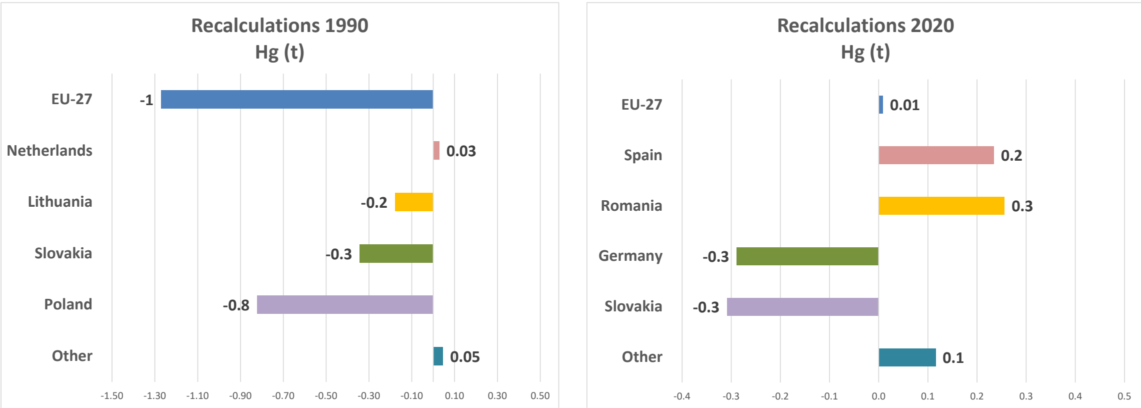
Recalculations of mercury emissions

Figure 5.11 shows the recalculations for mercury (Hg) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990 and 2020, recalculations of Hg emissions for the EU-27 add up to a decrease of 1% (1t) in 1990 and an increase of 0.02% (0.01t) in 2021.

Major recalculations of Hg emissions were performed in sectors 'Energy production and distribution' (Slovakia: categories 1A1c, 1A1a; Germany: 1A1a), 'Energy use in industry' (Spain: 1A2a; Lithuania and Romania: both 1A2f) and 'Waste' (the Netherlands: 5C1bv; Poland: 5C1biii; Spain: 5C1biv).

Figure 5.11 Recalculations for Hg emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

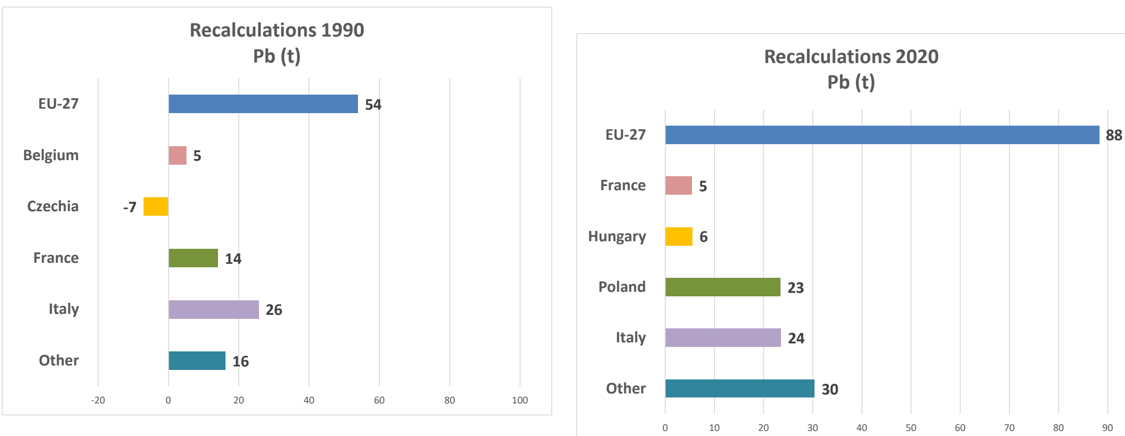
Recalculations of lead emissions

Figure 5.12 shows the recalculations for lead (Pb) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990 and 2021, recalculations of Pb emissions for the EU-27 add up to an increaseof 0.3% (54t) and and 10% (88t), respectively.

Recalculations of Pb emissions in the EU were dominated by recalculations in sectors 'Road transport' (France:category 1A3bi; Belgium, Italy, Hungary and Poland: all 1A3bvi), 'Non-road transport' (Czechia: 1A3ai(i); France: 1A3dii) and 'Commercial, institutional and households' (France: 1A4bi).

Figure 5.12 Recalculations for Pb emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

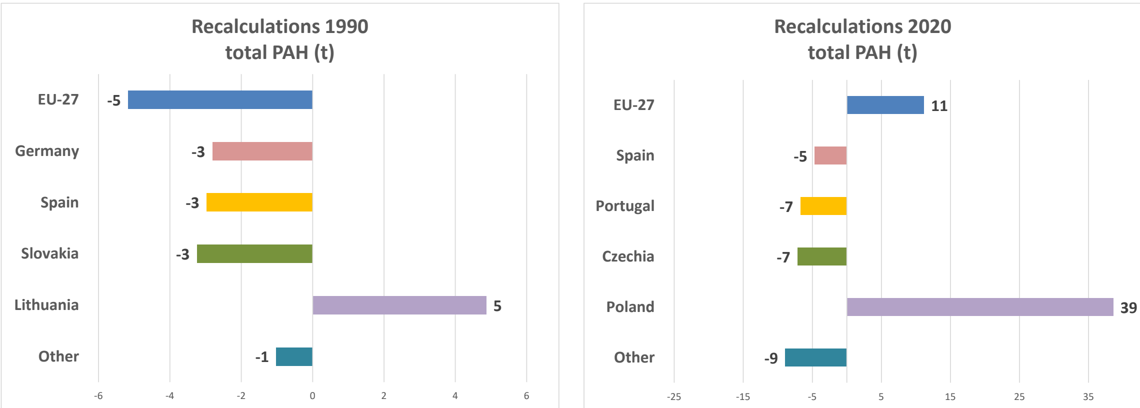
Recalculations of total polycyclic aromatic hydrocarbon emissions

Figure 5.13 shows the recalculations for total polycyclic aromatic hydrocarbon (PAH) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990, recalculations of total PAH emissions for the EU-27 add up to a decrease of 0.3% (5t) and in 2020 to an increase of 2% (11t).

Significant recalculations of total PAH emissions were reported in the sectors ‘Energy production and distribution’ (Germany and Lithuania: category 1A1a), ‘Energy use in industry’ (Slovakia: 1A2a, 1A2d), ‘Commercial, institutional and households’ (Lithuania: 1A4ai; Spain, Czechia and Poland: all 1A4bi) and ‘Industrial processes and product use’ (Portugal: 2D3i).

Figure 5.13 Recalculations for PAH emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. ‘Other’ is the sum of the recalculations from all other Member States.

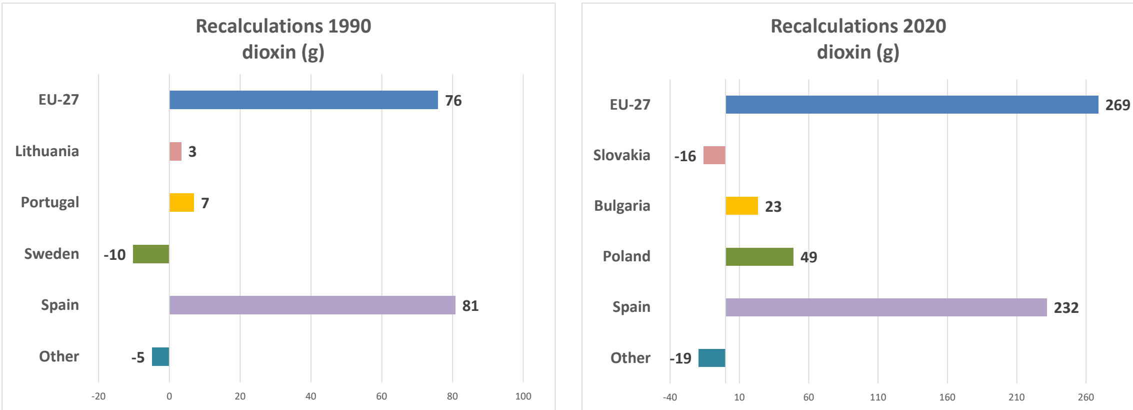
Recalculations of dioxin emissions

Figure 5.14 shows the recalculations for dioxin emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990 and 2020, recalculations of dioxin emissions for the EU-27 add up to increases of 1% (76g) and 15% (269g), respectively.

Recalculations in the sector ‘Waste’ (Spain and Slovakia: both category 5C1biv; Bulgaria: 5C1bi; Portugal: 5E) had the biggest impact on EU recalculations of dioxins. In addition, significant recalculations were performed in sectors ‘Energy production and distribution’ (Sweden: 1A1a), ‘Energy use in industry’ (Sweden: 1A2d) and ‘Commercial, institutional and households’ (Lithuania: 1A4ai; Poland: 1A4bi).

Figure 5.14 Recalculations for dioxin emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

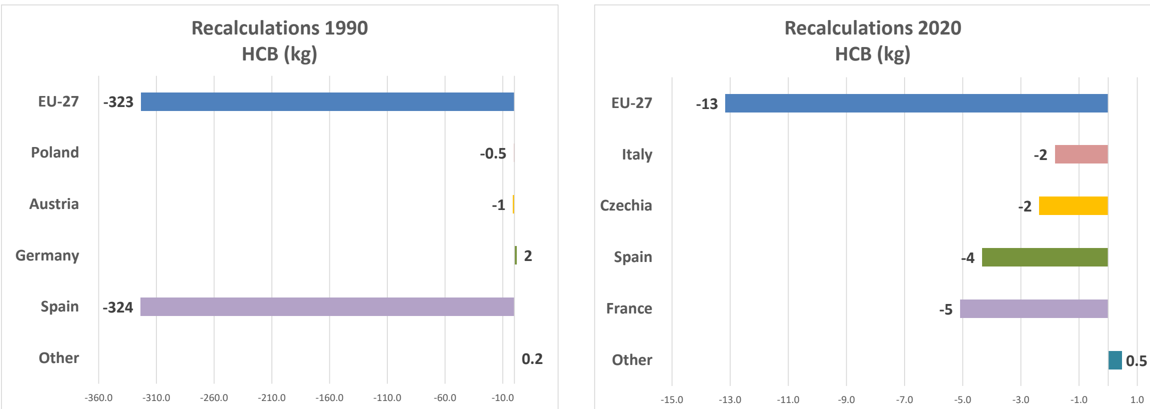
Recalculations of hexachlorobenzene emissions

Figure 5.15 shows the recalculations for hexachlorobenzene (HCB) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990 and 2020, recalculations of HCB emissions for the EU-27 add up to decreases of 5% (323kg) and 10% (13kg), respectively.

Significant recalculations of HCB emissions were performed mainly in the sectors 'Commercial, institutional and households' (Austria and Czechia: both category 1A4bi), 'Industrial processes and product use' (Spain: 2B10a) and 'Agriculture' (Germany, Lithuania, Spain, Italy and France: all 3Df).

Figure 5.15 Recalculations for HCB emissions for the years 1990 and 2020



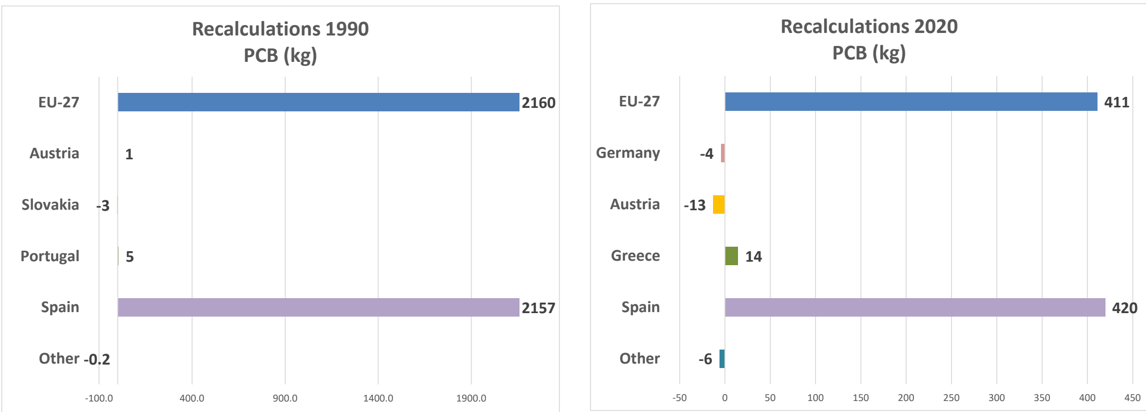
Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

Recalculations of polychlorinated biphenyl emissions
Figure 5.16 shows the recalculations for polychlorinated biphenyl (PCB) emissions for the EU-27 and the four biggest contributors to these recalculations for the years 1990 and 2020.

In 1990 and 2020, recalculations of PCB emissions for the EU-27 add up to increases of 46% (2,160kg) and 34% (411kg), respectively.

Recalculations of PCB emissions at the EU level are dominated by recalculations performed in the sector 'Industrial processes and product use' (Spain: category 2K; Austria: 2C1; Greece: 2C5). In addition, recalculations in sectors 'Energy production and distribution' (Germany: 1A1a), 'Energy use in industry' (Slovakia: 1A2a, 1A2d) and 'Waste' (Portugal: 5C1bi) were significant.

Figure 5.16 Recalculations for PCB emissions for the years 1990 and 2020



Note: The figure shows recalculations for the EU-27 and the four biggest contributors. 'Other' is the sum of the recalculations from all other Member States.

5.1.2 EU Member States' recalculations

Under the revised reporting guidelines (UNECE, 2022c), all countries should submit explanatory informative inventory reports (IIRs) that include details explaining any recalculations made. Some EU Member States provide very detailed explanations for their recalculations of parts of the time series or the whole time series (e.g. methodological improvements, revisions of emission factors, reallocations, revisions of activity data and corrections of errors).

Austria provided detailed information concerning its recalculations, which were carried out for several reasons, such as updated data and revised estimates. Detailed information is provided within Austria's IIR (see Austria's IIR, p. 478f, listed in Appendix 5).

Belgium provided detailed information on its recalculations for its individual regions (Brussels, Flanders and Wallonia) for the sectors energy, industrial processes and product use, agriculture, and waste. Among the main reasons for recalculations at the sectoral level were the application of emission factors from the inventory guidebook (EMEP/EEA, 2019), reallocation of emissions, error correction, updated and revised methodology and activity data, and the optimisation of models (see Belgium's IIR, p. 196f., listed in Appendix 5).

Bulgaria stated in its IIR that recalculations had been carried out for several sectors using emission factors from the guidebook, the revision of activity data, the introduction of updated models and information provided in the stage 3 review (see Bulgaria's IIR, p. 122, listed in Appendix 5).

Croatia did not provide a submission in 2023.

Cyprus stated that it had made some methodological improvements to its national emission inventory. The changes were made in response to previous recommendations from the Technical Expert Review Team (TERT) or technical corrections. This led to recalculations of the time series 1990-2020, aiming to improve the accuracy of the emission data. The main reason for the recalculations was the full implementation of the provisions of the new inventory guidebook (EMEP/EEA, 2019) and the implementation of the TERT's suggestions in 2017, 2018, 2019, 2020, 2021 and 2022 (see Cyprus's IIR, p. 167, listed in Appendix 5).

Czechia stated that recalculations were carried out, among other reasons, because of updated data (e.g. Eurocontrol fuel consumption for aviation), updated activity data, implementation of review recommendations and an update to Copert 5.5 (version 5.3 was previously used). More information about the recalculations is provided in Czechia's IIR (see Czechia's IIR, p. 113f., listed in Appendix 5).

Denmark provided detailed information on its recalculations within the sectoral chapters. The main reason for recalculation was an update of activity data (see Denmark's IIR, p. 466, listed in Appendix 5).

Estonia provided detailed information on its recalculations for the period 1990-2020. The reasons for the recalculations were updated activity data, an update to the Copert 5 programme, a change in emission factors and error corrections (see Estonia's IIR, p. 282, listed in Appendix 5).

Finland provided detailed information on its recalculations, which were carried out for several reasons. Most of the recalculations are due to the updating of statistical data and in some cases the application of new emission factors, allocation of emissions and error corrections (see Finland's IIR, 1B_General, p. 4, listed in Appendix 5).

France stated that recalculations were due to the updating of activity data, methodological improvements, correction of errors, implementation of recommendations from reviews, the availability of new information and a new methodology (see France's IIR, p. 586f, listed in Appendix 5).

Greece reported that all emissions were recalculated on account of changes in or refinements of methods, inclusion of new sources, re-allocation, updated activity data and correction of errors (see Greece's IIR, p. 148, listed in Appendix 5).

Hungary provided information on recalculations in the sector-specific chapters. These were mainly carried out because of the availability of updated and new activity data, the use of the new Copert 5 model, error corrections and changes in methodology (see Hungary's IIR, listed in Appendix 5).

Ireland provided information on recalculations in the sector-specific chapters. Among other reasons, recalculations were carried out because of the updating of emission factors to the most recent version of the inventory guidebook (EMEP/EEA, 2019), the availability of updated and revised activity data and reallocation of emissions (see Ireland's IIR, listed in Appendix 5).

Italy stated in its IIR that recalculations were mainly due to changes in methodologies, the use of the new Copert 5 model, recommendations from the review process, different allocation of emissions, error corrections and new available information (see Italy's IIR, p. 197, listed in Appendix 5).

Latvia provided detailed information on recalculations in the sector-specific chapters. They were carried out because of error corrections, data improvement or methodology enhancement and implementation of annual inventory review recommendations (see Latvia's IIR, p. 8, listed in Appendix 5).

Luxembourg provided detailed information on the recalculations in the sector-specific chapters of the IIR. Main reasons for recalculations were the update of activity data and emission factors, the correction of errors, the identification of new emission sources, the shift to higher tier methodologies and the allocation of emissions recommendations (see Luxembourg's IIR, p. 477ff, listed in Appendix 5).

Malta did not provide an IIR in 2023.

The **Netherlands** provided detailed information on the recalculations carried out. The main reasons for these were the inclusion of updated/improved activity data, reallocation of emissions, updated emission factors and error corrections. Compared with the IIR 2022, several improvements in source allocation and emission factors used were implemented in the Pollutant Release and Transfer (PRTR) system (see Netherlands' IIR, p. 211, listed in Appendix 5).

Poland reported that recalculations were carried out mainly because of updated emission factors, updated activity data, verified methodologies, new emission sources not estimated previously, recommendations resulting from review under the United Nations Economic Commission for Europe (UNECE) Air Convention and an update to the latest version of the Copert 5 software (see Poland's IIR, p. 186f, listed in Appendix 5).

Portugal provided detailed information on its recalculations in the sector-specific chapters. Since the last submission, recalculations have been carried out because of revised data, updated activity data, error corrections and updated methodology (see Portugal's IIR, listed in Appendix 5).

Romania noted that, following the review of the emission inventory, recalculations of emissions were carried out based on updated emission factors, new and revised estimates and activity data, corrections of emission factors, the application of a higher tier method, reallocation of data and error corrections (see Romania's IIR, p. 341, listed in Appendix 5).

Slovakia provided detailed information and figures and tables on its recalculations. The main reasons were the update of Implied Emission Factor calculations for historical years, correction of activity data, implementation of higher tier methods and improved activity data and methodology (see Slovakia's IIR, p. 342f., listed in Appendix 5).

Slovenia provided detailed information on its recalculations, which were carried out because of the implementation of the methodology and emission factors from the new *EMEP/EEA air pollutant emission inventory guidebook — 2019* (EMEP/EEA, 2019), error corrections, first-time reporting of emissions, new activity data, the application of a higher tier method and an update to the latest version of Copert 5. Some of these recalculations were carried out following recommendations from the TERT (see Slovenia's IIR, p. 284f, listed in Appendix 5).

Spain provided very detailed information on its recalculations, with the main reasons for them being error correction, recommendations resulting from reviews, the use of new emission factors, the availability of new data, updated activity data and methodological improvements (see Spain's IIR, p. 435, listed in Appendix 5).

Sweden provided detailed information on its recalculations in the sector-specific chapters. Reasons for recalculations mentioned by Sweden include newly available sources, revised emission factors, the updating of the Handbook emission factors for road transport road emission model, error corrections, inclusion of new and updated activity data and improved methods (see Sweden's IIR, listed in Appendix 5).

The annual European Monitoring and Evaluation Programme (EMEP) inventory review report (EMEP, forthcoming) presents a summary of the individual recalculations reported by EU Member States. This yearly report will be available on the Centre on Emission Inventories and Projections (CEIP) website in July 2023 (EMEP CEIP, 2023c).

5.1.3 Changes in EU Member States' emission inventories due to improvements based on the review

In addition, EMEP CEIP has the task of reviewing the emission inventories submitted to help Parties improve their national inventories (EMEP CEIP, 2023b; EMEP, forthcoming). These yearly reviews should help EU Member States compile their individual emission estimates and submit their improved inventories together with their IIRs.

The stage 1 review — an automated test — is held every year to assess timeliness, completeness and format. The stage 2 review assesses recalculations, key category analysis (KCA), inventory comparison, trends and time series. Stage 3 is an in-depth review by experts nominated by the Parties.

5.1.4 Improvements planned at the EU level

The EEA and the European Topic Centre on Human Health and the Environment (ETC HE) have noted that the main future challenge for EU Member States remains improving the quality of data submissions in order to deliver more complete and more timely emission inventories to the Air Convention). Improvements cannot be implemented at the EU level alone; the EU Member States themselves must also develop and prioritise reliable and timely inventory reporting systems.

The EEA and ETC HE have identified the following challenges:

- **Further progress on the completeness of reporting**. Although clear progress has been made in recent years on making reporting complete, a full set of emission inventory data for air pollutants is still not available for all EU Member States, as noted earlier in this report. In addition, for certain pollutants (mainly particulate matter (PM) and heavy metals (HMs)), data could not be fully gap filled because some EU Member States had not reported emission values in any year; this is especially the case for pollutants for which reporting is not obligatory (see Figure 1.5 and Figure 1.6).

- **Updating of emissions data by EU Member States**, including for previous years. The ETC HE has also identified a problem with gap filling using data submitted several years ago. In a number of cases, because countries have not submitted corrected or updated data sets, the EU inventory unavoidably includes inconsistencies. Therefore, the quality of the EU's inventory will be enhanced if the consistency and completeness of EU Member States' submissions improve. Such improvements would help reliable trend analysis to inform policy. Since 2017, emission inventory reviews have been conducted for each MS inventory under the National Emission reduction Commitments (NEC) Directive (EU, 2016b). The results of the review of these processes should also improve the quality of the Air Convention submissions.

- **Review of the current gap-filling procedures to ensure that they use the best approach**, reflecting real emissions. Although the improved inventory gap-filling procedure carried out since 2011 has helped to develop a more complete EU emission inventory, there is still room for improvement (e.g. by including manual changes in the procedure).

- **Reducing the need for gap filling**. This is achievable if the EU Member States report complete time series as far as possible, and if they have already provided the data in earlier submissions under the Air Convention. Current gap-filling procedures first use submissions received in the current reporting years under various reporting mechanisms and then use older Air Convention submissions. However, because of the yearly inventory review under the NEC Directive, it is expected that the completeness of submissions (under the NEC Directive and Air Convention) will improve.

- **More explanatory information on trends and recalculations**. This would be possible only if the MS IIRs included such information. Thus, countries are encouraged to provide it.

- **Further research on outliers in EU Member States' emission data to ensure that they reflect real emissions**. A comparison of Member States' contributions to the EU total reveals extraordinarily high or low proportions in some instances. Future investigation could determine whether these high proportions reflect actual emissions or are attributable to incomplete reporting (or underestimates) by other EU Member States.

- **More attention to data quality**. In several submissions from EU Member States and as a result of the automated gap-filling procedure, values of BC exceed $PM_{2.5}$ values, values of $PM_{2.5}$ exceed PM_{10} values, or values of PM_{10} exceed TSP values — all of which should be impossible. Adjustments in the gap-filling procedure and improved Member State emission data should resolve these problems.

5.2 Improvements implemented

The joint EMEP/EEA annual review of inventory data submitted under the Air Convention helps to improve the EU Member States' inventories. The review of data reported under the Air Convention is held in parallel to the review of data reported by the EU Member States under the NEC Directive ; they are nevertheless independent processes. Since 2009, there has been a centralised stage 3 review process under the Air Convention review process (EMEP CEIP, 2023b). Two teams of emission experts perform the reviews. EU Member States are encouraged to nominate reviewers for the EMEP roster of emission review experts; the details of the nomination process are available on the CEIP website. In 2020, the EU emission inventory report (1990-2018) under the UNECE Air Convention (UNECE, 2019b) was reviewed (UNECE/CEIP, 2021). The findings and their implementation are summarised in Table 5.2.

5.2.1 Improvements in response to the stage 3 review of the EU inventory in 2020

Table 5.2 lists the status of improvements implemented in response to the stage 3 review by an expert review team (ERT) in 2020 (UNECE/CEIP, 2020).

Table 5.2 EU stage 3 review results for 2020 and improvements implemented

Review findings (2020)			
Topic	**Recommendation**	**Implemented**	**Comment**
Transparency			
Timeliness	Submit the IIR a few weeks before the deadline of 30 May or, if that is not possible, provide the ERT with a draft IIR a few weeks earlier in those years when the EU is being reviewed, to facilitate the work of the ERT	Yes	The EU will provide the draft IIR before the reporting deadline in review years
Methodologies	Include in the IIR: summaries of the methodologies used by the MSs for emissions in the EU's key categories	No	Gathering this information would mean considerable effort; such an analysis is not feasible within the limited time-frame
Trends	Include in the IIR: explanations for all emission trends in the EU inventory, in consultation with the MSs	Partly	The EU has made efforts to provide explanations for trends in consultation with the MSs. More information on emission trends will be included in future submissions
Methods	Include in the IIR: sub-sector-level information on methods used to calculate emissions	No	MSs' inventories and IIRs are also part of the EU submission, and provide information on methods applied to sub-sectors. Including this information in the EU IIR is not feasible within the limited time-frame
Sources included	Include in the IIR: sub-sector-level information on sources included in the inventory, especially in the industry sector	No	MSs' inventories and IIRs are also part of the EU submission, and provide information on sources to sub-sectors. Including this information in the EU IIR is not feasible within the limited time-frame
Gap-filling procedure	Include in the IIR: information at the sector level in the main text of the IIR about the gap-filling procedure, or at least provide Annex D containing this information as a public part of the IIR	Yes	Annex D will be publicly available in future submissions
EU-level inventory improvement programme	Include in the IIR: information on improvements and progress on improvement work	Ongoing	Table 5.3 (improvements implemented) and Table 5.4 (improvements planned) are provided in the EU IIR

Review findings (2020)			
Topic	**Recommendation**	**Implemented**	**Comment**
Condensable component	Include in the IIR: summary information at the sectoral level on whether the condensable component of PM is included or not in MSs' inventories	Yes	Information on condensable components of PM is included in the EU IIR
Include links	Include in the IIR: links to relevant websites where gridded data and LPS data are available	Yes	The links are provided within the relevant sections of this report
Sector-specific QA/QC, trends	Implement sector-specific QA/QC procedures to investigate the data in detail and find explanations for real but unusual sector trends, and work with the individual MSs to provide more details on the drivers behind the trends	Ongoing	Work on outliers and unusual trends has already been established; further cooperation with the MSs is outside the scope of this report
Accuracy			
KCA to prioritise improvements	Use the results of the EU inventory's KCA to prioritise improvements in the inventory; include this issue in the improvement plan with clear steps and a schedule and report on progress in the next submissions	Ongoing	The EU is taking results from the KCA into account to improve the inventory and will provide information in the improvement plan
Completeness			
Completeness assessment	Include in the IIR: sector-specific assessment of the completeness of the inventory	No	This task would mean considerable effort; such an analysis is not feasible within the limited time-frame
Eurostat data for data gaps	Further improve the completeness and comparability of the inventory in consultation with the MSs by exploring the potential to use the Eurostat data or other data sources in cases where an MS does not include an existing source in its inventory although methods are available in the inventory guidebook	No	This task would mean considerable effort; such an analysis is not feasible within the limited time-frame
Activity data	Further improve the completeness and comparability of the inventory in consultation with the MSs by using the results of the NEC Directive technical review to improve the reporting of activity data in the EU submission	No	This task would mean considerable effort; such an analysis is not feasible within the limited time-frame
Fuel data	Further improve the completeness and comparability of the inventory in consultation with the MSs by including fuel data in the NFR tables for the years and the sectors for which this is possible	Ongoing	The EU will work on the provision of activity data in categories, where possible
Uncertainty of information from MSs	The ERT recommends that the Party include an uncertainty analysis in line with paragraph 31 of the reporting guidelines and work with the MSs to increase their reporting on uncertainties in their inventories and report on summarised information on uncertainties	No	To develop an uncertainty analysis, possibly on GAINS and IIASA data for the years 2005 and 2010, would exceed the workload of 2021
Uncertainty analysis	The ERT also recommends that the Party develops a parallel uncertainty analysis independent of the MSs' submissions, including an assessment of the impacts of the gap-filling procedure and improvements following the NEC Directive technical review on inventory uncertainty	No	Gathering this information would mean considerable effort; such an analysis is not feasible within the limited time-frame

Review findings (2020)			
Topic	**Recommendation**	**Implemented**	**Comment**
Comparability			
Notation keys	Always use notation keys in line with paragraph 12 of the reporting guidelines, and especially check that the use of the notation key 'NE' is in line with the reporting guidelines. Include information in the IIR to justify the uses of the notation keys; for 'IE' also document where the emissions are included	Ongoing	This needs further discussion within the framework of the Task Force on Emission Inventories and Projections
Compare MS data	Further improve the completeness and comparability of the inventory in consultation with the MSs by ensuring the comparability of MS data before aggregation at the EU level	No	This task would mean considerable effort; such an analysis is not feasible within the limited time-frame
Consistency			
Sector-specific QA/QC	Include in the IIR: sector-specific information on QA/QC procedures	No	This task would mean considerable effort; such an analysis is not feasible within the limited time-frame
Sector-specific recalculations	Include in the IIR: sector-specific information on recalculations wherever possible	Ongoing	Considerable efforts have already been undertaken to extract this information either from the IIRs or by contacting the MSs
Recalculations	Include in the IIR: information of the impacts of recalculations based on gap filling	Yes	Figures 1.5 and 1.6 of the EU IIR provide this information. Because of increasing completeness of reporting by the MSs, the percentage of gap-filled values within the EU inventory is steadily decreasing

Note: GAINS, Greenhouse Gas and Air Pollution Interactions and Synergies (model); IE, included elsewhere; IIASA, International Institute for Applied Systems Analysis; LPS, large point source; MS, Member State; NFR, nomenclature for reporting; QA/QC, quality assurance and quality control.

5.2.2 Further improvements undertaken in 2023

- The description of trends for all mandatory pollutants was improved and new graphs were added to visualise the impact of Member States' submissions on the EU trends.
- Explanations on unusual trends, peaks and troughs were improved.
- Quality control of data for PM_{10}, $PM_{2.5}$ and BC improved the gap-filled inventory.

5.2.3 Improvements at the Member State level

Improvements at the Member State level also automatically improve the EU inventory. Information on Member State-level improvements can be found within the respective IIRs (see Appendix 5).

The updated reporting guidelines (UNECE, 2022c, TFEIP, 2023) request that Parties to the Air Convention provide emission data using the NFR19 format. All the EU Member States that submitted data used the new template.

Units, symbols, abbreviations and acronyms

As	Arsenic
B(a)P	Benzo(a)pyrene
B(b)F	Benzo(b)fluoranthene
BC	Black carbon
B(k)F	Benzo(k)fluoranthene
Cd	Cadmium
CDR	Central Data Repository
CEIP	Centre on Emission Inventories and Projections
CO	Carbon monoxide
Cr	Chromium
Cu	Copper
DG	Directorate-General
EEA	European Environment Agency
Eionet	European Environment Information and Observation Network
EMEP	European Monitoring and Evaluation Programme
ERT	Expert review team
ETC	European topic centre
ETC HE	European Topic Centre on Human Health and the Environment
EU	European Union
FGD	Flue gas desulphurisation
Gg	1 gigagram=10^9g=1kilotonne (kt)
GNFR	Gridding nomenclature for reporting
HCB	Hexachlorobenzene
HCE	Hexachloroethane
Hg	Mercury
HM	Heavy metal

IE	Included elsewhere
IIR	Informative inventory report
IP	Indeno(1,2,3-cd)pyrene
I-TEQ	International toxic equivalent
KCA	Key category analysis
kg	1 kilogram=10^3g (gram)
LPS	Large point source
LRTAP	Long-range Transboundary Air Pollution; (UNECE) Air Convention
LTO	Landing/take-off
Mg	1 megagram=10^6g=1 tonne (t)
MMR	Monitoring Mechanism Regulation
NA	Not applicable
NE	Not estimated
NEC	National Emission reduction Commitments (Directive)
NFR	Nomenclature for reporting
NFR1	Nomenclature for reporting 1
NFR14	Nomenclature for reporting 14
NFR19	Nomenclature for reporting 19
NH_3	Ammonia
Ni	Nickel
NMVOC	Non-methane volatile organic compound
NO	Not occurring
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
NR	Not relevant
O_3	Ozone
PAH	Polycyclic aromatic hydrocarbon
Pb	Lead
PCB	Polychlorinated biphenyl

PCDD/F	Polychlorinated dibenzodioxin/dibenzofuran
PM	Particulate matter
$PM_{2.5}$	Particulate matter with a diameter of 2.5µm or less
PM_{10}	Particulate matter with a diameter of 10µm or less
POP	Persistent organic pollutant
QA	Quality assurance
QC	Quality control
Se	Selenium
SO_2	Sulphur dioxide
SO_X	Sulphur oxides
t	1 tonne (metric)=1 megagram (Mg)=10^6g
TERT	Technical Expert Review Team
TFEIP	Task Force on Emission Inventories and Projections
TSP	Total suspended particulate
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compound
WM	With measures (projections)
WaM	With additional measures (projections)
Zn	Zinc

Key category source sector abbreviations referred to in the main text

1A1a	Public electricity and heat production
1A1b	Petroleum refining
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals
1A2gvii	Mobile combustion in manufacturing industries and construction

1A2gviii	Stationary combustion in manufacturing industries and construction: Other
1A3bi	Road transport: Passenger cars
1A3bii	Road transport: Light duty vehicles
1A3biii	Road transport: Heavy duty vehicles and buses
1A3biv	Road transport: Mopeds and motorcycles
1A3bv	Road transport: Gasoline evaporation
1A3bvi	Road transport: Automobile tyre and brake wear
1A3bvii	Road transport: Automobile road abrasion
1A3dii	National navigation (shipping)
1A4ai	Commercial/institutional: Stationary
1A4bi	Residential: Stationary
1A4bii	Residential: Household and gardening (mobile)
1A4ci	Agriculture/forestry/fishing: Stationary
1A4cii	Agriculture/forestry/fishing: Off-road vehicles and other machinery
1B2aiv	Fugitive emissions oil: Refining/storage
1B2av	Distribution of oil products
2A1	Cement production
2A3	Glass production
2A5a	Quarrying and mining of minerals other than coal
2A5b	Construction and demolition
2B10a	Chemical industry: Other
2C1	Iron and steel production
2C3	Aluminium production
2C6	Zinc production
2C7a	Copper production
2D3a	Domestic solvent use including fungicides
2D3b	Road paving with asphalt
2D3d	Coating applications
2D3e	Degreasing

2D3g	Chemical products
2D3h	Printing
2D3i	Other solvent use
2G	Other product use
2H2	Food and beverages industry
2K	Consumption of POPs and heavy metals
2L	Other production, consumption, storage, transportation or handling of bulk products
3B1a	Manure management — Dairy cattle
3B1b	Manure management — Non-dairy cattle
3B3	Manure management — Swine
3B4gi	Manure management — Laying hens
3B4gii	Manure management — Broilers
3Da1	Inorganic N fertilisers (also includes urea application)
3Da2a	Animal manure applied to soils
3Da3	Urine and dung deposited by grazing animals
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products
3De	Cultivated crops
3Df	Use of pesticides
3F	Field burning of agricultural residues
5C1bi	Industrial waste incineration
5C1biii	Clinical waste incineration
5C1bv	Cremation
5C2	Open burning of waste
5E	Other waste

Country codes

AT	Austria
BE	Belgium
BG	Bulgaria
CY	Cyprus
CZ	Czechia
DE	Germany
DK	Denmark
EE	Estonia
EL	Greece
ES	Spain
FI	Finland
FR	France
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
MT	Malta
NL	Netherlands
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia

References

CAMS, 2021, *Interim annual assessment report for 2020 — European air quality in 2020*, Copernicus Atmosphere Monitoring Service (https://policy.atmosphere.copernicus.eu/reports/CAMS71_IAR_2020.pdf) accessed 22 March 2022.

EEA, 2009, *Proposed gap filling procedure for the European Community Air Convention emission inventory*, Technical paper for the meeting of the Air and Fuels Committee under Directive 96/62/EC, concerning 'Information on the EU Member States' reporting under the National Emission Ceilings Directive 2001/81/EC', 28 September 2009, Brussels, European Environment Agency (available on request).

EEA, 2012, *Eionet connects — sharing environmental information in Europe*, EEA Brochure No 1/2012, European Environment Agency (https://www.eea.europa.eu/publications/eionet-connects) accessed 20 March 2023.

EEA, 2014, *Effect of air pollution on European ecosystems*, EEA Technical Report No 11/2014, European Environment Agency (http://www.eea.europa.eu/publications/effects-of-air-pollution-on) accessed 20 March 2023.

EEA, 2019a, 'Emissions of primary $PM_{2.5}$ and PM_{10} particulate matter (CSI 003)', European Environment Agency (https://www.eea.europa.eu/data-and-maps/indicators/emissions-of-primary-particles-and-5) accessed 1 April 2022.

EEA, 2019b, 'Nitrogen oxides (NOx) emissions', European Environment Agency (https://www.eea.europa.eu/data-and-maps/indicators/eea-32-nitrogen-oxides-nox-emissions-1/assessment.2010-08-19.0140149032-3) accessed 17 March 2019.

EEA, 2022a, 'Air pollutant emissions data viewer (Gothenburg Protocol, LRTAP Convention) 1990-2020', European Environment Agency (https://www.eea.europa.eu/data-and-maps/dashboards/air-pollutant-emissions-data-viewer-4) accessed 21 March 2023.

EEA, 2022b, 'Emissions of the main air pollutants in Europe (CSI 040)', European Environment Agency (https://www.eea.europa.eu/ims/emissions-of-the-main-air) accessed 20 March 2023.

EEA, 2022c, 'Heavy metal emissions (AIR 001)', European Environment Agency (https://www.eea.europa.eu/ims/heavy-metal-emissions-in-europe) accessed 20 March 2023.

EEA, 2022d, *European Union emission inventory report 1990-2020 under the UNECE Convention on Long-range Transboundary Air Pollution (Air Convention)*, EEA Report No 5/2021, European Environment Agency (https://www.eea.europa.eu/publications/european-union-emissions-inventory-report) accessed 22 May 2023.

EEA, forthcoming, *Reporting by EU Member States under Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC*, EEA Briefing, European Environment Agency.

Eionet, 2023a, 'European Environment Information and Observation Network', European Environment Information and Observation Network (http://eionet.europa.eu) accessed 20 March 2023.

Eionet, 2023b, 'Eionet — Central Data Repository', European Environment Information and Observation Network (http://cdr.eionet.europa.eu) accessed 21 March 2023.

EMEP CEIP, 2023a, 'Annexes to the 2023 reporting guidelines', European Monitoring and Evaluation

Programme Centre on Emission Inventories and Projections (https://www.ceip.at/reporting-instructions/annexes-to-the-2023-reporting-guidelines/) accessed 20 March 2023.

EMEP CEIP, 2023b, 'Review process', European Monitoring and Evaluation Programme Centre on Emission Inventories and Projections (https://www.ceip.at/review-of-emission-inventories/review-process) accessed 20 March 2023.

EMEP CEIP, 2023c, 'Inventory review reports', European Monitoring and Evaluation Programme Centre on Emission Inventories and Projections (https://www.ceip.at/review-of-emission-inventories/technical-review-reports) accessed 20 March 2023.

EMEP CEIP, 2023d, 'In-depth review of air emission inventories', European Monitoring and Evaluation Programme Centre on Emission Inventories and Projections (https://www.ceip.at/review-of-emission-inventories/in-depth-review-of-ae-inventories) accessed 20 March 2023.

EMEP CEIP, 2023e, *Summary of the Stage 3 ad-hoc review 2022 of emission inventories submitted under the UNECE LRTAP Convention*, Technical Report CEIP 1/2023 (https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2023/dp176.pdf) accessed 20 March 2023.

EMEP/EEA, 2019, *EMEP/EEA air pollutant emission inventory guidebook — 2019*, EEA Technical Report No 13/2019, European Environment Agency (https://www.eea.europa.eu/publications/emep-eea-guidebook-2019) accessed 20 March 2023.

EMEP/EEA, 2022, *Inventory review 2022: review of emission data reported under the Air Convention — stage 1 and 2 review*, Technical Report CEIP 2/2023, European Monitoring and Evaluation Programme (https://www.ceip.at/review-of-emission-inventories/technical-review-reports/rr-2022) accessed 20 March 2023.

ETC/ACM, 2015, *Proposed unification of the gap filling procedures for the EU Air Convention emission inventory and the EMEP Air Convention emission inventory*, Technical Paper, European Topic Centre on Air Pollution and Climate Change Mitigation (available on request).

EU, 1998, Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC (OJ L 350, 28.12.1998, p. 58) (http://eur-lex.europa.eu/resource.html?uri=cellar:9cdbfc9b-d814-4e9e-b05d-49dbb7c97ba1.0008.02/DOC_1&format=PDF) accessed 20 March 2023.

EU, 1999, Council Regulation (EC) No 933/1999 of 29 April 1999 amending Regulation (EEC) No 1210/90 on the establishment of the European Environment Agency and the European Environment Information and Observation Network (OJ L 117, 5.5.1999, p. 1-4) (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31999R0933&from=SL) accessed 20 March 2023.

EU, 2013, 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 165/13, 18.6.2013, p. 13-40) (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0525&from=EN) accessed 20 March 2023.

EU, 2016a, Directive (EU) 2016/646 of 20 April 2016 amending Regulation (EC) No 692/2008 as regards emissions from light passenger and commercial vehicles (Euro 6) (OJ L 109, 26.4.2016, p. 22) (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0646&from=EN) accessed 20 March 2023.

EU, 2016b, Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC (OJ L 344, 17.12.2016, p.

31) (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2016:344:FULL&from=EN) accessed 19 March 2023.

TFEIP, 2023a, ‘Oxford 2023’, 23rd Joint Eionet and UNECE Task Force on Emission Inventories and Projections Meeting, 18-20 April, Task Force on Emission Inventories and Projections (https://www.tfeip-secretariat.org/oxford-2023) accessed 19 March 2023.

TFEIP, 2023b, Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution (https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/emissions_reporting_guidelines_2023_final.pdf), accessed 19 May 2023

UNECE, 1979, The 1979 Geneva Convention on Long-range Transboundary Air Pollution, United Nations Economic Commission for Europe (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:21979A1113(01)) accessed 20 March 2023.

UNECE, 1984, EMEP Protocol: the 1984 Geneva Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), United Nations Economic Commission for Europe (http://www.unece.org/env/lrtap/emep_h1.html) accessed 20 March 2023.

UNECE, 1985, The 1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent, United Nations Economic Commission for Europe (https://unece.org/sites/default/files/2021-10/1994.Sulphur.e.pdf) accessed 20 March 2023.

UNECE, 1988, Protocol concerning the Control of Emissions of Nitrogen Oxides: the 1988 Sofia Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes, United Nations Economic Commission for Europe (http://www.unece.org/env/lrtap/nitr_h1.html) accessed 20 March 2023.

UNECE, 1991, Protocol concerning the Control of Emissions of Volatile Organic Compounds: the 1991 Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes, United Nations Economic Commission for Europe (http://www.unece.org/env/lrtap/vola_h1.html) accessed 20 March 2023.

UNECE, 1994, Protocol on Further Reduction of Sulphur Emissions: the 1994 Oslo Protocol on Further Reduction of Sulphur Emissions, United Nations Economic Commission for Europe (https://unece.org/environment-policyair/protocol-further-reduction-sulphur-emissions) accessed 20 March 2023.

UNECE, 1998a, Protocol on Persistent Organic Pollutants (POPs): the 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs), United Nations Economic Commission for Europe (http://www.unece.org/env/lrtap/pops_h1.html) accessed 20 March 2023.

UNECE, 1998b, Protocol on Heavy Metals: the 1998 Aarhus Protocol on Heavy Metals, United Nations Economic Commission for Europe (http://www.unece.org/env/lrtap/hm_h1.html) accessed 20 March 2023.

UNECE, 1999, Protocol to Abate Acidification, Eutrophication and Ground-level Ozone: the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, United Nations Economic Commission for Europe (http://www.unece.org/env/lrtap/multi_h1.html) accessed 20 March 2023.

UNECE, 2006, Decision 2006/2: Implementation Committee, its structure and functions and procedure for review, ECE/EB.AIR/2006/2, United Nations Economic Commission for Europe (http://www.unece.org/fileadmin/DAM/env/documents/2006/eb/EB/EB Decisions/Decision 2006.2.pdf) accessed 20 March 2023.

UNECE, 2009, Guidelines for reporting emission data under the Convention on Long-range Transboundary Air Pollution, ECE/EB.AIR/97, United Nations Economic Commission for Europe (https://undocs.org/en/

ECE/EB.AIR/97) accessed 20 March 2023.

UNECE, 2012a, Decision 2012/3: Adjustments under the Gothenburg Protocol to emission reduction commitments or to inventories for the purposes of comparing total national emissions with them, ECE/EB.AIR/111, United Nations Economic Commission for Europe (http://www.unece.org/fileadmin/DAM/env/documents/2013/air/ECE_EB.AIR_111_Add.1__ENG_DECISION_3.pdf) accessed 20 March 2023.

UNECE, 2012b, Decision 2012/2: Amendment of the text of and annexes II to IX to the 1999

Protocol to Abate Acidification, Eutrophication and Ground-level Ozone and the addition of new annexes X and XI (https://unece.org/DAM/env/documents/2013/air/ECE_EB.AIR_111_Add.1__ENG_DECISION_2.pdf) accessed 20 March 2023.

UNECE, 2012c, Decision 2012/12: Guidance for adjustments under the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to emission reduction commitments or to inventories for the purposes of comparing total national emissions with them, ECE/EB.AIR/113, United Nations Economic Commission for Europe (http://www.unece.org/fileadmin/DAM/env/documents/2012/EB/Decision_2012_12.pdf) accessed 20 March 2023.

UNECE, 2014a, Guidelines for reporting emissions and projections data under the Convention on Long-range Transboundary Air Pollution, ECE/EB.AIR/125, United Nations Economic Commission for Europe (https://www.ceip.at/fileadmin/inhalte/ceip/1_reporting_guidelines2014/ece.eb.air.125_advance_version_reporting_guidelines_2014.pdf) accessed 20 March 2023.

UNECE, 2014b, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2014/10, United Nations Economic Commission for Europe (https://unece.org/fileadmin/DAM/env/documents/2014/AIR/EMEP/ECE_EB.AIR_GE.1_2014_10_ENG.pdf) accessed 15 May 2023.

UNECE, 2015, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2015/10- ECE/EB.AIR/WG.1/2015/13, United Nations Economic Commission for Europe (https://unece.org/fileadmin/DAM/env/documents/2015/AIR/EMEP/ece.eb.air.ge.1.2015.10_ece.eb.air.wg.1.2015.13.AV.pdf) accessed 14 May 2023.

UNECE, 2016, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2016/10-ECE/EB.AIR/WG.1/2016/18, United Nations Economic Commission for Europe (https://unece.org/fileadmin/DAM/env/documents/2016/AIR/EMEP/ece.eb.air.ge.1.2016.10_ece.eb.air.wg.1.2016.18.pdf) accessed 15 May 2023.

UNECE, 2017, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2017/10-ECE/EB.AIR/WG.1/2017/20, United Nations Economic Commission for Europe (https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2017/advance_ece_eb_air_ge_1_2017_10_ece_eb_air_wg_1_2017.pdf) accessed 15 May 2023.

UNECE, 2018, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2018/10- ECE/EB.AIR/GE.1/2018/21, United Nations Economic Commission for Europe (https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2018/adj_ece.eb.air.ge.1.2018.10-ece.eb.air.wg.1.2018.21_advance.pdf) accessed 15 May 2023.

UNECE, 2019a, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2019/10−ECE/EB.AIR/WG.1/2019/22, United Nations Economic Commission for Europe https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2019/ece_eb.air_ge.1_2019_10-1909789e.pdf) accessed 14 March 2023.

UNECE, 2019b, 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Long-range Transboundary Air Pollution, as amended on 4 May 2012; ECE/EB.AIR/114, United Nations Economic Commission for Europe (https://unece.org/sites/default/files/2021-10/ECE.EB_.AIR_.114_ENG.pdf) 25 May 2023.

UNECE, 2020, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2020/10−ECE/EB.AIR/WG.1/2020/21, United Nations Economic Commission for Europe (https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2020/adj-status_ece_eb.air_ge.1_2020_10-2008939e.pdf)

UNECE, 2021, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2021/10−ECE/EB.AIR/WG.1/2021/21, United Nations Economic Commission for Europe (https://www.ceip.at/fileadmin/inhalte/ceip/4_adjustments/ece_eb.air_ge.1_2021_10-2110972e.pdf) accessed 25 May 2023.UNECE, 2022a, Review of adjustment applications — Report by the Centre on Emission Inventories and Projections, ECE/EB.AIR/GE.1/2022/10−ECE/EB.AIR/WG.1/2022/21, United Nations Economic Commission for Europe (https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/ece_eb.air_ge.1_2022_10-2213009e.pdf) accessed 20 March 2023.

UNECE, 2022b, Report of the Executive Body on its forty-second session, ECE/EB.AIR/150, United Nations Economic Commission for Europe (https://unece.org/sites/default/files/2023-03/Advance%20version_ECE_EB.AIR_150.pdf) accessed 15 May 2023

UNECE, 2022c, Adoption of the updated Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution, ECE/EB.AIR/150/Add.1 (https://unece.org/sites/default/files/2023-04/Decision%202022_1%20%28E%29.pdf) accessed 19 May 2023

UNECE/CEIP, 2021, Report for the stage 3 in-depth review of emission inventories submitted under the UNECE Air Convention and EU National Emissions Ceilings Directive for: European Union, CEIP/S3.RR/2020/EU 24/11/2020CEIP/S3.RR/2017/EU, United Nations (https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2020_s3/eu_s3_rr_2020_final.pdf) accessed 20 March 2023.

Appendix 1. Notation keys

Where there are methodological or data gaps in the inventories, information on these gaps should be presented in a transparent manner. Parties should clearly indicate the sources that they have not considered in their inventories — although the inventory guidebook (EMEP/EEA, 2019) includes them — and explain the reason for excluding them. Similarly, each Party should indicate if it has excluded part of its territory and explain why. In addition, each Party should use the notations presented below to fill the blanks in all the tables in the nomenclature for reporting (NFR) inventory. This approach helps in assessing how complete the emission data reports are. The notations are as follows([23]).

NO ‘Not occurring’ means that an emission source or process does not exist in a country.

NE ‘Not estimated’ means that emissions occur but have not been estimated or reported. Where an inventory uses ‘NE’, the Party should indicate why it could not estimate emissions.

NA ‘Not applicable’ means that a source exists but relevant emissions are considered never to occur.

IE ‘Included elsewhere’ is for emissions that are estimated and included in the inventory but are not presented separately for the relevant source. Where it uses ‘IE’, the Party should indicate where the inventory includes the emissions from the displaced source category and should give the reasons for deviating from the expected category.

C ‘Confidential’ is for aggregated emissions that the inventory includes elsewhere because reporting at a disaggregated level could lead to the disclosure of confidential information. Where an inventory uses ‘C’, it should make reference to the protocol provision that authorises it.

NR ‘Not relevant’ eases reporting where different protocols do not strictly require details of the emissions. According to Article III paragraph 9 in the reporting guidelines, emission inventory reporting should cover all years from 1980 onwards if data are available. However, for example, some Parties do not need to report emissions of non-methane volatile organic compounds (NMVOCs) prior to 1988.

If a Party estimates emissions from country-specific sources, it should explicitly describe which source categories these are, as well as which methodologies, emission factors and activity data it has used to estimate them.

([23]) Further explanation and guidance concerning the use of these notation codes are in the European Monitoring and Evaluation Programme (EMEP) reporting guidelines (UNECE, 2022c).

Appendix 2. Air Convention emission-reporting programme for 2023

Emission data should be submitted to the European Monitoring and Evaluation Programme (EMEP) Centre on Emission Inventories and Projections (CEIP) by **15 February 2023**. Informative inventory reports (IIRs) should reach the centre no later than **15 March 2023**. Table A2.1 summarises information in the revised reporting guidelines (UNECE, 2022c).

Table A2.1 Summary of the information requested in the EMEP reporting guidelines

Description of contents	Pollutant(s)	Reporting years([a])
Yearly: minimum (and additional)		
A. National total emissions		
1. Main pollutants other than PM	NO_X, NMVOCs, SO_X, NH_3, CO	1990-2021
2. Particulate matter([b])	$PM_{2.5,}$ PM_{10} (TSPs, BC)	2000-2021
3. Heavy metals([b])	Pb, Cd, Hg, (As, Cr, Cu, Ni, Se, Zn)	1990-2021
4. Persistent organic pollutants([b])	PCDD/Fs, total PAHs, PCBs, HCB (PAHs: B(a)P, B(b)F, B(k)F, IP)	1990-2021
B. Emissions by NFR source category		
1. Main pollutants other than PM	NO_X, NMVOCs, SO_X, NH_3, CO	1990-2021
2. Particulate matter([b])	$PM_{2.5,}$ PM_{10}, (TSPs, BC)	2000-2021
3. Heavy metals([b])	Pb, Cd, Hg, (As, Cr, Cu, Ni, Se, Zn)	1990-2021
4. Persistent organic pollutants([b])	PCDD/Fs, total PAHs, PCBs, HCB (PAHs: B(a)P, B(b)F, B(k)F, IP)	1990-2021
C. Activity data	NO_X, NMVOCs, SO_X, NH_3, CO	1990-2021
4-yearly: minimum reporting (from 2017 to the next reporting year (2025))		
D. Gridded data in the EMEP 0.1°×0.1° longitude/latitude grid — sector emissions (GNFR19) ([c]) **and national totals (optional)**	NO_X, NMVOCs, SO_X, NH_3, CO, $PM_{2.5}$, PM_{10}, Pb, Cd, Hg, PCDD/Fs, PAHs, HCB, PCBs	2015 (1990, 1995, 2000, 2005, 2010 if not previously reported)
E. Emissions from large point sources (LPSs)	NO_X, NMVOCs, SO_X, NH_3, CO, $PM_{2.5}$, PM_{10}, Pb, Cd, Hg, PCDD/Fs, PAHs, HCB, PCBs	2015 (1990, 1995, 2000, 2005, 2010 if not previously reported)
F. Projected emissions and projected activity data		
1. National total emission projections	NO_X, NMVOCs, SO_X, NH_3, $PM_{2.5}$, BC	2025, 2030, where available 2040 and 2050
2. Emission projections by NFR19	NO_X, NMVOCs, SO_X, NH_3, $PM_{2.5}$, BC	2025, 2030, where available 2040 and 2050
3.Projected activity data by NFR19		2025, 2030, where available 2040 and 2050

Description of contents	Pollutant(s)	Reporting years([a])
5-yearly: additional reporting for review and assessment purposes		
VOC speciation/height distribution/temporal distribution		Parties are encouraged to review the information used for modelling at https://www.ceip.at/webdab-emission-database/emissions-as-used-in-emep-models (accessed 10 March 2023)
Land use data/Hg breakdown		
Percentage of toxic congeners of PCDD/F emissions		
Pre-1990 emissions of PAHs, HCB, PCDD/Fs and PCBs		
Information on natural emissions		

Notes: ([a]) As a minimum, data for the base year of the relevant protocol and from the year of entry into force of that protocol and up to the latest year (i.e. the second-last before the current year) should be reported.

([b]) Parties report the pollutants listed in brackets voluntarily.

([c]) Gap-filled NFR19.

As, arsenic; B(a)P, benzo(a)pyrene; B(b)F, benzo(b)fluoranthene; BC, black carbon; B(k)F, benzo(k)fluoranthene; Cd, cadmium; CO, carbon monoxide; Cr, chromium; Cu, copper; GNFR19, gridding nomenclature for reporting 19; HCB, hexachlorobenzene; Hg, mercury; IP, indeno(1,2,3-cd)pyrene; NFR, nomenclature for reporting; NFR19, nomenclature for reporting 19; NH_3, ammonia; Ni, nickel; NMVOC, non-methane volatile organic compound; NO_X, nitrogen oxides; LPSs, large point sources; PAH, polycyclic aromatic hydrocarbon; Pb, lead; PCB, polychlorinated biphenyl; PCDD/F, polychlorinated dibenzodioxin/dibenzofuran; $PM_{2.5}$, particulate matter with a diameter of 2.5µm or less; PM_{10}, particulate matter with a diameter of 10µm or less; Se, selenium; SO_X, sulphur oxides; TSP, total suspended particulate; VOC, volatile organic compound; Zn, zinc.

Reporting format

Each Party should use the reporting format in Annex IV of the Air Convention reporting guidelines (UNECE, 2022c) for its annual submissions. It should submit the information to the CEIP formally, preferably in electronic format, and notify the Air Convention via the United Nations Economic Commission for Europe (UNECE) Secretariat. The reporting format, including the nomenclature for reporting (NFR), is standardised for reporting estimates of emissions. It includes activity data, projected activity data, projected emissions and other relevant information. The reporting format aims to facilitate electronic submissions by making it easier to process emission information and prepare useful documentation about technical analysis and synthesis.

The nomenclature for reporting 19 (NFR19) format covers:

- national annual emissions and national annual sector emissions (Annex I);
- total and aggregated sector emissions for reporting emissions of nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOCs), sulphur oxides (SO_X), ammonia (NH_3), particulate matter (PM), black carbon (BC), carbon monoxide (CO), lead (Pb), cadmium (Cd), mercury (Hg), polychlorinated dibenzodioxins/dibenzofurans (PCDD/Fs), polycyclic aromatic hydrocarbons (PAHs), hexachlorobenzene (HCB) and polychlorinated biphenyls (PCBs) for the EMEP 0.1°×0.1° grid cell and from large point sources (LPSs) (Annexes V and VI);
- for 2020, 2025, 2030, 2040 and 2050, projected activity data and projected national total emissions of NO_X, NMVOCs, sulphur and NH_3, which Parties are to report for the source categories listed in Annex IV (A-with measures (WM); B-WM; A-with additional measures (WaM); B-WaM).

Table A2.2 EU: country groupings

EU-11 refers to the following 11 Member States of the EU: Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Greece, Portugal and Spain
EU-27 refers to the 27 Member States of the EU

Appendix 3. Status of reporting and timeliness

Table A3.1 EU Member State inventory submissions 2023: date received by the EEA, years covered and information provided (as of 25 May 2023)

Country	Reporting date and format								
Member State	Submission date (a)	Resubmission date	Adjustment date (Information or Annex submission)	Projection submission date	Grid submission date	LPS submission date	Date of additional information	Date of IIR	NFR template version
Austria	15.02.2023			15.03.2023				15.03.2023 24.04.2023	2019-1
Belgium	15.02.2023	15.03.2023		20.03.2023				15.03.2023	2019-1
Bulgaria	15.02.2023	22.02.2023 15.03.2023 03.04.2023		10.05.2023				15.03.2023	2020-1
Croatia									
Cyprus	15.02.2023	15.03.2023		17.03.2023				16.03.2023	2019-1
Czechia	15.02.2023	15.03.2023		15.03.2023 24.04.2023				15.03.2023	2019-1
Denmark	15.02.2023	03.04.2023	15.02.2023	15.03.2023				15.03.2023	2014-1
Estonia	10.02.2023	14.03.2023		15.03.2023				14.03.2023	2019-1
Finland	10.02.2023			14.03.2023				14.03.2023	2019-1
France	14.02.2023		07.02.2023	12.05.2023				15.03.2023	2019-1
Germany	10.02.2023	14.03.2023		02.05.2023				15.03.2023	2019-1
Greece	16.02.2023	03.03.2023		13.03.2023				13.03.2023	2019-1
Hungary	15.02.2023	21.03.2023		03.04.2023 (not publicly available)				21.03.2023	2019-1
Ireland	15.02.2023	15.03.2023		04.04.2023				15.03.2023 06.04.2023	2019-1
Italy	15.02.2023	15.03.2023		15.03.2023				15.03.2023	2019-1
Latvia	15.02.2023	15.03.2023 27.04.2023		06.04.2023 27.04.2023				15.03.2023 27.04.2023	2019-1
Lithuania	15.02.2023	10.03.2023 08.04.2023		21.04.2023 24.04.2023				16.03.2023	2019-1
Luxembourg	10.02.2023							12.05.2023	2019-1
Malta	28.02.2023			06.04.2023					2019-1
Netherlands	15.02.2023	15.03.2023 27.03.2023	15.02.2023	15.03.2023				15.03.2023 27.03.2023	2019-1
Poland	15.02.2023			15.03.2023				15.03.2023	2019-1
Portugal	14.02.2023	14.03.2023		09.05.2023				14.03.2023	2019-1
Romania	15.02.2023	15.03.2023		16.02.2023				15.03.2023	2019-1
Slovakia	15.02.2023	14.03.2023		15.03.2023 19.04.2023				15.03.2023 17.04.2023	2019-1
Slovenia	02.02.2023			14.03.2023				14.03.2023	2019-1
Spain	14.02.2023				27.04.2023	26.04.2023		15.03.2023	2019-1
Sweden	03.02.2023			10.03.2023				14.03.2023	2019-1

Notes: Dates in red indicate that data were submitted after the formal deadline for submissions (submissions 15 February; resubmissions 15 March; projections 15 March; IIR 15 March).

(a) Refers to the first submission of inventory data to the Central Data Repository (CDR); submission of other data are possible at later dates.

IIR, informative inventory report; LPS, large point source; NFR, nomenclature for reporting.

Table A3.2 EU Member State submissions of 2021 data (as of 25 May 2023)

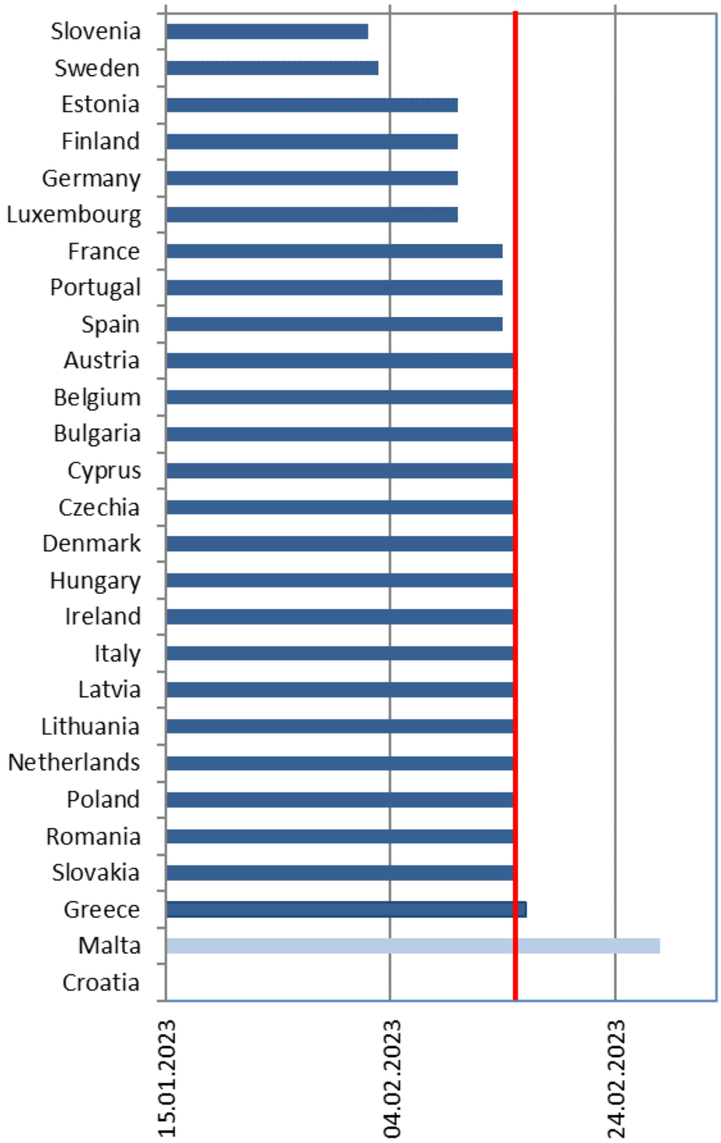
Country	Years reported										Comments
Member State	SO_2, NO_X, CO, NH_3, NMVOC	Cd,Hg, Pb	Additional HM	$PM_{2.5}$, PM_{10}	TSP	BC	POPs: PAH PCDD/F HCB PCB	Additional PAHs: B(a)P, B(b)F, B(k)F, IP	Activity data	Projections WM	
Austria	1990-2021	1990-2021		1990, 1995, 2000-2021	1990, 1995, 2000-2021		1990-2021	1990-2021	1990-2021	2025, 2030	
Belgium	1990-2021	1990-2021	1990-2021	2000-2021	2000-2021	2000-2021	1990-2021	1990-2021	1990-2021	2025, 2030	
Bulgaria	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021		
Croatia											
Cyprus	1990-2021	1990-2021	1990-2021	2000-2021	2000-2021	2000-2021	1990-2021	1990-2021	1990-2021	2025, 2030	
Czechia	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2040, 2050	
Denmark	1985-2021*	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2035, 2040	*SO_X from 1980
Estonia	1990-2021	1990-2021	1990-2021	2000-2021	1990-2021	2000-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2035, 2040, 2050	
Finland	1980-2021*	1990-2021	1990-2021**	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1980-2021	2025, 2030, 2040, 2050	*NMVOC from 1987, CO from 1990 **Se NT - "NE", but values available
France	1980-2021*	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1980-2021		*NMVOC from 1988
Germany	1990-2021	1990-2021	1990-2021	1995-2021	1990-2021	2000-2021	1990-2021	1990-2021	1990-2021		
Greece	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2040	
Hungary	1990-2021	1990-2021	1990-2021	2000-2021	2000-2021	2000-2021	1990-2021	1990-2021	1990-2021		
Ireland	1990-2021*	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2035, 2040, 2050	*SO_X, NO_X, NMVOC also 1987
Italy	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030	
Latvia	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2040, 2050	
Lithuania	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021		
Luxembourg	1990-2021	1990-2021		1990-2021	1990-2021		1990-2021	1990-2021	1990-2021		
Malta	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030	
Netherlands	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2035, 2040	
Poland	1990-2021	1990-2021	1990-2021*	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2035, 2040	*No Se reported
Portugal	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021		
Romania	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030	
Slovakia	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2040, 2050	
Slovenia	1980-2021*	1990-2021	1990-2021	2000-2021	2000-2021	2000-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2040, 2050	*NMVOC from 1990, NH_3 from 1986
Spain	1990-2021	1990-2021	1990-2021	2000-2021	2000-2021	2000-2021	1990-2021	1990-2021	1990-2021		
Sweden	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	1990-2021	2025, 2030, 2035, 2040, 2045, 2050	

Notes: Reporting of additional HMs is not mandatory.

EU Member States do not have to report TSPs if they report PM emissions.

B(a)P, benzo(a)pyrene; B(b)F, benzo(b)fluoranthene; BC, black carbon B(k)F, benzo(k)fluoranthene; Cd, cadmium; CO, carbon monoxide; PCDD/F, polychlorinated dibenzodioxin/dibenzofuran; HCB, hexachlorobenzene; Hg, mercury; HM, heavy metal; IP, indeno(1,2,3-cd)pyrene; NE, not estimated; NT, national total; NH_3, ammonia; NMVOC, non-methane volatile organic compound; NO_X, nitrogen oxides; PAH, polycyclic aromatic hydrocarbon; Pb, lead; PCB, polychlorinated biphenyl; particulate matter (PM); $PM_{2.5}$, particulate matter with a diameter of 2.5µm or less; PM_{10}, particulate matter with a diameter of 10µm or less; POP, persistent organic pollutant; Se, selenium; SO_2, sulphur dioxide; TSP, total suspended particulate; NT, National Total

Figure A3.1 Dates of first data submissions received from EU Member States (as of 28 February 2023)



Note: The red line marks the submission deadline of 15 February 2023.

Appendix 4. Conversion chart for aggregated sector groups

To enable the presentation of sectoral emission trends (Chapter 3), individual nomenclature for reporting (NFR) source categories for the EU-27 inventory were aggregated into the following main sector groups:

- energy production and distribution;
- energy use in industry;
- industrial processes and product use;
- commercial, institutional and households;
- road transport;
- non-road transport;
- agriculture;
- waste.

Table A4.1 provides a conversion chart showing which of the individual NFR source categories appeared in each of the aggregated sector groups.

Table A4.1 Conversion chart for aggregated sector groups

NFR code	Full name	EEA aggregated sector name
1A1a	Public electricity and heat production	Energy production and distribution
1A1b	Petroleum refining	Energy production and distribution
1A1c	Manufacture of solid fuels and other energy industries	Energy production and distribution
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Energy use in industry
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Energy use in industry
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Energy use in industry
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, paper and print	Energy use in industry
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Energy use in industry
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Energy use in industry
1A2gvii	Mobile combustion in manufacturing industries and construction	Energy use in industry
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	Energy use in industry
1A3ai(i)	International aviation LTO (civil)	Non-road transport
1A3aii(i)	Domestic aviation LTO (civil)	Non-road transport
1A3bi	Road transport: Passenger cars	Road transport
1A3bii	Road transport: Light duty vehicles	Road transport
1A3biii	Road transport: Heavy duty vehicles and buses	Road transport
1A3biv	Road transport: Mopeds and motorcycles	Road transport
1A3bv	Road transport: Gasoline evaporation	Road transport

NFR code	Full name	EEA aggregated sector name
1A3bvi	Road transport: Automobile tyre and brake wear	Road transport
1A3bvii	Road transport: Automobile road abrasion	Road transport
1A3c	Railways	Non-road transport
1A3di(ii)	International inland waterways	Non-road transport
1A3dii	National navigation (shipping)	Non-road transport
1A3ei	Pipeline transport	Non-road transport
1A3eii	Other	Non-road transport
1A4ai	Commercial/institutional: Stationary	Commercial, institutional and households
1A4aii	Commercial/institutional: Mobile	Commercial, institutional and households
1A4bi	Residential: Stationary	Commercial, institutional and households
1A4bii	Residential: Household and gardening (mobile)	Commercial, institutional and households
1A4ci	Agriculture/forestry/fishing: Stationary	Commercial, institutional and households
1A4cii	Agriculture/forestry/fishing: Off-road vehicles and other machinery	Commercial, institutional and households
1A4ciii	Agriculture/forestry/fishing: National fishing	Non-road transport
1A5a	Other stationary (including military)	Commercial, institutional and households
1A5b	Other, mobile (including military, land-based and recreational boats)	Commercial, institutional and households
1B1a	Fugitive emission from solid fuels: Coal mining and handling	Energy production and distribution
1B1b	Fugitive emission from solid fuels: Solid fuel transformation	Energy production and distribution
1B1c	Other fugitive emissions from solid fuels	Energy production and distribution
1B2ai	Fugitive emissions oil: Exploration, production, transport	Energy production and distribution
1B2aiv	Fugitive emissions oil: Refining/storage	Energy production and distribution
1B2av	Distribution of oil products	Energy production and distribution
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	Energy production and distribution
1B2c	Venting and flaring (oil, gas, combined oil and gas)	Energy production and distribution
1B2d	Other fugitive emissions from energy production	Energy production and distribution
2A1	Cement production	Industrial processes and product use
2A2	Lime production	Industrial processes and product use
2A3	Glass production	Industrial processes and product use
2A5a	Quarrying and mining of minerals other than coal	Industrial processes and product use
2A5b	Construction and demolition	Industrial processes and product use
2A5c	Storage, handling and transport of mineral products	Industrial processes and product use
2A6	Other mineral products	Industrial processes and product use
2B1	Ammonia production	Industrial processes and product use
2B2	Nitric acid production	Industrial processes and product use
2B3	Adipic acid production	Industrial processes and product use
2B5	Carbide production	Industrial processes and product use
2B6	Titanium dioxide production	Industrial processes and product use
2B7	Soda ash production	Industrial processes and product use
2B10a	Chemical industry: Other	Industrial processes and product use
2B10b	Storage, handling and transport of chemical products	Industrial processes and product use

NFR code	Full name	EEA aggregated sector name
2C1	Iron and steel production	Industrial processes and product use
2C2	Ferroalloys production	Industrial processes and product use
2C3	Aluminium production	Industrial processes and product use
2C4	Magnesium production	Industrial processes and product use
2C5	Lead production	Industrial processes and product use
2C6	Zinc production	Industrial processes and product use
2C7a	Copper production	Industrial processes and product use
2C7b	Nickel production	Industrial processes and product use
2C7c	Other metal production	Industrial processes and product use
2C7d	Storage, handling and transport of metal products	Industrial processes and product use
2D3a	Domestic solvent use including fungicides	Industrial processes and product use
2D3b	Road paving with asphalt	Industrial processes and product use
2D3c	Asphalt roofing	Industrial processes and product use
2D3d	Coating applications	Industrial processes and product use
2D3e	Degreasing	Industrial processes and product use
2D3f	Dry cleaning	Industrial processes and product use
2D3g	Chemical products	Industrial processes and product use
2D3h	Printing	Industrial processes and product use
2D3i	Other solvent use	Industrial processes and product use
2G	Other product use	Industrial processes and product use
2H1	Pulp and paper industry	Industrial processes and product use
2H2	Food and beverages industry	Industrial processes and product use
2H3	Other industrial processes	Industrial processes and product use
2I	Wood processing	Industrial processes and product use
2J	Production of POPs	Industrial processes and product use
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	Industrial processes and product use
2L	Other production, consumption, storage, transportation or handling of bulk products	Industrial processes and product use
3B1a	Manure management — Dairy cattle	Agriculture
3B1b	Manure management — Non-dairy cattle	Agriculture
3B2	Manure management — Sheep	Agriculture
3B3	Manure management — Swine	Agriculture
3B4a	Manure management — Buffalo	Agriculture
3B4d	Manure management — Goats	Agriculture
3B4e	Manure management — Horses	Agriculture
3B4f	Manure management — Mules and asses	Agriculture
3B4gi	Manure management — Laying hens	Agriculture
3B4gii	Manure management — Broilers	Agriculture
3B4giii	Manure management — Turkeys	Agriculture
3B4giv	Manure management — Other poultry	Agriculture
3B4h	Manure management — Other animals	Agriculture
3Da1	Inorganic N-fertilisers (includes also urea application)	Agriculture

NFR code	Full name	EEA aggregated sector name
3Da2a	Animal manure applied to soils	Agriculture
3Da2b	Sewage sludge applied to soils	Agriculture
3Da2c	Other organic fertilisers applied to soils (including compost)	Agriculture
3Da3	Urine and dung deposited by grazing animals	Agriculture
3Da4	Crop residues applied to soils	Agriculture
3Db	Indirect emissions from managed soils	Agriculture
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	Agriculture
3Dd	Off-farm storage, handling and transport of bulk agricultural products	Agriculture
3De	Cultivated crops	Agriculture
3Df	Use of pesticides	Agriculture
3F	Field burning of agricultural residues	Agriculture
3I	Agriculture other	Agriculture
5A	Biological treatment of waste — Solid waste disposal on land	Waste
5B1	Biological treatment of waste — Composting	Waste
5B2	Biological treatment of waste — Anaerobic digestion at biogas facilities	Waste
5C1a	Municipal waste incineration	Waste
5C1bi	Industrial waste incineration	Waste
5C1bii	Hazardous waste incineration	Waste
5C1biii	Clinical waste incineration	Waste
5C1biv	Sewage sludge incineration	Waste
5C1bv	Cremation	Waste
5C1bvi	Other waste incineration	Waste
5C2	Open burning of waste	Waste
5D1	Domestic waste water handling	Waste
5D2	Industrial waste water handling	Waste
5D3	Other waste water handling	Waste
5E	Other waste	Waste
6A	Other (included in national total for entire territory)	Other

Note: LTO, landing/take-off; NFR, nomenclature for reporting; POPs, persistent organic pollutant.

Appendix 5. EU Member State informative inventory reports

Table A5.1 List of submitted informative inventory reports (IIRs) including source and date of submission (as of 25 May 2023)

Country code	Title of IIR	Source	Date of submission
AT	Austria's Informative Inventory Report (IIR) 2023 submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. Report	https://cdr.eionet.europa.eu/at/un/clrtap/iir/envzezuoa	24.04.2023
BE	Informative Inventory Report about Belgium's air emissions submitted under the Convention on Long-range Transboundary Air Pollution CLRTAP and the National Emission Ceilings Directive NECD. March 2023	https://cdr.eionet.europa.eu/be/un/clrtap/iir/envzbjepq	15.03.2023
BG	Bulgaria's Informative Inventory Report 2023 (IIR). Submission under the UNECE Convention on Long-Range Transboundary Air Pollution	https://cdr.eionet.europa.eu/bg/un/clrtap/iir/envzbhsma	15.03.2023
CY	Cyprus Informative Inventory Report for 2021	https://cdr.eionet.europa.eu/cy/un/clrtap/iir/envzbfo3a	16.03.2023
CZ	Informative Inventory Report Czechia 2023. Submission under the UNECE Convention on Long-range Transboundary Air Pollution. Reported inventories 1990-2021	https://cdr.eionet.europa.eu/cz/un/clrtap/iir/envy90dea	15.03.2023
DE	German Informative Inventory Report 2023	https://iir.umweltbundesamt.de/2023/start	15.03.2023
DK	Annual Danish Informative Inventory Report. Emission inventories from the base year of the protocols to year 2021	https://cdr.eionet.europa.eu/dk/un/clrtap/iir/envzbangq	15.03.2023
EE	Estonian Informative Inventory Report 1990-2021. Submitted under the Convention on Long-Range Transboundary Air Pollution	https://cdr.eionet.europa.eu/ee/un/clrtap/iir/envzba5hw	14.03.2023
EL	Greece's Informative Inventory Report (IIR) 2023. Submission under the UNECE Convention on Long-rang Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants	https://cdr.eionet.europa.eu/gr/un/clrtap/iir/envza8cuq	13.03.2023
ES	Informative Inventory Report. Submission to the Secretariat of the Geneva Convention and EMEP programme. Reporting to the European Commission under Directive (EU) 2016/2284. 2023 edition (1990-2021)	https://cdr.eionet.europa.eu/es/un/clrtap/iir/envzbfuja	15.03.2023
FI	Finland's Informative Inventory Report 2023. Air Pollutant Emissions 1980-2021 under the UNECE CLRTAP and the EU NECD.	https://cdr.eionet.europa.eu/fi/un/clrtap/iir/envzbdhbg	14.03.2023
FR	Inventaire des émissions de polluants atmosphériques en France au titre de la convention sur la pollution atmosphérique transfrontalière à longue distance et de la directive européenne concernant la réduction des émissions nationales de certains polluants atmosphériques CEE — NU/NFR & NEC Mars 2023	https://cdr.eionet.europa.eu/fr/un/clrtap/iir/envzajrwa	15.03.2023
HR	No IIR provided		
HU	Informative Inventory Report. 1990-2021. Hungary	https://cdr.eionet.europa.eu/hu/un/clrtap/iir/envzbl5w	21.03.2023

Country code	Title of IIR	Source	Date of submission
IE	Ireland. Informative Inventory Report 2023. Air Pollutant Emissions in Ireland 1990-2021 reported to the Secretariat of the UN/ECE Convention on Long-range Transboundary Air Pollution and to the European Union	https://cdr.eionet.europa.eu/ie/un/clrtap/iir/envzc6cca	06.04.2023
IT	Italian Emission Inventory 1990-2021 Informative Inventory Report 2023	https://cdr.eionet.europa.eu/it/un/clrtap/iir/envzbiriw	15.03.2023
LT	Lithuania's Informative Inventory Report 2023. Air Pollutant Emissions 1990-2021. Under the UNECE CLRTAP and the EU NECD	https://cdr.eionet.europa.eu/lt/un/clrtap/iir/envzbj3kw	16.03.2023
LU	Luxembourg's Informative Inventory Report 1990-2021. Submission under the UNECE Convention on Long-Range Transboundary Air Pollution	https://cdr.eionet.europa.eu/lu/un/clrtap/iir/envzf37uq	12.05.2023
LV	2023. Latvia's Informative Inventory Report. Submitted under the Convention on Long-Range Transboundary Air Pollution	https://cdr.eionet.europa.eu/lv/un/clrtap/iir/envzeo57w	27.04.2023
MT	No IIR provided		
NL	Informative Inventory Report 2023. Emissions of transboundary air pollutants in the Netherlands 1990-2021	https://cdr.eionet.europa.eu/nl/un/clrtap/iir/envzcf0wg	27.03.2023
PL	Poland's Informative Inventory Report 2023 Submission under the UNECE CLRTAP and NEC Directive. Air pollutant emissions in Poland 1990–2021.	https://cdr.eionet.europa.eu/pl/un/clrtap/iir/envzbgafa	15.03.2023
PT	National Informative Inventory Report 2023 Portugal. Submission under the NEC Directive (EU) 2016/2284 and the UNECE Convention on Long-range Transboundary Air Pollution	https://cdr.eionet.europa.eu/pt/un/clrtap/iir/envzbczvq	14.03.2023
RO	Romania's Informative Inventory Report 2023. Submission under UNECE Convention on Long Range Transboundary Air Pollution	https://cdr.eionet.europa.eu/ro/un/clrtap/iir/envzbhkew	15.03.2023
SE	Informative Inventory Report Sweden 2023. Submitted under the Convention on Long-range Transboundary Air Pollution	https://cdr.eionet.europa.eu/se/un/clrtap/iir/envza73lg	14.03.2023
SI	Slovenian Informative Inventory Report 2023. Submission under the UNECE Convention on Long-Range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants	https://cdr.eionet.europa.eu/si/un/clrtap/iir/envza_j3w	14.03.2023
SK	Informative Inventory Report 2023. Submission under the CLRTAP and NECD	https://cdr.eionet.europa.eu/sk/un/clrtap/iir/envzd05hq	17.04.2023

Note: EMEP, European Monitoring and Evaluation Programme; IPPU, industrial processes and product use; NEC (also NECD), National Emission reduction Commitments (Directive); CLRTAP: Convention on Long-range Transboundary Air Pollution (the Air Convention).

European Environment Agency

European Union emission inventory report 1990-2021 under the UNECE Convention on Long-range Transboundary Air Pollution (Air Convention)

2023 — 166 pp. — 21 x 29.7 cm

ISBN: 978-92-9480-590-4
doi:10.2800/68478

European Environment Agency

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark
Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

Publications Office
of the European Union

TH-AL-23-003-EN-N
doi:10.2800/68478